June 5, 2015

Mr. Craig Welling
Deputy Director
Office of Advanced Reactor Technologies
U.S. Department of Energy
NE-74, Germantown Building
19901 Germantown Road
Germantown, Maryland 20874

SUBJECT: NRC STAFF QUESTIONS ON THE U.S. DEPARTMENT OF ENERGY REPORT, “GUIDANCE FOR DEVELOPING PRINCIPAL DESIGN CRITERIA FOR ADVANCED NON-LIGHT WATER REACTORS (INL/EXT-14-31179, REV. 1)”

Dear Mr. Welling:

By letter dated December 8, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14353A245), the U.S. Department of Energy submitted the report titled, “Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors,” (ML14353A246 and ML14353A248). The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the report and has developed questions pertaining to the content.

The attached enclosure contains the staff’s questions and there may be additional questions in the future as the staff continue its review. The NRC staff looks forward to receiving timely responses in order to continue our joint initiative to develop guidance for non-light water reactor technologies.

Should you have any questions, please contact Jan Mazza, Project Manager, at (301) 415-0498 or Jan.Mazza@nrc.gov.

Sincerely,

/RA/

Jan Mazza, Project Manager
Advanced Reactors and Policy Branch
Division of Advanced Reactors and Rulemaking
Office of New Reactors

Project No.: 0814

Enclosure: NRC Staff Questions on DOE Report

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Letter to Craig Welling from Jan Mazza dated June 5, 2015

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NRC Staff Questions on the DOE Report:
Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors
Department of Energy – Idaho National Laboratory
Docket No. PROJ 0814

1. ARDC 16

a. The Department of Energy (DOE) Report defines and introduces functional containment as: "*A reactor functional containment, consisting of a structure surrounding the reactor and its cooling system or multiple barriers internal and/or external to the reactor and its cooling system...*"

   Advanced reactor design criteria (ARDC) 16, which applies to sodium fast reactor design criteria (SFR-DC) 16 and modular high temperature reactor design criteria (mHTGR-DC) 16, adopt the definition of functional containment which removes the "essentially leak tight" qualification. ARDCs and SFR-DCs 38, 39, 40, 41, 42, 43, 50, 51, 52, 53, 54, 55, 56, and 57 refer to containment in the traditional sense in that these ARDCs/SFR-DCs specify traditional containment systems design, inspection, and testing (including leakage rate testing). The mHTGR-DCs assert that general design criteria (GDCs) 38, 39, 40, 41, 42, 43, 50, 51, 52, 53, 54, 55, 56, and 57 are not applicable to the mHTGR design. The mHTGR design features a vented low pressure reactor building that does not necessarily retain radionuclides. Was applying the functional containment concept only to mHTGRs considered?

b. ARDC 16 further states that the functional containment "*…shall be provided to control the release of radioactivity to the environment and to assure that the functional containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.*" For mHTGRs, the vented low pressure reactor building is designed to allow the controlled release of radionuclides, but other nonlight-water reactor (non-LWR) technologies may employ traditional essentially leak-tight containments. Did the DOE intend for these technologies to allow a controlled release from an essentially leak-tight containment? Should a new ARDC/SFR-DC be developed to address structures, systems, and components (SSCs) that control the release of radionuclides and ensure that Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20 limits to workers and the public are not exceeded for postulated accidents?

2. ARDC 25 & SFR-DC 25

The current draft version of American Nuclear Society (ANS) 54.1 (Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants) proposes the following revised language for SFR-DC 25 in the ANS 54.1 standard:

The protection system shall be designed to assure that specified acceptable fuel design limits are not exceeded during any anticipated operational occurrence resulting from a single malfunction of the reactivity control systems ~~such as accidental withdrawal (not ejection or dropout) of control rods.~~

Enclosure

Would ARDC 25 be modified in a similar way?

3. ARDC 34

The ARDC combines GDC 34 and 35. However in doing so the requirement for "suitable containment capabilities" in GDC 35 was deleted. Was the deletion intentional and if so what is the basis for the deletion?

4. ARDC 38

Proposed ARDC 38 states, *"suitable redundancy in components and features* ***(including electric power systems operations)****, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that the system safety function can be accomplished, assuming a single failure."* Should the phrase in parentheses be added to incorporate descriptions of onsite and offsite power systems for SFRs being built and in operation?

