TEUSA Response to NRC Feedback Questions and Observations Related to the TEUSA Principal Design Criteria White Paper

1. General

Feedback Item #	NRC Feedback	TEUSA Response
1.	TEUSA appears to claim almost, if not all, of the IMSR® design PDCs and associated bases are proprietary. What is the basis for claiming this information as proprietary? It isn't clear how PDCs that are copied, or slightly modified, from RG 1.232 are proprietary.	At this stage of the design process, TEUSA considers the specification of design PDCs and the supporting bases to be business sensitive and proprietary. Disclosure of this information at this time would provide other molten salt developers [ ] will be made public in support of the application.
2.	In the bases for many PDCs, TEUSA states that the IMSR® design will meet certain [ ]. NRC staff feedback on this white paper does not endorse the use of [ ]. The staff will review any exemption requests from USNRC regulations when they are submitted, and the results of those reviews could potentially impact the PDCs.	TEUSA understands that applications made to the NRC must meet U.S. NRC regulatory requirements. The intent of disclosing the [

		].
3.	Provide clarification for the use of the term "Primary Coolant Boundary." The NRC staff understands this boundary to contain the fuel salt which is both the fuel and coolant for the IMSR® design. However, in the white paper there are separate references to the fuel salt, and the primary coolant, even though the staff understands these to be the same.	TEUSA has revised the white paper to be consistent with the use of the term "primary coolant." It is true that in the IMSR®, the fuel salt mixture is the primary heat removal medium. [ ].
4.	The bases for some PDC state that design details are still being finalized. It should be understood that the staff's feedback is based on the design as described in the white paper. Any future design changes or development could affect the staff's conclusions.	TEUSA understands that the staff review and approval is limited by the current state of the design maturity. Design modifications that occur after completion of the staff review will be discussed in the future SDA application and any impacts on the PDC will be highlighted.
5.	There appears to be residual use of the term "sodium" from the original SFR-DCs. Specifically, PDCs [ ]. Please confirm or address, as appropriate.	TEUSA has modified the PDC to remove references to sodium. The IMSR® is a fluoride molten salt reactor.

2. Potential Missing PDCs

NRC General Feedback on Potential Missing PDCs

On page 18 of 113 in the TEUSA PDC White Paper, the Irradiated Fuel System (IrFS) is discussed. One of the specified main functions is to "[

]." As noted in References 1 and 2 below, molten fluoride salts are susceptible to radiolytic degradation when frozen. This is because the recombination reactions can be slower than the rate of radiolytic degradation when fluoride salts are in a solid state. The radiolytic degradation can be caused by fission products and radionuclides alone. The byproducts of this degradation can be fluorine gas (F_2), and/or uranium hexafluoride gas (UF_6), if the salt is re-heated. F_2 is highly toxic to humans and may pressurize the IrFS storage tanks or cause corrosion, and UF_6 represents a potentially mobile fissile material and source of radiation. Therefore, should the IrFS, or its components, be covered under a separate PDC and/or should the fuel be allowed to solidify?

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6a.	Depending on the composition fuel salt used in the IMSR® design it may be necessary to [ ] to prevent radiolytic degradation of the fuel salt. This [ ] will depend on the salt composition and radiation dose from fission products and radionuclides in the salt. Additionally, when graphite is exposed to F_2 gas it reacts to form CF_4 (Reference 3). Therefore, is re-introduction of a previously frozen salt a concern with regard to damage to the graphite moderator?	The staff comments states that it may be necessary to melt irradiated fuel for transferring. The irradiated fuel salt in the fuel salt storage tanks (FSST) will be held at or above [ ] The Irradiated fuel storage tanks and associated transfer piping will be [

		]. See PDC TEUSA-72 for additional information. [ ].
6b.	Additionally, this discussion may be applicable to PDC 61 if [ ]. See discussion under "PDC 61" below.	See response to 6a above
7.	PDC 61 – Item (4) in the proposed PDC is focused on [ ]. However, given that molten fluoride salts because susceptible to radiolytic degradation at low temperatures (i.e. below the freezing point of the eutectic), should the PDC be focused on [ ]? Heat removal is still important, but ensuring the salt isn't overcooled may also be important to [ ]. Additionally, would it be appropriate to add consideration of the potential creation of [ ]? These present hazards that may not be covered in the items in PDC 61. Also, it is not clear whether this PDC, or another, [ ].	See response to Comment 6 above for [ ]. TEUSA will ensure that the integrity of the SSCs important to safety will be maintained throughout the design life by establishing the necessary performance specifications for the subject equipment and assuring that the SSCs are environmentally qualified for the environment in which they will be required to function. PDC 61(5) is expressly included to address the [ ].
8.	PDC 63 – The same comment for PDC 61 regarding [ ] applies to PDC 63 as well.	See responses to staff comments 6 and 7. [ ].
9.	Is a new PDC necessary to address [ ]?	As the fuel salt mixture is designed, [preliminary assessments indicate that

		] TEUSA recognizes that research continues on the potential for criticality following a fuel mixture release. If new information arises that would necessitate a modification of this or any other PDC, the new information will be provided as part of the future SDA application.
10.	The staff needs clarification as to what is intended with PDC/ARDC 6-9.	TEUSA retained the numbering presented in RG 1.232. In the RG, ARDCs 6-9 are shown as "reserved." To retain alignment with the numbering of the ARDCs, TEUSA chose to list TEUSA PDCs 6-9 as "reserved." TEUSA does not plan to make any changes to the PDC because of this comment.
11.	Where is PDC 5 addressed?	During the final preparation of the document, [ ].
12.	The proposed wording for [ ]. Additionally, the staff believes that it may be appropriate for TEUSA to consider whether [	The language of PDCs 10 and 34 is [ ].

