TERRESTRIAL
ENERGY USA

Interfaces Between the IMSR® Core-unit and Reactor Auxiliary Building Structures and Systems

Abstract

This white paper contains a description of interfaces for structures, systems and components (SSCs) in the Reactor Auxiliary Building that interact directly with the structures, systems and components that comprise the IMSR® Core-unit. TEUSA plans to provide the detailed interface requirements and acceptance criteria in a subsequent white paper. TEUSA acknowledges that any future application for a combined license or Standard Design Approval under Part 52 or a construction permit under Part 50 will need to demonstrate that the interface requirements and acceptance criteria have been satisfied.

Terrestrial Energy USA, Inc.
537 Steamboat Road • Suite 200 • Greenwich • CT • 06830 • USA
www.TerrestrialUSA.com

Table of Contents

I. Purpose

The purpose of this white paper is to identify and describe the interfaces for structures, systems, and components (SSCs) in the Reactor Auxiliary Building that interact directly with the SSCs that comprise the IMSR® Core-unit. An interface is defined as the place at which two systems meet and interact.

This white paper supports the identification of interface requirements and boundary conditions necessary to establish the Core-unit as a "major portion" of the overall IMSR® power plant design in an application for a Standard Design Approval (SDA) for the Core-unit under 10 CFR Part 52, Subpart E.

Interface requirements are those requirements related to the interface and boundary conditions associated with the Core-unit. The interfaces will stem from the dependency of the SSCs that are within the scope of the application for a Core-unit SDA as well as on the functional and operational characteristics of SSCs that are not within the scope of the SDA.

Interfaces and boundary conditions can be distinct; however, they can also be used interchangeably. Nonetheless, together, they describe the limitations, constraints, assumptions, and conditions to define the relationship between the Core-unit and the remainder of the power plant.

An interface can include an operational assumption about system performance of the Core-unit, whereas a boundary condition can be a physical constraint or an explicit limit on an interfacing system or component, or a similar restraint or limitation associated directly with the Core-unit. Additionally, a boundary condition may be a well-defined physical point of separation, or departure, between an interfacing system and the Core-unit.

The information requirements for a Core-unit SDA application is a subset of the information requirements supporting an application for a construction permit or combined license, thereby supporting the longer-term licensing goals associated with IMSR® deployment. Information that supports an SDA application for the IMSR® Core-unit includes information identifying, defining, or describing:

- the IMSR® Core-unit,
- the associated Core-unit engineering boundary conditions,
- the interfaces between the Core-unit and the remaining portions of the IMSR® power plant,
- the IMSR® Principal Design Criteria (PDC),
- the Core-unit interface requirements & acceptance criteria, and
- other regulatory requirements applicable to the IMSR® Core-unit.

II. Introduction

Terrestrial Energy USA, Inc. (TEUSA) is developing the Integral Molten Salt Reactor (IMSR®) design to provide electricity or process heat to U.S. industrial heat users. TEUSA is planning for the first commercial deployment of this technology in the late 2020s. The IMSR® is a Generation IV advanced reactor power plant that employs a fluoride molten salt reactor (MSR) design. The IMSR® nuclear power plant (I-NPP) consists of a nuclear island containing at least one, approximately 442 MWth IMSR® (IMSR400) Core-unit. The IMSR400 has the potential to generate up to 195 MWe of electrical power or to export 600 °C of heat for industrial applications, or some combination of both. The I-NPP includes an adjacent balance-of-plant building that contains non-nuclear-grade, industry-standard power conversion and generation equipment.

The IMSR® design builds upon pioneering work carried out at Oak Ridge National Laboratory (ORNL) from the 1950s to the 1980s, where MSR technology was developed, built, and demonstrated with two experimental MSRs. The first MSR was the Aircraft Reactor Experiment (ARE) and next, the Molten Salt Reactor Experiment (MSRE). Based on the demonstrated feasibility of MSR technology, ORNL commenced a commercial power plant program for MSR technology. This program led to the Denatured Molten Salt Reactor (DMSR) conceptual design in the early 1980s.

TEUSA has developed and submitted a Regulatory Engagement Plan (REP) (Reference 5) to the Nuclear Regulatory Commission (NRC). The REP outlines topics and schedules for interaction with the NRC to achieve early resolution of general technical or regulatory matters related to the IMSR® design. Specifically, the REP highlights technical and regulatory topics that directly support the development and submittal of a 10 CFR 52, Subpart E application for an SDA of the IMSR® Core-unit. This white paper is one in a series of technical documents that support the TEUSA SDA application development efforts.

Company Background

TEUSA [

]. TEUSA is a Delaware C-Corp founded in August 2014 that started active business operations in 2015. TEUSA is a U.S. majority-owned company with corporate offices in Greenwich, CT. [

].

Canadian Nexus

TEUSA has [

]. TEUSA leverages the ongoing engineering and regulatory work that TEI accomplishes as TEI currently advances its regulatory activities under Phase 2 of the Vendor Design Review (VDR) process with the Canadian Nuclear Safety Commission (CNSC). Leveraging the efforts of TEI's VDR activities is possible because most of the technical and engineering information used for both regulatory reviews is the same. Leveraging TEI effort eliminates duplicate technical work in the U.S., and the approach also provides substantial cost savings for TEUSA. The figure below provides [

].

Figure 1: [ ]

[

]

Licensing Strategy and Objective

The REP provided to the NRC outlines the regulatory strategy for TEUSA activities. [

] to support a commercial operation date for the first U.S. plant in the 2020s. During regulatory reviews, the NRC uses its understanding of the design and operating characteristics as well as the supporting research and engineering work to perform its review responsibilities efficiently. To support the NRC understanding, TEUSA has begun familiarizing the NRC with the IMSR® design as well as the scope of the available and planned analyses, testing, and operational experience in support of the design. By initiating the process of introducing the IMSR® design information to the NRC, TEUSA expects that the NRC can identify any issues that may require further testing or technical analyses. Additionally, the NRC will be more able to estimate the resource and schedule requirements necessary to conduct regulatory activities associated with IMSR® licensing.

TEUSA's 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.

III. Regulatory Envelope and Related Guidance

The regulations governing the application process for an SDA can be found in Subpart E, "Standard Design Approvals," of 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The regulatory precedent for 10 CFR Part 52, Subpart E is 10 CFR Part 50 Appendix O, was first created in January 1975. The process outlined in Appendix O of 10 CFR part 50 was used to review standard designs for nuclear steam supply systems (NSSS), balance of plant systems, a nuclear island, and a turbine island. However, there is no regulatory precedent for using an SDA process for smaller portions of a plant design. The previously approved NSSS designs were subsequently incorporated into construction permit applications for specific plant sites.

10 CFR 52.135(a), "Filing of applications," states:

"any person may submit a proposed standard design for a nuclear power reactor of the type described in 10 CFR 50.22 to the NRC staff for its review. The submittal may consist of either the final design for the entire facility or the final design of major portions thereof."