5. SFR-DC 26

SFR-DC 26 states at least two independent reactivity control systems of different design principles shall be provided. According to 6.1.3 on page 22, two diverse scram systems are provided, a gravity driven rod drop and a powered rod drive-in. Figure 5, Core Layout on page 21 shows the control rod layout. Does the DOE believe that the example provided meets the intent of different design principles?

6. SFR-DC 28

a. Why is rod ejection (unless by positive means) deleted? For the GE-Hitachi Power Reactor Innovative Small Module (PRISM) design, features are in place to prevent rod ejection by a positive means but this may not be the case for all SFR designs.

b. Is control rod withdrawal considered an anticipated operational occurrence (AOO) or postulated accident for a SFR design? If it is a postulated accident, why is control rod withdrawal not included?

c. Does the DOE believe the SFR-DC 28 addresses the impact of a steam line break if no intermediate coolant loop exists as stated in SFR-DC 70, "***If*** *an intermediate coolant loop system is provided*?"

7. SFR-DC 34

a. Proposed addition to GDC 34 includes addressing postulated accidents by adding, "provide continuous effective core cooling during postulated accidents" but does not provide details on how effective core cooling is achieved like GDC 35 does for LWRs. GDC 35 states that effective core cooling is preserved by limiting fuel and clad damage; how is effective core cooling defined for SFRs and why is it not defined in SFR-DC 34?

b. According to NUREG-1368, GDC 34, page 3-41, item 4, “any fluid in the residual heat extraction system that is separated by a single passive barrier shall not be chemically reactive with the reactor coolant.” Why is this requirement not part of SFR-DC 34? Does the DOE believe that the PRISM design satisfies this GDC with respect to the reactor vessel auxiliary cooling system and auxiliary cooling system decay heat removal systems? Note that this requirement is stated for the intermediate heat transport system in SFR-DC 70.

8. SFR-DC 39

SFR passive heat removal systems require containment penetrations to accomplish their job. Should containment penetrations be included as shown (in bold) in SFR-DC 39?

“*The containment heat removal system shall be designed to permit appropriate periodic inspection of important components, such as [piping, **containment penetrations, etc.]** to assure the integrity and capability of the system.”*

9. SFR-DC 40

Since SFR containments are similar to traditional LWR containments, the leak-tight integrity of the containment is important, as is its pressure response vs. design pressure. Should pressure response and leak-tight integrity be included as shown (in bold) to SFR-DC 40?

*“The containment heat removal system shall be designed to permit appropriate periodic **pressure and** functional testing to assure (1) the structural **and leak-tight** integrity of its components, (2) the operability and performance of the system components, and (3) the operability of the system as a whole, and under conditions as close to the design as practical, the performance of the full operational sequence that brings the system into operation, including operation of associated systems.”*

10. SFR-DC 41

For ARDC 41 should the phrase in parentheses be added to ARDC 41 to incorporate descriptions of onsite and offsite power systems for SFRs being built and in operation? *“suitable redundancy in components and features **(including electric power systems operations)**, and suitable interconnections, leak detection, isolation, and containment capabilities shall be provided to assure that the system safety function can be accomplished, assuming a single failure.”*

11. SFR-DC 43

Since SFR containments are similar to traditional LWR containments, the leak-tight integrity of the containment is important, as is its pressure response vs. design pressure. Should pressure response and leak-tight integrity be included as shown (in bold) in SFR-DC 43?

*“The containment atmosphere cleanup system shall be designed to permit appropriate periodic **pressure and** functional testing to assure (1) the structural **and leak-tight** integrity of its components, (2) the operability and performance of the system*

components, and (3) the operability of the system as a whole, and under conditions as close to the design as practical, the performance of the full operational sequence that brings the system into operation, including operation of associated systems."

12. SFR-DC 54

SFR-DC 54 includes the phrase, "When isolation valves are required" on pages 91 and 92 of the DOE Report. This discussion is also included in Section 6.2.5, Reactor Containment (SFR Design Criteria 50-57), of the DOE Report on page 28. Why did the DOE include the phrase "when isolation valves are required" in SFR-DC 54, rather than including a requirement for isolation valves with the understanding that an applicant may propose an exemption from this requirement where justified?

