From: Richard Rivera
Sent: Friday, March 24, 2023 2:19 PM
To: Rusty Towell; Lester Towell; Jordan Robison; Tim Head; Alexander Adams
Cc: Edward Helvenston; Richard Rivera; Zackary Stone; Michael Wentzel; Greg Oberson (He/Him); Boyce Travis; Alexander Chereskin; Nicholas Hansing; Zachary Gran; Kyle Song; Charley Peabody; Steve Jones
Subject: Abilene Christian University - Audit Questions Regarding ACU CP Chapters 4, 6, and 9.6
Attachments: Audit Questions_Chapters 4, 6, & 9.6 (Round 1).pdf

Dear Dr. Towell,

Attached is a list of questions the NRC staff has prepared for Abilene Christian University (ACU) related to the ACU Preliminary Safety Analysis Report, Chapter 4, "Molten Salt Research Reactor Description," Chapter 6, "Engineered Safety Features," and Section 9.6, "Gas Management System." The NRC staff would like to discuss these questions within the scope of the ACU construction permit (CP) application review Audit Plan for Chapters 4, 6, and 9.6 (see audit plan dated 3/2/2023, ML23065A055), and I am providing these in advance to facilitate discussion during an audit meeting. Once ACU is ready to discuss, please let us know and we can set up an audit meeting. We will add this e-mail, with questions, to public ADAMS. If you have any questions, please let Edward, Zack, or I know.

Thank you,
Richard Rivera

Richard Rivera, MEM
Project Manager
U.S. Nuclear Regulatory Commission – HQ
NRR/DANU/UAL1
Ph. 301-415-7190
E-mail Richard.Rivera@nrc.gov

Docket No. 50-610

Distribution List (GovDelivery):
Abilene Christian University MSRR

Hearing Identifier: NRR_DRMA
Email Number: 2013

Mail Envelope Properties (SA0PR09MB7369FAE2DC20F304020ABC7787849)

Subject: Abilene Christian University - Audit Questions Regarding ACU CP Chapters 4, 6, and 9.6
Sent Date: 3/24/2023 2:19:10 PM
Received Date: 3/24/2023 2:19:13 PM
From: Richard Rivera

Created By: richard.rivera@nrc.gov

Recipients:
"Edward Helvenston" <Edward.Helvenston@nrc.gov>
Tracking Status: None
"Richard Rivera" <richard.rivera@nrc.gov>
Tracking Status: None
"Zackary Stone" <Zackary.Stone@nrc.gov>
Tracking Status: None
"Michael Wentzel" <Michael.Wentzel@nrc.gov>
Tracking Status: None
"Greg Oberson (He/Him)" <Greg.Oberson@nrc.gov>
Tracking Status: None
"Boyce Travis" <Boyce.Travis@nrc.gov>
Tracking Status: None
"Alexander Chereskin" <Alexander.Chereskin@nrc.gov>
Tracking Status: None
"Nicholas Hansing" <Nicholas.Hansing@nrc.gov>
Tracking Status: None
"Zachary Gran" <Zachary.Gran@nrc.gov>
Tracking Status: None
"Kyle Song" <Kyle.Song@nrc.gov>
Tracking Status: None
"Charley Peabody" <Charles.Peabody@nrc.gov>
Tracking Status: None
"Steve Jones" <Steve.Jones@nrc.gov>
Tracking Status: None
"Rusty Towell" <rxt01a@acu.edu>
Tracking Status: None
"Lester Towell" <ldt20a@acu.edu>
Tracking Status: None
"Jordan Robison" <jcr20b@acu.edu>
Tracking Status: None
"Tim Head" <tlh07b@acu.edu>
Tracking Status: None
"Alexander Adams" <axa20j@acu.edu>
Tracking Status: None

Post Office: SA0PR09MB7369.namprd09.prod.outlook.com

Files	Size	Date & Time
MESSAGE	1195	3/24/2023 2:19:13 PM
Audit Questions_Chapters 4, 6, & 9.6 (Round 1).pdf	241536	

Options

Priority:	Normal
Return Notification:	No
Reply Requested:	No
Sensitivity:	Normal
Expiration Date:	