The current regulations do not define what constitutes a "major portion" of a design making an applicant free to identify and justify the scope of the design for which the approval is being sought. Such freedom affords potential applicants substantial flexibility to standardize different portions of new or innovative technologies. Depending on the maturity of the design and engineering, an SDA could be developed for selected SSCs or larger integrated portions of the design at a level of detail analogous to that of a design certification application. The associated interface requirements could include significant conceptual design information for the remainder of the design.

Relevant Regulatory Guidance

In an effort to support technology developers interested in pursuing a staged licensing process, the Nuclear Innovation Alliance (NIA) developed two guidance documents that are relevant to developing an application for an SDA for a major portion of their design. In April 2017, NIA issued its first report "Clarifying 'Major Portions' of a Reactor Design in Support of a Standard Design Approval" (Reference 1) which discussed the options for using an SDA as part of a staged licensing approach. This report provided information to assist a reactor developer in determining if pursuing an SDA would support their licensing development interests.

In September 2019, NIA issued its second report, "Establishing Interface Requirements for 'Major Portions' Standard Design Approvals," (Reference 2). While the NIA report discussed options available for reactor designers seeking a staged licensing process, a key element of this guidance was that in an SDA application for a major portion of a technology, the developer should explicitly list all assumptions regarding the major portion's connection to other parts of the design to facilitate NRC review and any future use in subsequent licensing processes. These assumptions are frequently referred to as system interface requirements. The NIA document also provided guidance on a process that a potential applicant could use for establishing these interface requirements in its application.

The September 2019 NIA report (Reference 2) provides a process which may be used by developers of advanced reactor technologies. [

].

The process that TEUSA employed is briefly explained in the following section.

Process for Identifying Interfaces

For TEUSA, the definition of the scope of the Core-unit was presented in a white paper submitted to the NRC in March 2020 (Reference 4). Consistent with the TEUSA defined scope, TEUSA examined the interactions between the IMSR® Core-unit systems and other systems within the Reactor Auxiliary Building (RAB) to identify the types of interfaces that might exist, for which future interface requirements will need to be established.

Interface requirements should be thought of as boundary conditions between the portion of the design for which the SDA is being sought and the rest of the facility. In fact, 10 CFR 52.47(a)(25) states that an applicant must provide interface requirements to be met by those portions of the plant for which the application does not seek approval.

Figure 1 of the NIA September 2019 report "Establishing Interface Requirements for "Major Portions" Standard Design Approvals" (Reference 2) depicts a process for establishing interface requirements in support of an SDA for a major portion of a design. The NIA process calls for the designer to develop design criteria and recommends that a designer examine the guidance contained in Regulatory Guide 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors" (Reference 3). The regulatory guidance can also be used as a tool to assess, at a macro level, whether there could be a need to define boundary conditions and interface requirements in conjunction with the design process. The need for interface requirements stems from the dependency of the SSCs that are within the scope of the SDA application on the functional and operational characteristics of SSCs that are not within the SDA application scope. The process depicted in Table 1 of the referenced NIA report (Reference 2), proposes using the Advanced Reactor Design Criteria (ARDC) as a substitute for design-specific principal design criteria.

The scope of the IMSR® Core-unit and the systems included within it are summarized in the next section.

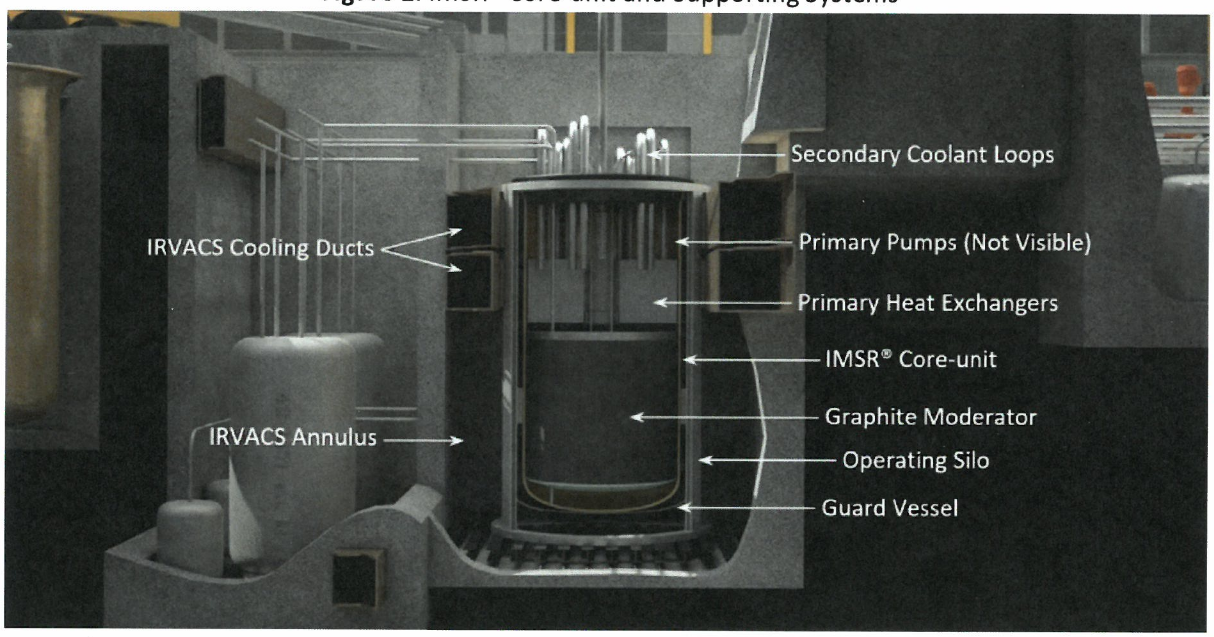
It is important to note that the design of important safety and non-safety related systems have interface requirements related to protection from natural phenomena. As no specific site has been selected, a plant parameter envelope of important natural phenomena values has been used for design development. Appendix B to this white paper provides current design parameters for natural phenomena for the IMSR® design.

IV Structures, Systems and Components that Constitute the IMSR® Core-unit

For ease of reference, this section provides a brief summary of information about the SSCs that comprise the IMSR® Core-unit. Reference 4 provides greater detail about the IMSR® Core-unit SSCs.

Figure 2 below provides a more detailed picture of the internal structures and components of the IMSR® Core-unit and supporting systems.

Figure 2: IMSR® Core-unit and Supporting Systems



Reactor Vessel

The Reactor Vessel is an upright, [ ] cylinder. It contains the full inventory of liquid fuel salt and there are no external fuel salt piping loops associated with the Reactor Vessel. All the nuclear heat fission energy is generated within the Reactor Vessel. [ ], the Reactor Vessel forms the primary nuclear boundary during normal operation, anticipated events, and Design-Basis-Accidents (DBAs).

The Reactor Vessel boundary performs the following functions:

- Contains the fuel salt,
- Provides a flow circulation path for the fuel salt, and
- Provides a support (anchor point) for the core internals.