13. SFR-DC 55

For a pool-type SFR design as is the case with PRISM, Super-PRISM, Toshiba (super, safe, small and simple) 4S, Experimental Breeder Reactor (EBR) II, etc., the intermediate heat exchanger (IHX) also resides within the reactor vessel (RV). The lines going from the RV to the containment would also include the intermediate heat transfer system. Why is "primary coolant" and not "primary and intermediate coolant" included in the brackets for the title and first sentence of SFR-DC 55?

14. SFR-DC 57

For a pool-type SFR design as is the case with PRISM, S-PRISM, 4S, EBR II, etc., the IHX also resides within the RV. The lines going from the RV to the containment would also include the intermediate heat transfer system. Why is "primary coolant" and not "primary and intermediate coolant" included in the brackets for first sentence of this SFR-DC 57?

15. SFR-DC 70

The initial phrase of the first sentence of proposed SFR-DC 70 states "If an intermediate coolant system is provided." This phrase would only be needed to account for an SFR design without an intermediate heat transport loop. No vendor has shared a plan to develop an SFR design without an intermediate coolant loop with the NRC.

a. What is the basis for accounting for an SFR design that does not use an intermediate heat transport loop?

b. Assuming industry were to propose an SFR design without an intermediate heat transport loop, propose an SFR-DC that requires:
   i. coolant for the secondary loop that is not chemically reactive with sodium, and
   ii. passive features to prevent overpressurization of the primary coolant boundary and pressure-pulse induced damage to SSCs within the primary coolant system in the event of a breach in the single passive barrier between primary coolant and secondary coolant.

c. Discuss the rationale for making the title plural, instead of singular.

16. SFR-DC 70

The remainder of the first sentence of proposed SFR-DC 70 states "the intermediate coolant shall be compatible with sodium if it is separated from the reactor primary coolant by a single passive barrier." No vendor has shared a plan with the NRC to develop an SFR design that uses anything other than a single passive barrier between the primary coolant and the intermediate coolant.

a. Describe the intended meaning of the phrase "compatible with sodium."

b. What is the basis for accounting for an SFR design that uses other than a single passive barrier between primary coolant and intermediate coolant?

c. Assuming there was a proposed SFR design that uses other than a single passive barrier between primary coolant and intermediate coolant, identify the most appropriate ARDC that would apply, or propose an SFR-DC with appropriate limiting design objectives for the barrier.

17. SFR-DC 70

The initial phrase of the second sentence of proposed SFR-DC 70 states, "Where a single barrier separates the reactor primary coolant from the intermediate coolant." Describe what is meant by the phrase "single barrier?" Regarding items 16 b and 16 c (above), are there SFR designs under consideration that have double walled primary coolant to intermediate coolant heat exchanger tubes? Would they be characterized as "a double passive barrier?"

18. SFR-DC 70

The remainder of the second sentence of proposed SFR-DC 70 states, "a pressure differential shall be maintained such that any leakage would flow from the intermediate coolant system to the reactor primary coolant system unless other provisions can be shown to be acceptable." Please describe what other provisions are envisioned and the primary rationale for their acceptability.

Staff notes that this phrase is apparently inherited from NUREG-0968, pages 3-19 & 3-20, which presents Clinch River Breeder Reactor (CRBR) design Criterion 31—Intermediate Coolant System, as follows (CRBR Criterion 31 with apparently inherited language highlighted in bold):

> *The intermediate coolant system shall be designed to transport heat reliably from the reactor coolant system to the steam/feedwater systems as required for the reactor coolant system to meet its safety functions under all plant conditions of normal operation, including anticipated operational occurrences, and postulated accident conditions.* ***The intermediate coolant*** *system shall contain coolant that* ***is not chemically reactive*** *with the reactor coolant.*
>
> ***A pressure differential shall be maintained across*** *a passive boundary between the reactor coolant system and the intermediate coolant system so that*

any leakage would *tend to* ***flow from the intermediate coolant system to the reactor coolant system unless it can be shown that other provisions are acceptable*** *on some defined basis.*

19. SFR-DC 70

The third sentence of proposed SFR-DC 70 states, "*The intermediate coolant boundary shall be designed to permit inspection and surveillance in areas where leakage can affect the safety functions of systems, structures and components.*"

a. Please describe what testing is envisioned by the term "surveillance" with respect to the intermediate coolant boundary. Is the intended meaning a material surveillance program?