Audit Plan: ML23065A055

PSAR Review Information Needs for Chapter 4 (General questions relevant to entire chapter)

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4-1	N. Hansing	3/24/2023	4 (General)	Fail-open helium gas valves are relied on to allow salts to drain into drain tanks for several scenarios in the safety analyses. This action is described as shutting down the nuclear reaction. Additional details are necessary supporting the design, qualification, testing, and inspection of these valves. NRC staff will need to confirm the reliability, redundancy, and independence of the valves to support findings around DC 21 and 22.
4-2	N. Hansing	3/24/2023	4 (General)	Please describe plans to monitor, test, and analyze for vibration and other dynamic effects which may be encountered during preoperational testing, startup and/or full power operation.
4-3	A. Chereskin	3/24/2023	4 (General)	Define the reactor system boundary, materials of construction, and which codes and standards are applicable to which SSCs. For example, are the fresh fuel and effluent tanks designed to ASME Code Division 5? Provide a description of all salt-wetted containment structures (e.g., preliminary arrangement/dimensions, fabrication, welds), and provide context for any reactor system boundary components for which the safety treatment is not consistent with other portions of the reactor system boundary.
4-4	A. Chereskin	3/24/2023	4 (General)	Reference 4.8-1 appears to show that ACU is using the 2021 edition of ASME Code Section III Division 5. The NRC staff has endorsed the 2017 edition of Section III Division 5 in RG 1.87, Revision 2, subject to certain limitations and conditions. Does ACU intend to use the 2021 edition? If so, provide the justification for why differences in the Code editions are acceptable.
4-5	A. Chereskin	3/24/2023	4 (General)	Design Criterion 32 states the fuel salt boundary shall be designed to be inspectable. However, it doesn't appear that a description of how the boundary will be inspected is provided in either Chapter 4 or Chapter 5. Describe how inspections will be performed, and what portions of the boundary are subject to inspection in order to meet DC 32.
4-6	A. Chereskin	3/24/2023	4 (General)	Provide clarification on what is meant by "stainless steel 316H **or equivalent** (as determined by the carbon content)."
4-7	A. Chereskin	3/24/2023	4 (General)	Does ACU plan to use coatings on any salt-wetted materials? If so, provide context/a comprehensive description of preliminary information for relevant SSCs.
4-8	A. Chereskin	3/24/2023	4 (General)	Confirm or provide context to assure that no galvanically dissimilar metals are used in the fuel salt boundary (this includes the base metal and weld fillers).
4-9	A. Chereskin	3/24/2023	4 (General)	Chapter 14 of the ACU PSAR states that composition, level and leakage of the fuel salt will be used as preliminary technical specifications. Describe or provide context on how technical specification limits will be determined. For example, are novel means being used to measure these parameters?
4-10	A. Chereskin	3/24/2023	4 (General)	Given that the fuel salt boundary interfaces with a pressurized gas system, describe how, or provide a commitment that the fuel salt boundary will be protected from dynamic effects associated with the failure of a pressurized piping system (e.g., pipe whip).
4-11	A. Chereskin	3/24/2023	4 (General)	Provide the expected preliminary temperature profile for each of the fuel-salt-bearing SSCs to provide assurance that these components will remain within their qualified parameters in the proposed operating envelope.
4-12	A. Chereskin	3/24/2023	4 (General)	To the extent possible, describe how inspection, monitoring, and testing programs (e.g., salt chemistry, radiation damage, chemical damages, erosion, pressure pulses, deterioration during the projected lifetime) will be planned and implemented. For example, consideration of surveillance specimens measuring critical degradation mechanisms (e.g., stress needed for creep, welds). If a

				description of these programs is premature, provide context on what commitments will be made in the PSAR to implement these programs.

PSAR Review Information Needs for Chapter 4, Section 4.1, "Summary Description"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.1-1	C. Peabody	3/24/2023		References to the refueling cycle require clarification between loading and unloading the reactor and adding UF_4 through the reactor access vessel (RAV). Once the UF_4 is in solution, given it is not possible to remove it, will that impact the fuel handling system (FHS) if it is utilized during the operational period?