Liquid Fuel Salt

The IMSR® design operates by fissions of low-assay low enriched uranium (LEU) [ ] dissolved in a molten primary coolant comprised of a fluoride salt-mixture. The primary purpose of the fuel salt-mixture is to deliver the low-enriched fissile uranium into the IMSR® graphite core for heat generation through a sustained fission chain reaction and subsequent transportation of the heat to the Primary Heat Exchangers. The [ ] over the 7-year lifetime. In any potential emergency involving a sudden temperature increase, the core negative temperature reactivity

coefficient will inherently stabilize the reactor such that the Internal Reactor Vessel Auxiliary Cooling System (IRVACS) can passively remove the heat it produces.

Primary Pumping System

The Primary Pumping System performs the essential function to circulate the fuel salt through the Core-unit. Its purpose is to provide enough flow through the Primary Heat Exchangers and Moderator to facilitate full power operation without exceeding the material temperature limits of the Core-unit components. The Primary Pumping System is wholly contained within the sealed Core-unit.

Graphite Moderator

The purpose of the Graphite Moderator is to provide the medium for slowing down neutrons to promote the nuclear chain reaction. The core design provides fuel channels for the passage of fuel salt, using pumping force, through the moderator region, to the Primary Heat Exchangers. The graphite [

].

Shutdown Rods

IMSR® reactor shutdown (i.e., sub-criticality) is not required to reach a safe end-state for any Anticipated Operation Occurrence (AOO) or DBA (a safe end-state for the IMSR® design is defined to be the reactor at low power, the Reactor Vessel temperature within acceptable limits, and no fuel (salt) boiling). However, as a defense-in-depth safety measure, and for operational purposes, the IMSR® design includes a Shutdown Mechanism (SDM) as an independent means of shutting down the reactor.

The purpose of the SDM is to bring the reactor to a sub-critical state. The SDM makes use of Shutdown Rods to bring the reactor to a shutdown sub-critical state, which would eventually result in cooldown to a cold condition as decay heat subsides.

[

]. See Figure 4-22 of Reference 6 for more detail about Reactor Vessel internals.

Primary Heat Exchangers

The Primary Heat Exchangers (PHXs) provide heat transfer between the circulating Fuel Salt and a separate closed-loop coolant salt. The PHXs [

].

Cover Gas & Off-gas Management System

[

]. Additional details about the Cover Gas & Off Gas Management System is provided below.

This system [ ].

V. Identification of Structures, Systems and Components that Interface with the IMSR® Core-unit

This section identifies SSCs that are not contained within the Core-unit but connect directly to systems in the Core-unit. Section VI lists the interfacing systems and structures, identifies categories of interfaces for the selected system or structure identified, and provides references to potentially relevant principal design criteria associated with the selected system or structure.

Instrumentation and Control

In general, the control functions are not challenging in terms of complexity and performance due to the passive and inherent safety design features of the IMSR®. The I&C system's main functions deal fundamentally with integrated control of production, interlocks for safety coordination, and monitoring system status. Compared to conventional nuclear technology, some of the in-core instrumentation and process equipment for the salt systems operate in a higher temperature environment, [ ].

Makeup Fuel System (MFS)

The purpose of the MFS is to provide the initial fuel load for a new Core-unit and to periodically add fuel to the operating Core-unit during operation. Fuel additions are to maintain the reactivity of the core and maintain the fuel temperature at the desired value.

The system has a safety function to limit the rate and amount of reactivity that can be added to the Core-unit to ensure the fuel temperature does not increase in an uncontrolled manner. This system also ensures that fuel outside the Core-unit cannot go critical. Additionally, the design ensures the system meets safeguards requirements.

This system operates intermittently, is normally isolated from the Core-unit, and kept at, or near, atmospheric pressure. Note that the MFS has no heat removal requirements for the fuel.

Secondary Coolant System

The purpose of the Secondary Coolant System is to deliver heat from the Primary Heat Exchanger to the Secondary Heat Exchanger, where heat is transferred to the Tertiary Salt Loop. Figure 2 shows the relationship of Secondary Coolant System piping to the IMSR® Core-unit and other SSCs.

Internal Reactor Vessel Auxiliary Cooling System (IRVACS)

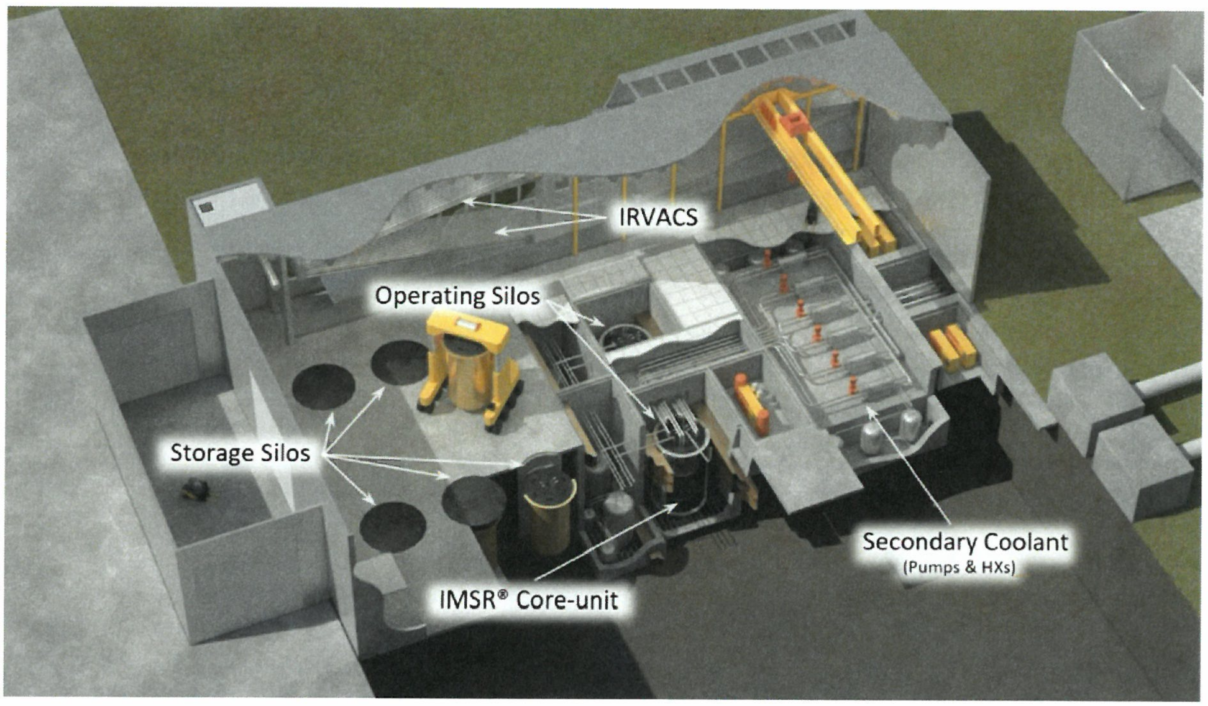
Under normal heat removal conditions, the fuel salt mixes convectively in the Core-unit and transfers heat out through the primary heat exchangers to the secondary heat exchangers. The IRVACS functions as an alternate emergency heat sink to passively remove heat generated within the Core-unit during transients, accidents, or whenever normal heat removal is unavailable.