   Staff notes that this sentence is apparently partially inherited from CRBR design Criterion 33—Inspection and Surveillance of Intermediate Coolant Boundary, as follows (CRBR Criterion 33 with apparently inherited language highlighted in bold):

   > *Components that are part* ***of the intermediate coolant boundary shall be designed to permit*** *(1) periodic* ***inspection*** *of* ***areas*** *and features important to safety to assess their structural and leaktight integrity* ***and*** *(2) an appropriate material* ***surveillance*** *program for the intermediate coolant boundary. Means shall be provided for detecting intermediate coolant leakage.*

   If the intended meaning is a "material surveillance program" as indicated above by item (2), why was "material" excluded from SFR-DC 70?

b. Since the intermediate coolant system interfaces not only with the primary coolant system, but also the tertiary coolant system, was consideration given to including provisions regarding the (1) intermediate coolant system interface with the tertiary coolant system; and (2) selection of intermediate boundary areas for "inspection and surveillance" based on potential impacts of tertiary system coolant leakage into the intermediate coolant system?

20. SFR-DC 70

Based on assuming that SFR-DC need only address SFR designs with an intermediate cooling system where primary and intermediate coolants are separated by a single passive barrier, and considering 19 a and b (above), are the additions and deletions to SFR-DC 70 as depicted below appropriate?

> *Intermediate coolant systems*
> *~~If an~~* ***An*** *intermediate coolant system ~~is provided, the intermediate coolant shall be compatible with sodium if it is and~~* ***shall be provided.*** *~~separated from the~~* ***A single passive barrier shall separate intermediate coolant from*** *reactor primary coolant;* ***at least a single passive barrier shall separate tertiary coolant from intermediate coolant*** *~~by a single passive barrier~~.* ***The intermediate coolant shall be chemically nonreactive with***

sodium. ~~*Where a single barrier separates the reactor primary coolant from the intermediate coolant, a*~~ ***A*** *pressure differential shall be maintained* ***across the primary to intermediate barrier*** *such that any* ***coolant barrier*** *leakage would flow from the intermediate coolant system to the reactor primary coolant system* ~~*unless other provisions can be shown to be acceptable*~~*. The intermediate coolant boundary shall be designed to permit* ~~*inspection and*~~ ***the conduct of a material*** *surveillance* ***program and inspection*** *in areas where* ***intermediate coolant*** *leakage* ***out of the intermediate coolant system, or tertiary coolant leakage into the intermediate coolant system,*** ~~*can*~~ ***may hinder or prevent*** ~~*affect the safety functions of systems,*~~ ***a*** *structure*~~*s*~~***, system,*** ~~*and*~~ ***or*** *component*~~*s*~~ ***from performing any of its intended safety functions****.*

With additions and deletions applied, SFR-DC 70 would state:

Intermediate coolant system
An intermediate cooling system shall be provided. A single passive barrier shall separate intermediate coolant from reactor primary coolant; at least a single passive barrier shall separate tertiary coolant from intermediate coolant. The intermediate coolant shall be chemically nonreactive with sodium. A pressure differential shall be maintained across the primary to intermediate barrier such that any coolant barrier leakage would flow from the intermediate coolant system to the reactor primary coolant system. The intermediate coolant boundary shall be designed to permit the conduct of a material surveillance program and inspection in areas where intermediate coolant leakage out of the intermediate coolant system, or tertiary coolant leakage into the intermediate coolant system, may hinder or prevent a structure, system, or component from performing any of its intended safety functions.