PSAR Review Information Needs for Chapter 4, Section 4.2, "Active Reactor Core"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.2-1	A. Chereskin/C. Peabody	3/24/2023	4.2.1	Section 4.2.1 indicates that more specific ranges of salt composition and volume will be provided in the OL, however this information is needed to verify the flow dynamics in the vessel and the RAV, as well as the flow and heat transfer in the heat exchanger. Salt composition ranges and volume changes will need to address fission product contamination ranges since the non-gaseous fission products are expected to remain in the salt solution for the remainder of the operating cycle. Provide the nominal and bounding compositions of the fuel salt. Provide fuel salt thermophysical and thermochemical properties as a function of temperature and composition, including off-normal temperatures and compositions. This should include any properties needed to model salt behavior in an accident and normal operations. Allowable compositions should include consideration of fission products, corrosion products, and other impurities, as build-up will affect thermophysical (e.g. viscosity) and thermochemical (e.g. CsI formation) properties.
4.2-2	A. Chereskin	3/24/2023	4.2.1	What are the solubility limits for actinides in the molten salt and what measures are in place to ensure these are not exceeded?
4.2-3	A. Chereskin	3/24/2023	4.2.1	Will technical specifications (TS) be provided to limit fuel salt composition?
4.2-4	A. Chereskin	3/24/2023	4.2.1	What is the allowable O_2 ingress/concentration to avoid precipitation of UO_2? Will any circulating buffer like ZrF_4 be used?
4.2-5	C. Peabody	3/24/2023	4.2.1	4.2.1.2 describes how the fuel salt is consistent with DC 10 and 16. Provide the technical basis for these statements.
4.2-6	C Peabody	3/24/2023	4.2.1	Provide the technical basis for the conclusion stated in section 4.2.1.3, "These changes are managed such that they do not impact reactor safety."
4.2-7	C. Peabody	3/24/2023	4.2.1	What is the expected fuel salt vapor phase in the RAV and drain tank head spaces and what chemical and radiological migration impacts are expected. As none are described, is there a technical basis for zero or negligible vapor phase?

4.2-8	C. Peabody	3/24/2023	4.2.1	Provide the basis for the Helium remaining soluble except in the RAV bubbler. Specifically, address homogenous mixing of Helium, preclusion of void formation, and consideration of 2-phase flow in and around the Helium Bubbler Off-gas system.
4.2-9	C. Peabody	3/24/2023	4.2.1.7	What are the allowable pressure limit boundaries which correspond to the temperature limit boundaries provided in 4.2.1.7?
4.2-10	C. Peabody	3/24/2023	4.2.2	Do the RPS and RCS shutdown margin calculations consider any amount of fuel salts seeping in between the graphite moderator blocks? Provide either the basis for no seepage or, if seepage can occur, describe the reactivity and timing effects on the reactor drainage sequence..
4.2-11	C. Peabody	3/24/2023	4.2.2	Section 4.2.2 states the RCS is credited as a separate and diverse means of bringing the reactor subcritical but doesn't play a role in the shutdown. What is the safety function of the RCS (versus the RPS)?
4.2-12	C. Peabody	3/24/2023	4.2.2	What is the MHA SCRAM time acceptance criteria and how is it measured (e.g., the bottom of the graphite at 1 min; a k_{eff} level corresponding to subcritical (~15s))? • More specifically what is the shutdown margin acceptance criteria for the RPS? • What is the SCRAM time acceptance criteria for the RPS? These would likely be in the form of a calculation.
4.2-13	N. Hansing	3/24/2023	4.2.2	Section 4.2.2.2 discusses the control rod (CR) assemblage as structurally attached to the top of the reactor vessel and supported by it. Please provide additional details on the means of attachment and how its interaction with the reactor vessel is analyzed.
4.2-14	N. Hansing	3/24/2023	4.2.5	4.2.5.1 states "the consequent movement of graphite is accounted for in the mechanical design of both the grid plate and the graphite." Provide additional details to explain this statement, potentially in a preliminary design specification.
4.2-15	N. Hansing	3/24/2023	4.2.5	Additional details are requested to better understand the core support structure and how it interfaces with other elements of the facility. For example, the eye hooks and notches/ledges mentioned in Section 4.2.5.3.
4.2-16	N. Hansing	3/24/2023	4.2.5	Are there penetrations and supports for detectors?