	]. If adequate heat removal is not provided, properties of the fuel salt crucial to retention of radionuclides may be impacted. This includes changes to thermophysical properties. For example, increased temperature may decrease the solubility of radionuclides and fission products in the salt as well as increase their vapor pressures leading to potential releases of radionuclide and fission product species from the fuel salt.	While it is true that [ ]. See the separate white paper on PIE for more details. TEUSA recognizes that research continues on the development of radionuclide releases under off normal conditions. If new information arises that would necessitate a modification of this or any other PDC, the new information will be provided as part of the future SDA application. [ ].

Specified Acceptable Fuel Design Limits (SAFDLs)

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13.	PDC 10 moves away from the [	TEUSA does not support the concept that [

	].	TEUSA does note that research continues on the fuel chemistry requirements for the IMSR. If new information arises that would necessitate a modification of this or other PDC, the new information will be provided as part of the future SDA application.].
14.	PDC 12 [ ] PDC 10, 25, 34, and 78.	TEUSA has [ ].

Emergency Core Cooling System (ECCS)

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15.	[ ]. The staff notes that the high-level purpose of the traditional ECCS	TEUSA [

	isn't simply to add coolant, but instead to remove heat (the addition of coolant is the means by which heat is removed after a loss of coolant accident). While the IMSR® does not need coolant addition into the fuel salt, it does need to remove heat in the event of a postulated accident (PA). In the event of a PA, the IMSR® relies on the IRVACS to remove heat. Based on the [ ].	]. TEUSA agrees that the required cooling is not just for the core region but for the fuel mixture contained within the primary loop.

Use of Passive Safety Features to Either Meet or Not Adopt DCs

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16.	PDCs 20-25 – Why are [ ]? For some PDCs it seems that TEUSA plans to [ ].	The IMSR® design does [ ]. The distinction made by TEUSA is [ ].

17.	PDC 26 – This PDC [ ] IMSR® is in fact designed with a secondary shutdown mechanism capable of shutting down the reactor. The staff does not feel that [ ].	TEUSA [ ]. The supporting basis section of PDC 26 [ ].

PDC Specific Comments:

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18.	[ ].	For reasons provided in its comments, the staff supports the position that [ ].

19.	PDCs 41-43 - Do the [ ] Are other systems available to provide containment clean-up outside of the reactor vessel? Cover gas clean-up systems for MSRs are unique systems. Are there requirements to consider that would not be applicable to typical containment cleanup systems? For example, could the [ ] be required to remove fission products and other impurities in order to maintain proper salt chemistry/composition and not just to limit release of fission products?	The off-gas system is provided [ ]. As mentioned earlier, the final design of the off-gas system is still under development. Presently, the off-gas system is NOT used as a system that would clean up containment airborne radionuclides. The details of the system requirements for containment cleanup systems or reactor auxiliary building cleanup systems will be developed at a later date.
20.	PDC 55 – [ ]. The staff agrees that the primary loop does not exit the guard vessel, however, the primary loop of IMSR® contains fuel whereas the primary loop of an SFR (or LWR for that matter) only contains coolant. If a leak were to occur in the IMSR® primary heat exchanges (i.e. a single failure of the heat exchanger), fuel salt would [	TEUSA [

	].	].
21.	PDC 64 – Should this describe the [ ]? It appears the [ ] provides radionuclide retention functions during operations and not the [ ] which TEUSA describes as [ ].	In its basis for [ ].
22.	PDC 70 – Similar to the clarification regarding the primary coolant boundary in Question 3, clarify which system is the "intermediate" coolant system.	[ ].
23.	PDC 71 – Should this PDC discuss the [ ] It appears that the [ ]. This indicates that the [ ].	TEUSA has [ ].
24.	PDC 72 – The proposed PDC states the [ ]. Will the heating system also be designed to keep the salt molten at all times? This is important because for a fluoride salt to be radiolytically and chemically stable it must be kept in a molten state. Therefore, it may be useful to specify that the salt heating system will [	The Irradiated fuel salt in the fuel salt storage tanks (FSST) will be held at or above [ ] The Irradiated fuel storage tanks and associated transfer piping will be [

	].	].
25.	PDC 73 – TEUSA states that [ ]. However, part of SFR DC-73 is "Systems from which sodium leakage constitutes a significant safety hazard shall include measures for protection, such as inerted enclosures or guard vessels." Although the IMSR® design does not use a coolant that is highly reactive with air or water, like sodium, leakage of the molten salt fuel can still constitute a significant safety hazard. NUREG-1368, "Preapplication Safety Evaluation Report for the Power Reactor Innovative Small Module (PRISM) Liquid-Metal Reactor," Section 3.2.4.1, "Protection Against Sodium Reaction," notes that a new PDC to monitor sodium leakage is needed for liquid sodium reactor designs. In its rationale, the staff noted that this criterion is needed to limit consequences resulting from a sodium leak including means to detect spills and protect	[ ].

	plant equipment and personnel from corrosive and radioactive corrosion products. [ ].	
26.	PDC 79 - Should this PDC apply to the [ ] as well? In the TEUSA basis for PDC 79 it states that the [ ]. This PDC is [ ].	[ ].
27.	[ ] on which the staff would need additional clarification in order to provide feedback. SFR-DC 19 specifically calls out the need for prompt hot shutdown capabilities and [ ]. The staff would need additional clarification/justification to be able to provide feedback.	First, the [ ]. Second, the IMSR® is [

		]. However, as a defense-in-depth safety measure, and for operational purposes, the IMSR® design will [ ].