IRVACS [ ] system that operates [ ] to transfer heat from the Core-unit to the atmosphere. The IRVACS is always operating and does not require any AC or DC electrical power. The system functions continuously irrespective of Core-unit status or plant state. The system has no actuation devices, no flow control mechanisms, nor any other type of control device. The heat removal capacity is sized to remove the maximum postulated decay-heat load, including situations where normal heat removal might not be available.

Reactor Auxiliary Building

The seismically qualified Reactor Auxiliary Building (RAB) houses, (i) the IMSR® Core-units and associated nuclear systems, (ii) various heat removal systems (excluding Steam Generators) and, where required, additional heat transfer equipment to supply process heat to industrial users, and (iii) electrical systems and various auxiliary systems required to safely control, and monitor the plant during all postulated operating conditions. Figure 3 below shows the arrangement of the storage silos, operating silos, a portion of the IRVACS (Internal Reactor Vessel Auxiliary Cooling System), and the location of the secondary coolant system, primarily the secondary coolant pumps and heat exchangers. Importantly, Figure 3 shows the physical relationship between the operating silos, storage silos, and the IMSR® Core-unit.

Figure 3: Reactor Auxiliary Building



Main Control Room and Secondary Control Area

The Main Control Room (MCR) is located in the Control Building and is the center for all plant operations. The Control Building is seismically qualified and is designed to withstand the effects of all postulated natural phenomena so that control room operators should not need to leave the control room during plant transients and postulated accidents. From the MCR, the operator can perform all plant control, monitoring, and safety functions. In the event the MCR is unavailable, operators would move to the Secondary Control Area (SCA) to monitor and ensure that the plant remains in a safe state. Local instrument rooms, which contain local monitoring and control capability, are distributed throughout the plant as needed.

Silos

There are eight silos included in the IMSR® facility. Two silos are for operating Core-units, and six are for Core-unit storage. One of either of these two operational silos houses the operating Core-unit for its 7-

year operational life; the second silo houses the previously operated (spent) Core-unit during its radioactivity decay cooldown period. Following cooldown, preparations are made for a new Core-unit by transferring the previously operated Core-unit from its operating silo into a storage silo. The six storage silos only house spent Core-units that have completed the required radioactivity decay cooldown period. The silos interface with the Reactor Vessel and Reactor Support Structure. Figure 2 shows the relationship of the Silo to the Guard Vessel, Core-unit, and SSCs.

Guard Vessel

The Guard Vessel is a stainless-steel vessel that is fitted around and supports the Reactor Vessel. The primary purpose of the Guard Vessel is to catch and retain any fuel salt leakage or radioactive release from the IMSR® Core-unit to protect from any unintended release from the Core-unit. In the event of a Beyond Design Basis failure of the Reactor Vessel, the Guard Vessel will catch and contain any leaked fuel salt. Unlike the Reactor Vessel, which is a component part of the replaceable Core-unit, the Guard Vessel is a component of the containment boundary. The Guard Vessel is designed to last for the operating life of the plant. Figure 3 (above) shows the relationship between the Guard Vessel, Silo, Core-unit, and other SSCs.

Reactor Support Structure

The Reactor Support Structure is a steel structure located in the silo. The Reactor Support Structure is used to support and provide alignment of the Guard Vessel inside the Silo. By extension, the Reactor Support Structure also provides support and alignment of the Core-unit. Figure 3 shows the relationship between the Reactor Support Structure, Silo, Guard Vessel, Core-unit, and other SSCs.

Containment

The Containment system forms a sealed, low-leakage envelope to house all systems that may contain highly radioactive material, specifically the Core-unit (active reactor), the off-gas lines/storage, irradiated fuel tanks, and any pipe transferring irradiated liquid fuel. In the event of a leak in any of these systems, the containment prevents the release of any radioactive materials to the Reactor Auxiliary Building. The Containment system also minimizes releases in the unlikely event of a severe accident. The Containment system includes the Guard Vessel and a common containment boundary that encloses the top plate of the Reactor Vessel, the off-gas and fuel transfer lines, and the irradiated fuel storage tanks.

Cover Gas & Off Gas Management System

Above the [ ]. It also accommodates [ ] over its 7-year operational life. A subsystem of the Irradiated Fuel System, the Off-Gas System provides [ ].

[

].

Irradiated Fuel System (IFS)

The primary purpose of the IFS is to remove the fuel from the Core-unit and transfer the fuel to storage tanks for long term on-site storage. This system [ ]. The system can store all of the irradiated fuel generated over the 60-year life of the plant. At [ ], this system [ ].

VI. IMSR® Core-Unit Interfaces

This section outlines the interfaces for each of the systems or structures that interact directly with the IMSR® Core-unit but are not part of the defined IMSR® Core-unit SDA application scope. Information for each interface is presented in a tabular format. In each table, the design functions for the interface are listed. [ ], the tables include examples of potentially relevant PDC for each of the listed Interface Categories. The listed "potentially relevant" PDC are not proposed as a comprehensive set and are provided only as illustrative examples.

The interface requirements for design, procurement, fabrication, and construction will be captured under an approved quality assurance plan. To reduce the redundancy within the tables, the interfaces to be governed by the quality assurance (QA) plan are simply listed once in the first interface category (Materials). TEUSA notes that for other interface categories, this relationship is implicit as it will be contained in the relevant standards used in the development of the detailed design of the interfacing SSCs and will also be prescribed in the overall QA program in the future.

The interface tables (Tables 1 through 12) refer to the PDCs presented in Appendix A, which are those listed for use for a sodium fast reactor in RG 1.232, Appendix B (Reference 3). Each of the RG 1.232 PDCs have been assigned a unique TEUSA number. No inference of applicability of the listed PDC in this paper or in Appendix B of RG 1.232 to the IMSR® design should be made at this time.

The IMSR®-specific [ ] will be presented to the NRC as the subject of a separate white paper. The system and structure specific interface requirements, and necessary acceptance criteria, [ ].