PSAR Review Information Needs for Chapter 4, Section 4.3, "Vessel"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.3-1	N. Hansing	3/24/2023	4.3	More definitive statements are needed for the codes and standards used for this design. Please specify the Code Edition and Addenda and indicate whether the Codes and Standards used will incorporate the conditions imposed on them by the NRC for acceptable use. This supports the staff's findings regarding DC 1.
4.3-2	N. Hansing	3/24/2023	4.3	Section 1.2.3.3 states "Reactor loop consists of the reactor vessel, access tank, reactor (fuel salt) pump, heat exchanger, drain tank and associated 2.5-in. (nominal) diameter piping." Clarify if the reactor loop contains any valves, orifices, or other SSCs. Further granularity on Table 3.4-1 would be helpful for understanding how DC 1 will be satisfied. Clarity on the boundaries between classifications and which specific SSCs fall into which category would further support satisfaction of DC 1.
4.3-3	A. Chereskin	3/24/2023	4.3	Although several ACU MSRR DC are listed as applicable to Section 4.3, it is not clear how these are met. Provide a description that demonstrates how all relevant DC are or will be satisfied, and that the selected DC are appropriate for the SSCs in this Section.

4.3-4	A. Chereskin	3/24/2023	4.3.1	Section 4.3.1 states that this section describes design features common to **all** fuel-salt-bearing components within the reactor enclosure. As part of the audit, describe all components that are covered by the analysis in this section and provide preliminary descriptions of these components (e.g. preliminary dimensions, fabrication methods, penetrations, consequence of loss of integrity etc.). Additionally, provide the lifetimes for all fuel-salt-wetted SSCs, and whether any components are anticipated to need replacement during the MSRR life, based on anticipated degradation.
4.3-5	A. Chereskin	3/24/2023	4.3.10	PSAR Section 4.3.10 states that small leaks from the gas management system (GMS) will be detected by the radiation monitoring system (RMS). ACU MSRR DC 30 requires that means be provided to detect and identify the location/source of fuel salt leakage. Clarify whether this is meant to be leaks from the GMS and/or from the fuel salt boundary. Additionally, describe how the RMS will detect leaks and if leaks can be detected throughout the entirety of the fuel-salt boundary.
4.3-6	A. Chereskin	3/24/2023	4.3	Describe whether the gas composition and gas purity can affect the structural materials. Additionally, can the differences in heat transfer properties of Helium and the fuel salt cause thermal stresses in surrounding SSCs at the salt-gas interfaces?
4.3-7	A. Chereskin	3/24/2023	4.3 (Degradation Mechanisms)	Section 4.3.5, “Radiation Damage to Reactor System,” states that 0.1 dpa is below levels of mechanical property degradation in SS. Are all SR metallic components expected to see <= 0.1 dpa? Fluence at the vessel wall may be less than other components as it is shielded by the graphite components. Provide the data used to determine that mechanical property degradation at 0.1 dpa is negligible.
4.3-8	A. Chereskin	3/24/2023	4.3 (Degradation Mechanisms)	Provide context on whether the effects of potential coolant salt ingress have been assessed (e.g. in the event of heat exchanger failures).
4.3-9	A. Chereskin	3/24/2023	4.3 (Degradation Mechanisms)	Provide context on whether the effects of salt freezing or precipitation (e.g. thermal expansion, gas generation) have been assessed to determine its effects on component integrity.
4.3-10	A. Chereskin	3/24/2023	4.3 (Welds)	Provide preliminary information about how welds will be performed on salt-wetted components. This includes the filler metal to be used, welding method, etc. Different weld filler materials are qualified to different allowable temperatures in ASME Code Section III Division 5. Describe how the chosen weld filler materials meet Code requirements for the maximum allowable temperature or provide appropriate commitments to ensure that there are appropriate materials available for the proposed use case and such materials will be procured for use in the MSRR.
4.3-11	A. Chereskin	3/24/2023	4.3 (Welds)	Provide context on how the effects of stress relaxation cracking will be assessed, and what data will be used to determine the adequacy of degradation of welds in the fuel salt environment of the MSRR?
4.3-12	A. Chereskin	3/24/2023	4.3 (Fuel Salt Chemistry/ Purity)	Provide context regarding chemistry control measures in place for the drain tank and/or RTMS (e.g., will these measures be needed)?
4.3-13	A. Chereskin	3/24/2023	4.3 (Fuel Salt Chemistry/ Purity)	Provide context on how heat transfer is considered and assessed when setting salt purity limits (e.g., effects from fouling, composition changes). If conservative values are assumed, provide context on how these values will be confirmed during operation (e.g., technical specifications).
4.3-14	A. Chereskin	3/24/2023	4.3 (Fuel Salt Chemistry/ Purity)	MSRE experience showed that when adding metallic Be for redox control, dendrites formed in the basket used to lower the Be into the salt. Provide context on how the effect of dendrite formation and potential flow blockages are considered.

