From:	Stuart Rubin
To:	AdvancedRxDCComments Resource
Subject:	[External_Sender] Draft Advanced Non-Light Water Reactor Design Criteria
Date:	Wednesday, June 08, 2016 4:47:15 PM
Attachments:	image001.png Advanced Non-LWR Design Criteria SDR Comments.docx

Dear Sir or Madam,

The attached file provides my comments on Draft Advanced Non-Light Water Reactor Design Criteria.

Thanks you.

Stuart Rubin

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Comments on Advanced Non-Light Water Reactor Design Criteria

Criterion	Current GDC Language	ARDC Language/ Rationale for Modification	SFR-DC Language/ Rationale for Modification (Comment)	mHTGR-DC Language/ Rationale for Modification (Comment)
1	Quality standards and records			mHTGR-DC utilizes a risk-informed and performance-based approach to quality requirements. That is, mHTGR SSCs important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the risk importance of the safety functions to be performed. It is unclear how the proposed language will allow for a RI -PB approach to quality
2	Design bases for protection against natural phenomena			None
3	Fire protection		There is no mention of the use of *combustible* materials (i.e., sodium) in the SFR-DC language. Since SFRs utilize sodium throughout the primary system and because sodium is highly combustible when in contact with water or steam this GDC should be augmented in the area of sodium fire *prevention. This would include* SSC sodium-water interface barrier design aspects, sodium akage detection systems, etc.	None
4	Environmental and dynamic effects design bases.			mHTGRs such as the PBMR, MHTGR and NGNP proposed using a direct power cycle in which one or more very high speed, very high energy gas turbines are located *inside* the primary coolant pressure boundary system

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				(e.g., PB piping). The presence of one or more very high energy turbines inside the primary system creates the potential that a catastrophic dynamic failure of the gas turbine (e.g., at power) could result in consequential catastrophic failure of the primary system pressure boundary due to the failure rotating turbine components. Such a pressure boundary failure at power could be well beyond design basis pressure boundary failure events that have been considered here to fore in LWR designs. If high energy gas turbines are to be allowed to be located inside of the mHTGR primary pressure boundary, the DC language in the area of prevention, protection and mitigation of turbine dynamic failure should be strengthened to support such a power conversion system design approach.
5	Sharing of structures, systems, and components			None
10	Reactor design.			The proposed language with respect to *specified acceptable core radionuclide release design limits are not exceeded* is too limited and not a workable mHTGR-DC. The DC should be related to the integrated radionuclide release from the "reactor-

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				plant" rather than the radionuclide release from the "core." The release from the reactor-plant is due to, and may be limited by, transport and release of radionuclides outside the core, radionuclides from inside the core, or a combination of these releases over the duration of the event (e.g., Depressurized Conduction Cooldown). Additionally, as radionuclide buildup outside of the core increases over the plant lifetime, the acceptable releases from the reactor core will need to be lowered. Also the concept of specified acceptable radionuclide release design limits (SARRDL), which limits the amount of radionuclide inventory that escapes the fuel and circulates within the helium coolant boundary under normal operations and AOO is incomplete. Neither does it take into account radionuclide plate out buildup on reactor coolant system surfaces over time nor the radionuclides absorbed in core graphite materials (e.g., the graphite reflectors) over time. The subsequent liftoff, desorption and release of these radionuclides (outside

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				the fuel) from the reactor coolant system during LBEs. The amount of radionuclide plate out and radionuclide absorption at the beginning of an event are complex calculations with significant uncertainties.
11				None
12				None
13	Instrumentation and control.			The operating, transient and accident temperatures of the fuel are the primary determinants of fuel performance and fuel radionuclide release during operating, transient and accident conditions. The in core temperatures are too high during normal operation, transients and accidents to provide reliable and continuous in core temperature monitoring during these conditions with current temperature instrumentation technology. Accordingly, it is unclear how this DC will be met with respect to fuel and core temperature monitoring. The same holds true for in core flux monitoring needed to calibrate excore flux monitors which are used for determining in core power distributions.
14	Reactor coolant pressure boundary.			Reactor coolant pressure boundary" has been relabeled

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				as "reactor helium pressure boundary." For mHTGRs with a direct cycle design (e.g., GTMHR, MHTGR, NGNP) the helium pressure boundary involves both the reactor and the power turbine(s). As such, the term "reactor helium pressure boundary" would not be appropriate for these designs (but would be appropriate for indirect designs involving steam turbines). Suggest using the term "helium pressure boundary" to cover both direct and indirect mHTGR designs. Also insert italics words into sentence to state: "…..unacceptable *levels of* ingress of air, secondary coolant, or other fluids *into the reactor core*."
15	Reactor coolant system design			Same comment as for GDC 14
16	Containment design			Suggest the following alternative wording: *A functional containment, consisting of multiple barriers and holdup mechanisms internal and external to the helium pressure boundary shall be provided to control the release of radionuclides to the environment and to assure that the functional containment design conditions important to safety are not exceeded*