Table 1. Interfaces for the Digital Instrumentation and Control System

Digital Instrumentation and Control System		
System Functions:	• Provide integrated control of production • Provide interlocks for safety coordination • Monitor system status • Provide capability for monitoring and operations in Main Control Room	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [ ]	[ ]
System performance	• [• • • • •]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [ ]	[ ]
Radionuclide retention or removal	• [ ]	[ ]

Table 2. Interfaces for the Makeup Fuel System

Makeup Fuel System (MFS)		
System Functions:	• Provides the initial fuel load for new Core-units • Periodically adds fuel during operation to maintain core reactivity and fuel temperature at the desired values • Ensures that fuel outside the Core-unit cannot go critical	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• • • •]	[ ]
System performance	• [• • • • • • • • • •]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [• •]	[ ]
Structural	• [• •]	[ ]
Radionuclide retention or removal	• [ ]	[ ]

Table 3. Interfaces for the Secondary Coolant System

Secondary Coolant System		
System Functions:	• Delivers heat from the primary heat exchanger to the secondary heat exchanger by using a secondary cooling salt loop • Forms the primary coolant boundary within the primary system heat exchangers	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• • • •]	[ ]
System performance	• [• • • • • • • •]	[ ]
Heat removal	• [• •]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [•]	[ ]

Table 4. Interfaces for the Internal Reactor Vessel Auxiliary Cooling System

Internal Reactor Vessel Auxiliary Cooling System (IRVACS)		
System Functions:	• Alternate emergency heat sink to remove heat generated in the IMSR® Core-unit during transients, accidents, or whenever normal heat removal paths are unavailable	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• •]	[ ]
System performance	• [• •]	[ ]
Heat removal	• [• •]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [ ]	[ ]
Radionuclide retention or removal	• [ ]	[ ]

Table 5. Interfaces for the Reactor Auxiliary Building

Reactor Auxiliary Building		
System Functions:	• Houses (i) the IMSR® Core-units and associated nuclear systems, (ii) the heat removal systems before the steam generators and any additional heat transfer equipment to supply process heat to industrial users, and (iii) the electrical systems and various auxiliary systems required to operate safely, control, and monitor the plant during all postulated operating conditions	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [•]	[ ]
System performance	• [ ]	[ ]
Heat removal	• [• • •]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [• • • •]	[ ]
Radionuclide retention or removal	• [•]	[ ]

Table 6. Interfaces for the Control Building

Control Building		
System Functions:	• Houses the main control center, the security and operations staff, associated change rooms, and facilities required for the operation of the plant • Capability to operate all required safety systems when necessary	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [ ]	[ ]
System performance	• [•]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [ ]	[ ]

Table 7. Interfaces for the Silos

Silos		
System Functions:	• 2 silos are used for operating Core-units: one houses the operating Core-unit for its 7-year operational life; the other houses the previously operated (spent) Core-unit during its cooldown period • 6 silos are used for Core-unit storage	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [ ]	[ ]
System performance	• [ ]	[ ]
Heat removal	• [•]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [•]	[ ]

Table 8. Interfaces for the Guard Vessel

Guard Vessel		
System Functions:	• Supports the Reactor Vessel and by extension, the IMSR® Core-unit • Catch and retain any fuel salt leakage or radioactive release from the IMSR® Core-unit to protect from any unintended release as a result of a beyond design basis event	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• • • •]	[ ]
System performance	• [• •]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [ ]	[ ]
Radionuclide retention or removal	• [• • •]	[ ]

Table 9. Interfaces for the Reactor Support Structure

Reactor Support Structure		
System Functions:	• Supports and provides alignment of the guard vessel inside the silo, and by extension provides support and alignment to the IMSR® Core-unit	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [•]	[ ]
System performance	• [ ]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [ ]	[ ]

Table 10. Interfaces for the Containment

Containment		
System Functions:	• Houses all systems that may contain highly radioactive material, including the IMSR® Core-unit, the off-gas lines/storage, irradiated fuel tanks, and any pipe transferring irradiated liquid fuel • Provides a passive barrier for high activity sources within the plant to protect workers and the public from radiation doses during normal operations and accidents • Minimizes leakage to assure that normal operation release limits are met, and that AOOs and DBAs do not result in exceeding dose acceptance criteria	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• •]	[ ]
System performance	• [•]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [• • • •]	[ ]

Table 11. Interfaces for the Cover Gas & Off Gas Management System

Cover Gas & Off Gas Management System		
System Functions:	• [*Cover Gas:* • Facilitates gas expansion, fission gas holdup, and passive cooling • Accommodates the added fuel salt volume from make-up fuel additions • Isolated and not used during reactor power operation • *Off-Gas System:* • Removes gaseous fission products from the Core-unit during power operation • Replaces any pressure control functions during reactor power operation]	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [•]	[ ]
System performance	• [• • •]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [ ]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [• • • •]	[ ]

Table 12. Interfaces for the Irradiated Fuel System

Irradiated Fuel System (IFS)		
System Functions:	• Removes the fuel from the Core-unit and transfers the fuel to storage tanks for long term on-site storage	
Interface Category	**Interface**	**Principal Design Criteria**
Materials	• [• • • •]	[ ]
System performance	• [• • • • • • • •]	[ ]
Heat removal	• [ ]	[ ]
Fuel design	• [•]	[ ]
Structural	• [•]	[ ]
Radionuclide retention or removal	• [•]	[ ]

VI. Conclusion

This white paper identifies the interfaces between the IMSR® Core-unit and systems and structures located in the Reactor Auxiliary Building or Control Building that provide important functions in support of the operation and safety of the IMSR® plant. Interface requirements will be necessary for each of these interfacing systems or structures in an application for either a combined license or an SDA under Part 52, or a construction permit under Part 50. The specific proposals for interface requirements for the systems and components that support the IMSR® Core-unit will be presented in a future white paper.

Appendix A – Listing of Principal Design Criteria

Principle Design Criteria

[

]

Appendix B – IMSR400 Design Generic Site Characteristics

[

]

Abbreviations and Acronyms

AOO – Anticipated Operational Occurrence

ARDC – Advanced Reactor Design Criteria

ARE – Aircraft Reactor Experiment

BDBA – Beyond Design-Basis Accident

BeF_2 – Beryllium Fluoride

CFR – Code of Federal Regulations

CNSC – Canadian Nuclear Safety Commission

Cs - Cesium

DBA – Design Basis Accident

DMSR – Denatured Molten Salt Reactor

I&C – Instrumentation and Control

IFS – Irradiated Fuel System

I-NPP – IMSR Nuclear Power Plant

IMSR® – Integral Molten Salt Reactor

IRVACS – Internal Reactor Vessel Auxiliary Cooling System

KF – Potassium Fluoride

LEU – Low Enriched Uranium

LiF – Lithium Fluoride

MCR – Main Control Room

MFS – Makeup Fuel System

MW – Megawatt

MWe – Megawatt Electric

MWth – Megawatt Thermal

MSR – Molten Salt Reactor

MSRE – Molten Salt Reactor Experiment

NaF – Sodium Fluoride

NIA – Nuclear Innovation Alliance

NRC – Nuclear Regulatory Commission

NSSS – Nuclear Steam Supply Systems

ORNL – Oak Ridge National Laboratory

PDC – Principal Design Criteria

PHX – Primary Heat Exchanger

PSA – Probabilistic Safety Assessment

QA – Quality Assurance

R&D – Research and Development

RAB – Reactor Auxiliary Building

REP – Regulatory Engagement Plan

SCA – Secondary Control Area

SDA – Standard Design Approval

SDM – Shutdown Mechanism

SHX – Secondary Heat Exchanger

Sr - Strontium

SS – Stainless Steel

SSC – Structures, Systems, and Components

TEI – Terrestrial Energy, Inc.

