U.S Nuclear Regulatory Commission Staff Observations on Terrestrial Energy's Integral Molten Salt Reactor Core-Unit Interfaces White Paper

Note: [[ ]] denotes proprietary information.

1. General
   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: (1) chemistry control system, (2) chemistry monitoring system, and (3) fuel salt heating system.
   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.
   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.
   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 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.
   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 structural integrity is already captured in the system performance, please consider whether **[[ ]]**
   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.

g) In the white paper under the section titled “Process for Identifying Interfaces,” there are eight categories listed which the interfaces generally fall into. However, the interface tables do not include a row for Analytical Capabilities and Assumptions. A future revision of the report should address this discrepancy.
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.
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.
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.

2. Systems/Structures Feedback
   2.1. Instruments and Controls (I&C)
      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.
      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.
      c) System performance interface requirements in Table 1 lists 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.

   2.2. Makeup Fuel System (MFS)
      a) 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 fall under the category of Analytical capabilities and Assumptions.

b) It is unclear what is meant by **[[ ]]**. Is this referring to mechanical requirements, dimensional requirements, chemical compatibility, or something else?

c) 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.

d) **[[ ]]**. 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 **[[ ]]**.

e) **[[ ]]** appears to be overly broad. It is difficult for the staff to comment on what the actual interface requirement might be.

f) 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 **[[ ]]**

g) Are there composition or purity requirements for the makeup fuel salt that should be included as an interface requirement?

2.3. Secondary Coolant System

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?

b) **[[ ]]** for the secondary coolant system should be added as an interface.

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?

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?

2.4. Internal Reactor Vessel Cooling System (IRVACS)

a) Under "System Requirements", consider replacing **[[ ]]** with **[[ ]]** where specified capability includes any required margin.

b) The Core-unit Definitions White Paper states that the IRVACS has no flow control mechanisms nor any other type of control device and is sized to the maximum postulated decay-heat load**.** 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.

c) 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.

2.5. Reactor Auxiliary Building (RAB) System

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.
b) For the materials should **[[ ]]** be identified as an interface.
c) Will the RAB provide a **[[ ]]** for the Core-unit?
d) Will the RAB provide a **[[ ]]** for the Core-unit?
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.

2.6. Control Building

a) Does the control building have a **[[ ]]** for the Core-unit?
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?

2.7. Silos

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, **[[ ]]** 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.

2.8. Guard Vessel

a) 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 **[[**
] while the guard vessel lists **[[**

]]

b) In general, components which are support structures, including the reactor support structure, the guard vessel, and the silo have interface requirements related to the **[[** **]]**. Please consider adding these as **[[** **]]** to the structure interface, if necessary.
c) It is not clear if a leakage detection system is to be part of the guard vessel or a different system.
d) It is not clear if the guard vessel is essential in the transfer of energy from the Core-unit to the IRVACS. **[[**

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e) 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, **[[** **]]**
f) If the Guard Vessel is designed to catch and retain fuel salt leakage, **[[**

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2.9. Reactor Support Structure

No structure-specific comments were noted, but some of the general comments apply.

2.10. Containment

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.
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.
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.

2.11. Cover Gas and Off Gas Management System

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.

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?

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 **[[ ]**.

2.12. Irradiated Fuel System (IFS)

a) The Core-unit White Paper states that 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?

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?

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.