21. SFR-DC 71

SFR-DC 71 appears to be based on NUREG-0968 (page 3-21), CRBR design Criterion 34— Reactor and Intermediate Coolant and Cover Gas Purity Control, with differences as shown by the following CRBR and SFR-DC 71 design criterion:

CRBR Criterion 34 - *Systems shall be provided to monitor and maintain reactor, intermediate coolant, and cover gas purity within specified design limits. These limits shall be based on consideration of (1) chemical attack, (2) fouling and plugging of passages, (3) radionuclide concentrations, and (4) detection of sodium-water reactions.*

SFR-DC 71 - *Systems shall be provided as necessary to maintain primary coolant purity and cover gas purity within specified design limits. These limits shall be based on consideration of (1) chemical attack, (2) fouling and plugging of passages, and (3) radioisotope concentrations.*

a. Please discuss why intermediate coolant purity is not addressed by an SFR-DC.

b. Please discuss why the term “sodium” is not explicitly used; e.g., “purity of primary coolant system sodium and cover gas,” since SFRs use sodium.

c. Please discuss why the term “radioisotope” was used in place of “radionuclide” which is the term used for all GDC, mHTGR-DC, and all other SFR-DC in the DOE report.

22. SFR-DC 72

The rationale for SFR-DC 72 provided on page 97 of the DOE report states:

> *NUREG-1368 (page 3-56) (ML063410561) Section 3.2.4.2 suggested the need for a separate criterion for sodium heating systems. Also, a separate criterion was included in NUREG-0968 (ML082381008) (CRBR design Criterion–7 Sodium Heating Systems).*

The differences between SFR-DC 72 and NUREG-0968 (page 3-10) CRBR design Criterion 7—are shown in the following:

CRBR Criterion 7 - *Heating systems shall be provided as necessary for systems and components important to safety that contain, or may be required to contain, sodium or sodium aerosol. The heating systems and their controls shall be appropriately designed with suitable redundancy to ensure that the temperature distribution and rate of change of temperature in sodium systems and components are maintained within design limits assuming a single failure. The heating system shall be designed so that its failure will not impair the safety function of associated systems and components.*

SFR-DC 72 - *Heating systems shall be provided as necessary for systems and components important to safety, which contain or could be required to contain sodium. These heating systems and their controls shall be appropriately designed to assure that the temperature distribution and rate of change of temperature in systems and components containing sodium are maintained within design limits assuming a single failure.*

The justification in NUREG-0968 states in part that the “intent of this criterion is to require that systems important to safety that contain sodium or sodium aerosols and that require a controlled temperature for the system to perform its safety function be provided with a heating system capable of ensuring that desired temperatures are maintained and designed to preclude overheating the components to which they are attached…external heat is required to be supplied to the sodium systems under certain plant conditions to keep the sodium molten and to keep sodium aerosol from condensing and plugging flow paths exposed to sodium vapor.”

NUREG-1368 Section 3.2.4.2 Sodium Heating Systems (page 3-56) refers to CRBR design Criterion 7, and states “The intent of the criterion is to require that systems important to safety, and which contain sodium or sodium aerosols and require a controlled temperature for the system to perform its safety function, be designed and maintained to preclude overheating (creating aerosols) and underheating (condensing aerosols and freezing sodium) the system.” It also states “Requirements for system features similar to those listed in SRP Section 9.3.4, Item III.A.9 (Ref. 3.9), should be developed for sodium systems in LMRs."

a. SFR-DC 72 does not appear to require designing the heating system to prevent it from overheating sodium. Discuss why this is not a design concern that should be more explicitly accounted for in an SFR-DC.

b. SFR-DC 72 does not appear to address providing external heat to the primary coolant sodium cover gas system to maintain cover gas temperature within limits. Discuss why keeping sodium aerosol (or vapor) from condensing and plugging flow paths exposed to sodium vapor is not a design concern that should be explicitly accounted for in an SFR-DC.

c. Discuss why proposed SFR-DC 72 does not use the terms "sodium aerosol" and "sodium vapor."

d. Discuss why proposed SFR-DC 72 contains no language corresponding to the last sentence of NUREG-0968 CRBR design Criterion 7, which states "The heating system shall be designed so that its failure will not impair the safety function of associated systems and components."

e. Discuss whether portions of the sodium heating system would be required following a postulated event for accident mitigation and fuel protection. If sodium heating would be needed following a postulated event, which proposed ARDC and SFR-DC would ensure that the SFR design will provide sufficient onsite electrical power to support operation of credited sodium heating systems?