TEUSA – Terrestrial Energy USA, Inc.

U.S. – United States

VDR – Vendor Design Review

Xe - Xenon

References

1. Nuclear Innovation Alliance, "Clarifying "Major Portions" of a Reactor Design in Support of a Standard Design Approval," April 2017.

2. Nuclear Innovation Alliance, "Establishing Interface Requirements for "Major Portions" Standard Design Approvals," September 2019.

3. Regulatory Guide 1.232, Revision 0, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors", April 2018, U.S. Nuclear Regulatory Commission

4. TEUSA, "IMSR® Core-unit Definition - Applicable Structures, Systems and Components," March 2020.

5. TEUSA, "Integral Molten Salt Reactor (IMSR®) – U.S. Regulatory Engagement Plan," March 2020.

6. IMSR-CSAR-000.00-00001-R00, CSAR Chapter 4, "Reactor", August 2016.

7. IMSR400-30000-PPS-001, Plant Performance Specification (PPS) for the IMSR400, December 2018

8. IMSR400-22500-DD-001, "Design Description Irradiated Fuel System," September 2020.

9. IMSR400-22500-DR-001, "Design Requirement Gas Management System," September 2020.

Terrestrial Energy USA Response to U.S Nuclear Regulatory Commission Staff Observations on the Integral Molten Salt Reactor Core-Unit Interfaces White Paper

1. General

Feedback Item #	NRC Feedback	TEUSA Response
1-a	The staff has identified some potential interfaces that are not listed in the white paper. It is recognized that the design is not final, but the staff recommends that the following items be considered to determine if they are indeed additional interfaces that should be included: [ ].	TEUSA agrees that [ ]. The details on these systems will be disclosed in a later report after further design maturation.
1-b	The usefulness of the staff's feedback towards future submittals will depend on the level of detail provided in the white paper. For example, stating that "protection against natural phenomena" is an interface requirement doesn't provide enough detail for the staff to say whether all relevant natural phenomena are covered.	TEUSA agrees with this comment and has included a table of site parameters into a new Appendix B to provide further detail in the white paper.
1-c	Throughout the white paper, it seems that there is a blurred line between what is defined as an interface and what would typically be considered a system design requirement. This is often found in items listed as system performance interfaces. For example, "system functions" would typically outline the interface for flow, mass transfer, heat transfer, etc., since they could affect the performance of the main system. Other aspects can be considered design aspects that can be left to the designer. These design aspects will be important during later reviews of the design but might not be necessary here (see comment "1e" for an example). Please consider the interfaces listed in any future submittals to determine if they are design related items instead and can be left out.	TEUSA has added a clear definition of "interface" which can be found in the first paragraph of Section I.

1-d	The general system level interfaces, such as safety classification and seismic classification are important from a regulatory perspective. Knowing the Core-unit is supported by either a safety-related system or a non-safety-related system has important impacts on the analyses. The same can be said for seismic classification. Where these changes occur would typically imply some change in a system, such as a valve installation that would close upon some specific action or event. Usually, such isolation valves would be part of the main system rather than the interfacing system. Please review the reactor design as it matures before future submittals and include these or other related items, as applicable.	TESUA will provide details about the safety and seismic classification in a future "System/Structure Classification" white paper. TEUSA does note that isolation valves will take the safety and design requirements of the interfacing system that has a higher safety importance classification
1-e	The use of design and construction codes are important in the design and review phase for the specific system but are of less importance as an interface on the Core-unit. For example, Table 3 includes [ ] as an interface for the structural interface category. Because the [ ].	For purposes of comprehensive coverage and subsequent reports, TEUSA will [ ].
1-f	The interface requirements for the standard design approval (SDA) can be influenced by whether the reactor design's safety case is based on either a traditional deterministic approach or a risk-informed and performance-based approach (e.g., Regulatory Guide 1.233, which endorses Nuclear Energy Institute 18-04). Therefore, addressing the interface requirements should be coordinated with the safety case approach taken for the SDA. For example, a set of licensing basis events, as well as structures, systems, and components (SSC's) classification are expected to be different depending on the approach taken. Please consider this comment when making future licensing decisions.	TEUSA notes that in the current white paper, the interfaces to the Core-unit are [ ].

1-g	In the white paper under the section titled "Process for Identifying Interfaces," there are eight categories listed in which the interfaces generally fall. However, the interface tables do not include a row for Analytical Capabilities and Assumptions. A future revision of the report should address this discrepancy.	TEUSA has removed the list of categories in the sub-section "Process for Identifying Interfaces" in Section III.
1-h	In the white paper under Section I, "Purpose," it states that an interface could include a programmatic requirement or operational assumption about system performance of the Core-unit. However, neither of these options were captured in the list of interface categories on page 8, nor are there rows for programmatic requirements or operational assumptions in the interface tables. Staff acknowledges some programmatic requirements (e.g. inspection and testing) and operational assumptions (e.g. pump operational requirements) are included in the interface tables under different categories (e.g. system performance). Please address the discrepancy between the "Purpose" section and the interface requirements in any future revision to this white paper.	TEUSA has removed "programmatic requirement" from Section I, "Purpose."
1-i	Under the system performance interface category, [ ] are included in some, but not all of the tables. Staff would like to understand this apparent inconsistency. Additionally, while programmatic requirements are important to the design and review phase of the system, systems that support programmatic requirements may not need to be interface requirements. Please consider whether programmatic requirements such as [ ] or [ ] should be included as an interface to the core unit.	TEUSA has removed programmatic discussions as interfaces and [ ] from all tables in Section VI. As for [ ], TEUSA recognizes the import role that salt chemistry performs for molten salt technologies. See response to NRC comment 1 for additional information.
1-j	Provide additional detail on what is meant by the "Plant protection" interface category. For example, several tables list [ ] as an interface. However, this is relatively ambiguous as it could be related to workers or the interfacing system.	TEUSA has eliminated all discussions of "plant protection" from the white paper and has removed it as an interface category in the tables in Section VI.

2. Systems/Structures Feedback

2.1. Instruments and Controls (I&C)

Feedback Item #	NRC Feedback	TEUSA Response
2.1-a	System performance should include a summary of the controls for safety significant I&C systems that are required to be provided, including logic, interlocks, variables, and the sensing and actuation times needed for the Core-unit to perform its safety function. This is to show that variables and systems that can affect the safety functions are maintained within appropriate ranges. It is not clear whether [ ] in the Interface column includes these elements.	TEUSA agrees that the types of controls for instrumentation and control systems are important in understanding the system design and safety functions. However, TEUSA does not agree that all of the listed topics are interface requirements. TEUSA will use the information provided in this comment as input into the development of a future white paper that will provide more specific requirements for parameter values.
2.1-b	System performance interface requirements should also contain a summary of secondary system I&C since secondary systems could often affect the reactor design's licensing basis events such as anticipated operational occurrences. Identification and evaluation of licensing basis events is important in building a safety case for the reactor design.	TEUSA will consider this staff comment as we continue to mature the design. No changes will be made to the white paper in response to this feedback. However, this comment will be considered in the development of future white papers, as appropriate.
2.1-c	System performance interface requirements in Table 1 list the principles of [ ]. To be comprehensive, additional principles should be included (e.g., [ ]. However, these principles may not be needed for SDA if I&C performance objectives (e.g., reliability goals) can be established.	TEUSA has added [ ] to Table 1 under "System performance."