4.3-15	A. Chereskin	3/24/2023	4.3 (Fuel Salt Chemistry/ Purity)	It is not clear to the NRC staff how the proposed redox probe arrangement accounts for potential local effects throughout the reactor system. As part of the audit, describe how redox probes mounted from the top of the RAV will able to adequately measure the redox potential throughout the fuel salt system.

PSAR Review Information Needs for Chapter 4, Section 4.4, "Biological Shield"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.4-1	Z. Gran	3/24/2023	4.4.4	PSAR Section 4.4.4, "Design Methods," the applicant states: *"In general, Monte Carlo methods are used for shielding analyses to allow accurate representation of the MSRR geometry and, in particular, to enable accounting for penetrations directly."* Based on the staff's understanding of the statement, please confirm what codes are used to perform these shielding calculations.
4.4-2	Z. Gran	3/24/2023	4.4.4	The staff requests to audit/review the shielding calculation files from the previous question, the Monte Carlo Neutral Particle Transport Program (MCNP) input and output files, along with any other supporting documentation. This review is conducted so that the staff may verify the shielding specifications and the targeted dose rates specified for the areas around the reactor. a. Seeking information on the source term used for the bioshield analysis, the materials used in the analysis, and the geometry used in the analysis. b. The staff also requests available information on how air activation and soil activation are determined.

PSAR Review Information Needs for Chapter 4, Section 4.5, "Nuclear Design"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.5-1	C. Peabody	3/24/2023	4.5.1	The staff requests the Reactor Physics Model of the MSRE stated to be available upon request in Section 4.5.1.3 to be made available.
4.5-2	C. Peabody	3/24/2023	4.5.2	The limiting parameters that are of safety interest (highest power density, largest source term, and highest excess reactivity are listed but not quantified with acceptance criteria. Will acceptance criteria be defined for these parameters? If so, when (e.g. PSAR, OL, UFSAR)?
4.5-3	C. Peabody	3/24/2023	4.5.2	A 0.04 percent void fraction was chosen based on the MSRE. Is this consistent with the values assumed in calculations (e.g., those in Chapter 13, which appears to use a He entrainment fraction of 0.018, consistent with the discussion in Section 4.5.4)? The void fraction needs to be realistic, because overestimating voids can assume a more negative reactivity effect than would be present in the core during operating conditions.
4.5-4	C. Peabody	3/24/2023	4.5.2	Regarding the Off Gas system impact on reactivity, the system is assumed not to run for the source term and power density for conservatism. However, the system running has a non-conservative impact on the void reactivity coefficient. What is the treatment and effects of the off gas system for transients where the void reactivity coefficient would be the most limiting reactivity parameter. ()?