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				for as long as the licensing basis event conditions require.
17	Electric power systems			These requirements are not applicable to current mHTGR designs. Current mHTGRs all involve the exclusive use passive safety features. These safety features perform their safety functions without the use of or the need for need for electrical power. The requirements for offsite power being retained for defense-in-depth considerations is not rational or applicable to power reactor designs that use SSCs that do not use electrical power to perform their safety functions. That is, there is nothing to connect the electrical power source to. Defense in depth for safety functions is provided by redundant and diverse *passive* SSCs that also do not require electrical power. Alternatively one could insert the following introductory language: *In designs where either safety features or redundant safety features require electrical power to perform their safety functions……* Further the requirement that the onsite

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				electric power supplies, including the batteries, and the onsite electric distribution system, shall have sufficient independence, redundancy, and testability to perform their safety functions *assuming a single failure* is inappropriate for mHTGRs. In SECY-03-0047 "Policy Issues Related To Licensing Non-Light-Water Reactor Designs" the following is stated: *Issue 4: To what extent can a probabilistic approach be used to establish the licensing basis?* *The staff recommends that the Commission take the following action: Replace the single failure criterion with a probabilistic (reliability) criterion.* *This recommendation is consistent with a risk-informed approach.* In Staff Requirements - SECY-03-0047 – "Policy Issues Related To Licensing Non-Light-Water Reactor Designs" the following statement is provided *The Commission has approved the staff's recommendations as outlined in this paper for issues 2, 4, 5, and 7.*

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18	Inspection and testing of electric power systems.			These requirements are not applicable to mHTGR designs since all mHTGR designs involve the exclusive use of passive safety features such that all safety functions are performed without the need for electrical power
19	Control room.			None
20	Protection system functions			mHTGRs are designed such that its inherent and passive features provide adequate protection despite operational errors or equipment failures. These passive safety functions do not utilize or need protective systems to sense accident conditions or to initiate the operation of systems and components important to safety. mHTGR reactivity control systems *do* utilize or need protective systems to sense AOO or accident conditions and insert control rods. mHTGR protection systems are also used for *tripping* systems (e.g., helium circulator trip) for potential DBA and BDBA accident conditions. According, it is suggested that the language be revised to limit protection system functions that are associated with *initiating* the operation of systems to initiating the operation of reactivity control systems for AOOs and accident conditions.

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21	Protection system reliability and testability.			Requirement that (1) *no single failure* results in loss of the protection function is inappropriate for mHTGRs. In SECY-03-0047 "Policy Issues Related To Licensing Non-Light-Water Reactor Designs" the following is stated: *Issue 4: To what extent can a probabilistic approach be used to establish the licensing basis?* *The staff recommends that the Commission take the following action: Replace the single failure criterion with a probabilistic (reliability) criterion.* *This recommendation is consistent with a risk-informed approach.* In Staff Requirements - SECY-03-0047 – "Policy Issues Related To Licensing Non-Light-Water Reactor Designs" the following statement is provided *The Commission has approved the staff's recommendations as outlined in this paper for issues 2, 4, 5, and 7.*
22	Protection system independence.			None
23	Protection system failure modes.			None
24	Separation of protection and control systems.			None
25	Protection system requirements for			None

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	reactivity control malfunctions.			
26	Reactivity control system redundancy and capability.			The phrase "At least" should be deleted as it is not needed.
27	Combined reactivity control systems capability.			None
28	Reactivity limits.			It should be understood that mHTGR reactivity increase accidents can be caused by events other than unexpected control rod movement. These include reactivity increases events due to pebble bed reactor pebble compaction from an earthquake and reactivity increase due to moisture ingress into the helium pressure boundary and reactor core due to the failure of connected water bearing system (e.g., steam generator tube failure). Protection against potential reactivity increases due to such events are not addressed by this criterion.
29	Protection against anticipated operational occurrences.			None
30	Quality of reactor coolant pressure boundary.			"*Quality of reactor helium pressure boundary*" should be changed to "*Quality of helium pressure boundary*" so as to include the other helium pressure boundary components such as the HPB cross connect duct and the helium pressure boundary vessels surrounding the power conversion system components.