2.2. Makeup Fuel System (MFS)

Feedback Item #	NRC Feedback	TEUSA Response
2.2-a(i)	Values for parameters, such as flow rates, volume addition, etc. that are used in analyzing the Core-units should become interface requirements so that the regulator can be assured that the interface systems will be designed to satisfy the design basis requirements for the Core-units. Perhaps those assumptions used in the analyses would	TEUSA agrees with the comment. At this stage of the design process, many of these parameter values are in the final development process. This information (parameter values, etc.) will be included in a later white paper.

	fall under the category of Analytical capabilities and Assumptions.	
2.2-a(ii)	a) It is unclear what is meant by [ ]. Is this referring to mechanical requirements, dimensional requirements, chemical compatibility, or something else?	TEUSA has included additional information about [ ] in Table 2.
2.2-b	Does [ ] include seismic performance requirements? It should be made clear what codes and standards are used to ensure the appropriate level of seismic response is achieved. This might already be covered in the "structural" interface category, but it was unclear to the staff.	The action of equipment qualification includes both seismic and environmental qualification. As applied within TEUSA, environmental qualification involves only qualification to harsh environmental conditions following design basis accident. It also includes aging of components subject to harsh environments. Seismic qualification is a separate topic area.
2.2-c	There are no heat removal requirements listed. The approach to accident analyses has not been presented to the staff at this point so the staff can't capture all possible interfaces. However, if TEUSA relies on [ ] then this heat removal requirement should be included here.	[ ]. TEUSA has added this information into Section V. TEUSA notes that the MFS is being designed to preclude the possibility of inadvertent criticality.
2.2-d	[ ] appears to be overly broad. It is difficult for the staff to comment on what the actual interface requirement might be.	TEUSA agrees with this comment and has defined [ ] in Table 2 in terms of its parameters of importance [ ].
2.2-e	Similar to comment 2.2.d), if there is an [ ] will the fuel salt be credited for any radionuclide retention functions? Currently the listed Interface requirement is [ ]	Radionuclide retention will be credited in the safety analyses as an analytical assumption. This is not an interface requirement and the degree of credit will be determined by R&D and provided in the Core-unit safety analysis. TEUSA will provide the details of the safety analyses and supporting documentation during the SDA application.
2.2-f	Are there composition or purity requirements for the makeup fuel salt that should be included as an interface requirement?	[ ].

2.3. Secondary Coolant System

Feedback Item #	NRC Feedback	TEUSA Response
2.3-a	Are there purity requirements for the secondary coolant system? Is that what is intended by the [ ] or should it be included as a separate interface?	[ ]. TEUSA has added this into Table 3.
2.3-b	[ ] for the secondary coolant system should be added as an interface.	TEUSA agrees with this comment and has added [ ] under "System performance" in Table 3.
2.3-c	The key interface between the Secondary Coolant System and the Core-unit is the [ ]. There is limited information provided regarding the secondary coolant system. For example, does the secondary coolant system include provisions to detect radionuclides? If the tubes or plates used for heat transfer (or that which is used to transfer heat) become perforated, is leakage from the secondary system into the primary system or from the primary system into the Secondary Coolant System. Should leak detection be included for system performance?	TEUSA notes that the secondary coolant system is designed such that the secondary loop pressure is maintained at a pressure greater than the pressure in the primary cooling loop. For that reason, any leaks in the primary loop heat exchanger tubes will be from the secondary cooling loop into the primary cooling loop. Nonetheless, a more detailed discussion of leakage monitoring will be included in the next update of the Core-unit definition white paper in the first quarter of 2021. TEUSA agrees with the comment that the [ ] is an important system interface requirement.
2.3-d	The [ ] can be a key interface with the Core-unit to determine the Core-unit response to transients. Are there any operational characteristics that should be considered interfaces?	TEUSA has removed [ ] from the discussions in the white paper.

2.4. Internal Reactor Vessel Cooling System (IRVACS)

Feedback Item #	NRC Feedback	TEUSA Response
2.4-a(i)	Under "System Requirements", consider replacing [ ] with [ ] where specified capability includes any required margin.	TEUSA agrees with this comment. We have replaced [ ] with [ ] and have included [ ] and [ ] in Table 4.
2.4-a(ii)	The Core-unit Definitions White Paper states that the IRVACS has [ ]. Therefore, it is not clear to the staff how [ ] would be an interface. Provide additional information in a future revision to describe how the [ ] would be an interface with the Core-unit if this is the case.	TEUSA will provide more detailed information regarding [ ] in a future white paper.
2.4-b	Additionally, because the IRVACS is a closed-loop, passive system, an interface to [ ] may be appropriate given that the IRVACS needs to [ ] to meet its decay-heat removal function.	TEUSA agrees with the comment and has added [ ] under "System performance" in Table 4.

2.5. Reactor Auxiliary Building (RAB) System

Feedback Item #	NRC Feedback	TEUSA Response
2.5-a	While the interface for the [ ] is listed, the RAB would also provide protection to the Core-unit from other SSC's outside the operating and storage silos. This would include internal flooding considerations, pipe break protection, salt leak detection, etc.	The internal structures within the RAB would likely provide some protection from leakage or handling, however at this moment, they are not credited as providing such protection. More specific information on the credit for the internal RAB structures will be provided as part of the SDA application. At this time, TEUSA will not include [ ] as the focus of this white paper are specific interfaces with the Core-unit.

2.5-b	For the materials should [ ] be identified as an interface.	TEUSA agrees with the comment and has added [ ] as an interface in Table 5.
2.5-c	Will the RAB provide a security interface for the Core-unit?	[ ]. If it becomes apparent that there is a [ ] white paper.
2.5-d	Will the RAB provide a radiation shielding interface for the Core-unit?	[ ].
2.5-e	The RAB is not a leak tight, pressure retaining structure, but it is a seismically qualified structure and can provide protection against natural hazards. Without more extensive design and licensing information being available (e.g. whether or not the building will be credited for any sort of fission product hold-up in the dose calculations), the staff cannot fully comment on the completeness of the interfaces for the RAB. The staff recommends ensuring that the final PDCs and interfaces complement each other accordingly.	TEUSA acknowledges this comment, however, the focus of the current white paper is not on interfaces for the RAB but rather on the interfaces for the Core-unit. Nonetheless, consequence assessments for the IMSR® accident potential radionuclide releases have not been completed at this time so the potential release pathways and credit for retention in the RAB are unknown at this time. Once the safety analyses and consequence assessments are completed, applicable results and related requirements will be provided as a part of the SDA application.