23. SFR-DC 73

The rationale for SFR-DC 73 and SFR-DC 74 provided on page 97 of the DOE Report states:

> *NUREG-1368 (page 3-56) (ML063410561) Section 3.2.4.1 [Protection Against Sodium Reactions] suggested the need for a separate criterion for protection against sodium reactions. Also, a separate criterion was included in NUREG-0968 (ML082381008) (Criterion–4 Protection against Sodium and NaK reactions).*

Content in NUREG-0968 (page 3-10) CRBR design Criterion 4 and SFR-DC 74 are shown below:

> CRBR Criterion 4 - *Systems, components, and structures containing sodium or NaK shall be designed and located to limit the consequences of chemical reactions resulting from a sodium or NaK spill. Special features such as inert atmosphere vaults shall be provided as appropriate for the reactor coolant system. Fire-control systems and means to detect sodium, NaK, or their reaction products shall be provided to limit and control the extent of such reactions to ensure that the functions of components important to safety are maintained. Means shall be provided to limit the release of reaction products to the environment, as necessary, to protect plant personnel and to avoid undue risk to the public health and safety. Material that might come in contact with sodium or NaK shall be chosen to minimize the adverse effects of possible chemical reactions or microstructural changes. In areas where sodium or NaK chemical*

reactions are possible, structures, components, and systems important to safety, including electrical wiring and components, shall be designed and located so that the potential for damage by sodium chemical reactions is minimized. Means shall be provided as appropriate to minimize possible contacts between sodium/NaK and water. A single failure of a passive boundary shall not permit the contact of primary coolant with water/steam. The effects of possible interactions between sodium/NaK and concrete shall be considered in the design.

SFR-DC 73 - *Means to detect sodium leakage and to limit and control the extent of sodium-air and sodium-concrete reactions shall be provided as necessary to assure that the safety functions of structures, systems and components important to safety are maintained. Special features such as inerted enclosures or guard vessels shall be provided as appropriate for systems containing reactor primary sodium coolant.*

a. Discuss why SFR-DC 73 includes no language specifically addressing means to detect, control, and extinguish a fire resulting from leaked sodium reacting with air, concrete, or water.

b. Discuss why SFR-DC 73 includes no language specifically requiring (as appropriate) means to detect sodium leakage or special features such as inerted enclosures or guard vessels for the intermediate coolant system or any system containing sodium.

24. SFR-DC 74

SFR-DC 74 contains criteria for sodium/water reaction prevention and mitigation. Considering a and b (below), are the additions and deletions to SFR-DC 74 as depicted below appropriate?

a. The source of molten sodium that could potentially come into contact with water or steam may not be limited to systems considered "important to safety." Discuss why this criterion is limited to sodium-containing SSCs that are considered "important to safety."

b. The term "consequences" has a connotation of estimated radiological dose from radionuclides released during an event, such as a design basis accident. Discuss why this SFR-DC does not focus on the more immediate adverse impact of a sodium and water reaction on operability of SSCs with required safety functions.

Structures, systems, and components ~~important to safety~~ containing sodium shall be designed and located to limit the ~~consequences~~ ***adverse effects of chemical reactions between sodium and water*** *on* ***the capability*** *of ~~safety functions of~~ any ~~systems,~~ structure~~s~~,* ***system, or*** *~~and~~ component~~s~~* ***to perform any of its intended safety functions****. Means shall be provided as appropriate to limit possible contacts between sodium and water.*

25. SFR-DC 74

SFR-DC 74 contains criteria for sodium/water reaction prevention and mitigation. The second paragraph specifically discusses the sodium-steam generator system.

a. Was the possibility of a coolant medium other than water (i.e. helium, or other inert gas) in the tertiary system considered along with the use of the Brayton Cycle for power conversion? Would a new SFR-DC addressing a non-water tertiary coolant system be appropriate?

b. Would a new SFR-DC addressing the higher pressures of the Brayton Cycle power conversion system be appropriate?

c. In consideration of the phrase from the second paragraph, "the sodium-steam generator system shall be designed to . . . limit the effects of the energy and reaction products released," when would "the effects" be beyond the "limit"? Consider that the limit could be in the range from (i) one redundant subsystem degraded but operable, to (ii) loss of a redundant subsystem with the other redundant subsystem degraded but operable (recognizing that a passive safety system may not be redundant).

d. Why does the initial phrase of the second paragraph of SFR-DC 74, "If necessary to prevent loss of any plant safety function," need to be included? If the tertiary system uses high pressure steam and water and the intermediate system coolant is sodium (or other medium that reacts strongly with water), then the heat transfer interface between the intermediate and tertiary heat transport systems must be designed consistent with the stipulations of the remainder of the paragraph (except, see item c above).