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31	Fracture prevention of reactor coolant pressure boundary.			Same comment as for GDC 30. It should be noted that the mHTGR helium pressure boundary is designed for the maximum temperatures associated with the relatively cool reactor core helium *inlet* temperature. By design, the helium pressure boundary must be protected against the much higher helium temperatures associated with the reactor core *outlet* helium flow impinging on the helium pressure boundary . This potential HPB failure (due to *high* temperatures) is not addressed by this GDC.
32	Inspection of reactor coolant pressure boundary.			Same comment as for GDC 30.
33	Reactor coolant makeup.			None
34	Residual heat removal.			Delete the word “passive.” For normal operations and anticipated transients residual heat is to be removed by active systems. For DBAs residual heat will be removed by passive systems. Suggest the following wording: *Systems to remove residual heat during anticipated operational occurrences and accidents shall be provided. The safety function of the systems shall be to transfer fission product decay heat and other residual heat from the*

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				reactor core at a rate such that specified acceptable core radionuclide release design limits and the design conditions of the reactor coolant pressure boundary are not exceeded. Suitable redundancy and reliability of components and features shall be provided.
35	Emergency core cooling			A separate passive decay heat removal system is provided to remove core decay heat during accident conditions. The passive heat removal system is to be capable of removing decay heat for depressurized conduction cooldown accidents (events involving loss of helium coolant without active) and pressurized conduction cooldown accidents (events involving loss of helium coolant) without credit for active decay heat removal systems. Suggest the following wording: *A passive system to provide adequate emergency core cooling shall be provided. The safety function of the passive system shall be to effectively remove accident decay heat from the reactor core following the loss of the normal core heat removal system and*

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				the loss of the active standby core heat removal systems. Suitable redundancy in components and features of the passive core cooling system shall be provided Note: Electrical power is not required for the passive emergency core cooling system to perform its safety function.
36	Inspection of emergency core cooling system.			None
37	Testing of emergency core cooling system.			None
38	Containment heat removal			None
39	Inspection of containment heat removal system.			None
40	Testing of containment heat removal system			None
41	Containment atmosphere cleanup.			Replace the GDC title with "*Helium cleanup within the helium pressure boundary*" Suggest the following wording *Systems shall be provided, as necessary, to control radionuclide buildup in the circulating helium coolant within the HPB to radionuclide levels consistent with the maximum*

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				levels assumed in the mHTGR safety analysis.
42	Inspection of containment atmosphere cleanup systems.			Replace with "Inspection of helium cleanup systems
43	Testing of containment atmosphere cleanup systems			Replace with "Testing of helium cleanup systems
44	Cooling water.			Replace the GDC title with *"System, structure and component cooling*." Suggest the following language: *Systems shall be provided to transfer heat from structures, systems, and components important to safety to an ultimate heat sink. The safety function of the cooling systems shall be to maintain the systems, structures, and components important to safety below the maximum temperature that they are qualified for normal operating and accident conditions.* *Redundancy in the electrical power is not required as loss of the SSC cooling is related to loss of investment protection*
45	Inspection of cooling water system.			Replace the GDC title with "*Inspection of the system, structure and component cooling system."*
46	Testing of cooling water system.			Replace the GDC title with "*Testing of the system, structure and component*

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				cooling system."
50	Containment design basis			Replace GDC with "*Reactor Building Design Basis"* Much of the Current GDC language would apply: *The reactor building structure, including radionuclide release pathways, shall be designed so that the reactor building structure and its internal compartments can accommodate without exceeding the design basis loadings, the calculated pressure and temperature conditions resulting from any loss-of helium coolant accident. Margins in the loadings shall reflect consideration of the effects of potential energy sources which have not been included in the determination of the peak conditions, such as energy in steam generators* *The reactor building design shall be provide for re-closure following the blowdown of the helium coolant pressure boundary in order to limit the magnitude of air ingress into the hot reactor core.*
51	Fracture prevention of containment pressure boundary.			None

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52	Capability for containment leakage rate testing.			None
53	Provisions for containment testing and inspection.			None
54	Piping systems penetrating containment			Since mHTGRs do not have a reactor containment, this GDC should not apply. Additionally, for mHTGRs there are no helium coolant piping systems that penetrate the reactor building. For indirect cycle mHTGRs (with steam generators), there is a potential for water or steam filled systems to penetrate the reactor building. Such piping systems do not require leak detection isolation or containment capabilities.
55	Reactor coolant pressure boundary penetrating containment.			None
56	Primary containment isolation			Replace GDC with "Reactor building *isolation."* *The reactor building design shall provide for re-closure following the blowdown of the helium coolant pressure boundary in order to limit the magnitude of air ingress into the hot reactor core*
57	Closed system isolation valves			None
58	Control of releases of radioactive			None

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	materials to the environment.			
61	Fuel storage and handling and radioactivity control.			None
62	Prevention of criticality in fuel storage and handling			None
63	Monitoring fuel and waste storage.			None
64	Monitoring radioactivity releases.			None