2.6. Control Building

Feedback Item #	NRC Feedback	TEUSA Response
2.6-a	Does the control building have a radiation shielding and control room habitability interface for the Core-unit?	[ ].

2.6-b	The control building has access routes for routing of auxiliary, electrical, instrumentation, and communication conduits between the buildings. Does this mean that it has [ ] with the Core-unit?	[ ]. The specifics are still under design.

2.7. Silos

Feedback Item #	NRC Feedback	TEUSA Response
2.7-a	It is not clear if the heat transfer path from the Core-unit to the IRVACS is through the guard vessel and silo, or if there is just heat transfer via the atmosphere surrounding the reactor vessel. If the heat transfer path is through the vessel and silo, a heat transfer rate may then be an interface related to the Core-unit. This may also be the case if the silo is relied upon to transfer heat in the storage location, however the heat transfer rate may be significantly different in this location.	[ ]. TEUSA will provide a more comprehensive discussion of the heat transfer paths and system requirements in the future white paper that provides the applicable [ ].

2.8. Guard Vessel

Feedback Item #	NRC Feedback	TEUSA Response
2.8-a(i)	The guard vessel is a part of the containment system. Similar interface criteria would be expected for the guard vessel as for the containment system. Several differences were noted between the containment system and the guard vessel, including [ ]; under system performance, there are [ ]; for heat removal, the containment lists [ ]; the containment structural interface category lists [ ]; for plant protection, the containment lists [ ]; and for radionuclide retention or removal for containment lists [ ] the IMSR® Core-unit to protect from [ ].	TEUSA appreciates the comment and has aligned the interface discussions between the containment and guard vessel presented in Tables 8 and 10.
2.8-a(ii)	In general, components which are support structures, including the reactor support structure, the guard vessel, and the silo have interface requirements related to the support of other components. Please consider adding these as support structure interfaces to the structure interface, if necessary.	TEUSA acknowledges the comment and will provide information related to structural interfaces of the Core-unit in a future white paper on interface requirements.

2.8-b	It is not clear if a leakage detection system is to be part of the guard vessel or a different system.	[ ]. Additional information regarding the role of the leakage detection system and leakage detection performance will be provided in a future white paper.
2.8-c	It is not clear if the guard vessel is essential in the transfer of energy from the Core-unit to the IRVACS. [ ].	Yes, the guard vessel has an essential role in the transfer of energy from the Core-unit to the IRVACS during normal operation and under accident conditions. TEUSA has provided [ ] as a heat removal interface in Table 8.
2.8-d	One of the stated system functions for the Guard Vessel is to catch and retain fuel salt leakage or radioactive release from the IMSR® Core-unit. The Guard Vessel is designed to last for the operating life of the plant. The "Materials" Interface Category [ ]. If the Guard Vessel is required to maintain its integrity in the event of a fuel salt or radionuclide leak for the entire operating lifetime of the plant, [ ].	TEUSA agrees with the comment and has added [ ] in Table 8.
2.8-e	If the Guard Vessel is designed to catch and retain fuel salt leakage, [ ].	TEUSA notes that the inherent physics associated with the enrichment of the fuel salt mixture and the need for substantial moderation would inhibit any criticality outside of the graphite region within the Core-unit. TEUSA notes that that the [ ]. Nonetheless, TEUSA has included the consideration to [ ] in Table 8.

2.9. Reactor Support Structure

Feedback Item #	NRC Feedback	TEUSA Response
2.9-a	No structure-specific comments were noted, but some of the general comments apply.	TEUSA notes that structural interface requirements were not included in this white paper. TEUSA will include structural interface requirements in the subsequent white paper.

2.10. Containment

Feedback Item #	NRC Feedback	TEUSA Response
2.10-a	The white paper considers the guard vessel a separate SSC from the containment. Yet the white paper also states that the containment includes the guard vessel.	The specific boundaries for containment and the guard vessel will be clarified in a future white paper on interface requirements.
2.10-b	The staff notes that there are differences between the [ ]. It is not clear to the staff if this was intentional. See comment 2.8(a) for additional description.	TEUSA appreciates the comment and has fixed inconsistencies between Tables 8 and 10.
2.10-c	It is not clear to the staff what constitutes the entirety of the containment boundary for the IMSR®. The figures in the white paper do not highlight the containment boundary, but some of the SSC's that make up the containment boundary are pictured. Additionally, the text identifies some components of the containment boundary (e.g. core-unit, piping, storage tanks, etc.), but it's not clear to the staff based on the wording if there are additional components included in the containment boundary. Therefore, the staff's feedback regarding containment interfaces might be incomplete.	TEUSA agrees with this comment. The specific containment boundaries are still evolving, and the final design boundaries will become available in Q1 of 2021. Additional detail will be provided in a future white paper.

2.11. Cover Gas and Off Gas Management System

Feedback Item #	NRC Feedback	TEUSA Response
2.11-a	The description of the cover gas system includes reference to [ ]. It is not clear to the staff if this system would provide any [ ] for the Core-unit. If so, this would be an appropriate interface to list.	TEUSA has added [ ] as a system performance interface in Table 11. TEUSA notes that [ ]
2.11-b	It is noted that the Off-Gas System [ ]. In order to [ ] are there any chemical processing/purification requirements for the Off-Gas System that may be considered interface requirements?	The design details of the Off-gas system were still being finalized. As such, the details of the chemical/purification requirements are still evolving, TEUSA has [ ] until the requirements have been finalized.
2.11-c	Are there any purity requirements (e.g. air ingress) for the Cover Gas and Off Gas Management System? It is not clear whether this gas volume needs [ ].	See response to comment 2.11 (b).

2.12. Irradiated Fuel System (IFS)

Feedback Item #	NRC Feedback	TEUSA Response
2.12-a	The Core-unit White Paper states that the main functions of the IFS include transfer of irradiated fuel back into any operable Core-unit as well as to provide a space for off gas of the Core-unit. These are not listed as system functions for the IFS in the Core-unit Interfaces White Paper. Should these be considered interfaces and if so does that change the interface requirements listed in the table?	TEUSA notes that there have been design modifications affecting the Irradiated Fuel System that have recently been finalized. The design modifications are discussed in References 8 and 9 to the Interfaces white paper. TEUSA will include the modified system discussions in the next revision of the Core-unit white paper during the first quarter of 2021. [ ].

2.12-b	Under the "Materials" Interface Category it lists an Interface as [ ] What is meant by this phrase? Is this meant to indicate that the [ ], does it mean that the [ ], or does it mean something else?	TEUSA has added clarification about the parameters of interest in Table 12.
2.12-c	Similar to item b) above, under the "Fuel design" Interface Category there is an Interface for [ ] It is not clear what this is meant to represent.	TEUSA defined [ ]