26. HTGR-DC 5

The DOE report specifically modified GDC 5 for mHTGR-DC 5 to replace "nuclear power unit" with "reactor module" and "nuclear reactor units" with "module groups." Further, mHTGR-DC 5 includes the sentence *"SCCs important to safety shall not be shared among reactor modules or reactor module groups."* Was it the DOE's intent to imply that sharing within a reactor module group is acceptable? Also there are other advanced non-LWR designs that feature modularity (e.g., PRISM). Why was modularity considered only for the mHTGR design?

27. HTGR-DC 10

The intent of GDC 10 is to set limits and/or design protection systems with appropriate margin to protect against fuel failures caused by events likely to occur during normal operation in the lifetime of the plant. The specified acceptable core radionuclide release design limit (SARRDL) approach appears to accommodate potential AOO caused fuel failures and does not set a specified acceptable fuel design limit (SAFDL) to preclude them. How would the proposed SARRDL approach preclude additional fuel failures caused by an AOO?

28. HTGR-DC 10

HTGR-DC 10 replaces the concept of SAFDLs with SARRDLs. HTGR-DCs 12, 17, 20, 25, 26, 34 also propose the same change. Pages 41-42 of the DOE Report describe the basis for this change and state that the SARRDL value (to be determined on a design-specific basis) will be set so that the calculated offsite doses do not exceed the regulatory requirements at the Exclusion Area Boundary for each of the most limiting licensing basis events.

a. Are only accidents considered for the SARRDLs?

b. Which regulatory requirements is DOE assuming should be met at the EAB – the 10 CFR 50.34/10 CFR 52.47 design and siting criterion (25 rem total effective dose equivalent (TEDE) over a maximum 2-hr release period), 10 CFR Part 20 limits to the public, or other regulatory requirements?

c. If only accidents and the siting and design dose criteria are used to set an acceptable SARRDL, how would this assure that the radioactivity in the system is controlled so that 10 CFR Part 20 limits to workers and the public are not exceeded for normal operation? For AOOs?

29. HTGR-DC 13

For HTGR-DC 13, the ARDC 13 was modified to remove "reactor core, [reactor coolant pressure boundary, the containment and its associated systems]." Why should the reactor core and helium pressure boundary be excluded from monitoring?

30. HTGR-DC 20

The intent of GDC 20 is to establish protection system setpoints to prevent SAFDLs from being violated during an AOO. To prevent the SARRDL from being violated, a means of predicting additional fuel failures and associated radionuclide inventory would need to be developed for postulated AOOs and protective systems setpoints established. Does the DOE envision development of protective setpoints to ensure SARRDLs are not violated for AOOs?

31. HTGR-DC 25

The current draft version of ANS 54.1 (Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants) proposes the following revised language for SFR DC 25:

SFR-GDC 25 Protection system requirements for reactivity control malfunctions.

The protection system shall be designed to assure that specified acceptable fuel design limits are not exceeded during any anticipated operational occurrence for any resulting from a single malfunction of the reactivity control systems ~~such as accidental withdrawal (not ejection or dropout) of control rods.~~

Would mHTGR-DC 25 be modified in a similar way?

32. HTGR-DC 30

In the DOE Report Table 9.3, mHTGR-DC 14, "Reactor Helium Pressure Boundary" specifies that the reactor helium pressure boundary be designed, fabricated, erected, and tested with a low probability of abnormal leakage including unacceptable ingress of air, secondary coolant or other fluids. However, mHTGR-DC 30, “Quality of the Reactor Helium Pressure Boundary,” only specifies a means to detect helium leakage out of the boundary but does not address detection of air, secondary coolant or other fluids into the boundary. Why was the detection of substances leaking in not included in mHTGR-DC 30?

33. HTGR-DC 33

GDC 33 requires maintaining reactor inventory such that the SAFDLs are not violated for small breaks or leaks. This is based on normal operations including AOOs. On page 111 of the report the rationale for this mHTGR-DC states the helium makeup system does not assure the SARRDLs are met by this system. Are the SARRDLs met for small leaks and breaks of the coolant boundary (i.e., a partial loss of coolant)? How would normal operation leaks and breaks meet the SARRDLs and not just the adequate cooling criterion (which is taken to mean a postulated accident criterion)?

34. HTGR-DC 34

Why wouldn’t a design requirement of the reactor cavity cooling system (RCCS) to maintain system geometry, including pressure vessel geometry, be included?

It is understood that there are other means to provide cooling during normal shutdown, but the write-up in Section 7.2.4 states the RCCS “is applicable to both normal and accident conditions,” so why was *“*all shutdown conditions following normal operation…” deleted*?*

35. HTGR-DC 54

The DOE Report, page 119 states that “the modular HTGR Reactor Building does not provide a pressure retention function, and is not relied upon to meet the offsite dose requirements of 10 CFR 50.34 (10 CFR 52.79).” However, the INL report on page 104 indicates that ARDC 16, Containment Design, applies to the mHTGR design. Discuss why ARDC 54 for piping systems penetrating containment should not continue to apply to the mHTGR.

36. HTGR-DC 70

In the rationale for modification for mHTGR-DC 70, “reactor system” is synonymous with “reactor internals.” The current design requirements for reactor internals in light water reactors are typically GDC 2, 4 and 10. No similar DC is proposed for the SFR-DCs and the ARDCs. Would mHTGR-DC 70 would still be needed if HTGR-DC 10 were modified as shown below:

*The reactor ~~core~~ system and associated **[~~coolant~~ heat removal]**, **structures**, control, and protection systems shall be designed with appropriate margin to assure that specified acceptable ~~fuel~~ core radionuclide release design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.*

37. HTGR-DC 73

As discussed in the NRC staff's pre-licensing assessment reports for Next Generation Nuclear Plant (ML14174A626), the major accidents to be considered for determining the siting source terms for modular HTGRs may include severe air ingress accidents with significant graphite oxidation in the core and support structures. That discussion refers to the Staff Requirements Memorandum (SRM) to SECY-93-092, which specifically directs the staff to consider "chimney effect" air ingress events. The published technical literature shows that some modular HTGR developers are pursuing design features that would limit the progression of air ingress and graphite oxidation during such major accidents and also support or enable the timely termination of graphite oxidation by air.

Should design criteria for such design features be specified by either supplementing any of the currently proposed HTGR-DC or by adding a new design criterion for that purpose (e.g., HTGR-DC 73)? Are there emergency procedures or other programmatic measures that would support the effectiveness of such design features for terminating oxidation in the context of mitigating strategies?

38. General Question

Given that the DOE Report limits its scope to design basis accidents (DBAs), what relevant information, if any, was utilized from Reference 6 of Chapter 8 (C. Boardman, et. al., "Containment Performance of S-PRISM under Severe Beyond Design Basis Conditions" 9th International Conference on Nuclear Engineering, Paris, France, April 2001) which deals with Severe Beyond Design Basis Accidents?

39. General Question

Page xiv of the DOE Report defines the acronym "SFR" as "sodium fast reactor." Subsequent titles in Chapter 6 of the report also refer to "sodium fast reactors." However, on page 27, Section 6.2.2, lines 6-7, the authors state "…sodium-cooled fast reactors generally have two heat transfer systems, both of which typically contain sodium." The widely used term used by the SFR community is "sodium-cooled fast reactors." Why was "sodium-cooled fast reactors" not used throughout the report?

40. General Question

In Section 3.1, Definitions, the DOE Report on page 7 specifies that structures, systems, and components (SSCs) that provide reasonable assurance the facility can be operated without undue risk to the health and safety of the public are designated as safety-related, and are relied upon to remain functional during design-basis accidents. However, Appendix A to 10 CFR Part 50 includes SSCs beyond only those that must remain functional during design-basis accidents. For example, SSCs that must be designed to not cause SSCs to fail to perform their safety functions because of seismic loads are included in Appendix A. Please comment on the consistency of the scope of the DOE Report with the current scope of SSCs covered by Appendix A to 10 CFR Part 50.