4.5-5	C. Peabody	3/24/2023	4.5.2	When evaluating the reactivity coefficient in the last paragraph of 4.5.2.2 a temperature of 600°C was used. This is the average system temperature not the minimum system temperature of 550 °C. Shouldn't the minimum temperature be used, as that is the most limiting per the last paragraph of section 4.5.2.1?
4.5-6	C. Peabody	3/24/2023	4.5.2	What safeguards are in place to ensure that the correct amount of UF_4 is added through the RAV without effectively increasing or decreasing the mole fraction of UF_4 in the fuel salts? Over-addition of UF_4 would invalidate many of the assumptions in section 4.5.2, and if this is a realistic possibility then these scenarios should be analyzed as reactivity control accidents.
4.5-7	C. Peabody	3/24/2023	4.5.2	Has any evaluation been done to ensure that plutonium buildup from U-238 through core life is managed and that the fast fission cross section does not have an adverse impact on fuel salt subcriticality margin outside of the reactor vessel?
4.5-8	C. Peabody	3/24/2023	4.5.3	The thermal expansion described between the vessel and the graphite portends uncertainty about the molten salt flow through the core. What is the expected vessel flow fraction between: a. Fuel Salt Channels b. Annular region between moderator blocks and reactor vessel wall c. Flow between the adjacent surfaces of the graphite moderator block
4.5-9	C. Peabody	3/24/2023	4.5.3	Will the core end of life (EOL) prompt neutron lifetime calculation in the OL account for plutonium generation and fast fission cross section?
4.5-10	C. Peabody	3/24/2023	4.5.3	Will the variance in axial or radial power density across the core cause any deformation to the flow path, particularly in the graphite channels?
4.5-11	C. Peabody	3/24/2023	4.5.3	Is the graphite moderator expected to react chemically to any of the fuel salts, fission, or activation products?
4.5-12	C. Peabody	3/24/2023	4.5.4	NRC staff is seeking further information to support the assertion in 4.5.4.6 that "it is concluded that the MSRR does not have a limiting core configuration" in conjunction with the statement that "[hot spots] are monitored during operation and can be accurately modeled with appropriate tools." Staff recognizes that the term "limiting core configuration" may not be applicable in this instance, and will be seeking to ensure that limiting conditions are assessed as appropriate for the events analyzed in Chapter 13.
4.5-13	C. Peabody	3/24/2023	4.5.4	Why is the maximum reactivity insertion pressure initial condition 150kPa in 4.5.4.4 so different from the maximum operating pressure of 500kPa? Also, what is the anticipated normal operating pressure, assuming that the maximum of 500kPa is a safety limit?

PSAR Review Information Needs for Chapter 4, Section 4.6, "Thermal Hydraulic Design"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
4.6-1	K. Song	3/24/2023	4.6	According to PSAR 4.6, Thermal-hydraulic (TH) design cooling capacity is consistent with DC 34 and 35, which is sufficient to maintain the salt at temperatures that will not damage the reactor systems. It is not clear how pressure is regulated in the heat removal system during normal or postulated accidents without a pressure relief valve(s). Does the MSRR TH design or RTMS require any pressure relief valve(s)?
4.6-2	K. Song	3/24/2023	4.6	PSAR 4.6.1.1 states the radiator is cooled by atmospheric air and Figure 4.6-1 labels this as "PHR" air, but PHR is not defined in the list of acronyms or described in the text. What is the PHR?

PSAR Review Information Needs for Chapter 6, "Engineered Safety Features", Section 6.2, "Detailed Descriptions"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
6.2-1	S. Jones	3/24/2023	6.2	NRC staff is seeking additional information regarding the confinement function for fuel salt storage tanks and off-gas system components, which represent potential pathways for radionuclide release.
6.2-2	S. Jones	3/24/2023	6.2	It is not clear based on the information provided in the PSAR what the applicability of PDC to the reactor cell is. NRC staff requests that ACU provide context on how the reactor cell function is addressed within the proposed PDC.
6.2-3	S. Jones	3/24/2023	6.2	NRC staff is seeking additional context on the cited 1 percent per day leakage rate. Specifically, the staff requests ACU provide context on how this value is planned to be confirmed or achieved (e.g., construction codes, methods, planned tests). This question also pertains to some of the information needs submitted regarding Chapter 13.
6.2-4	B. Travis	3/24/2023	6.2.3	ACU should provide context (make the analysis available and potentially summarize relevant findings) regarding the preliminary analysis to support the following PSAR statement: "Sufficient thermal mass exists within the reactor system, reactor enclosure, reactor cell, and research bay to ensure completely passive cooling mechanisms (conduction, natural convection, and thermal radiation) safely remove decay heat without violating a thermal limit."
6.2-5	K. Song	3/24/2023	6.2.4	Provide the supporting basis (e.g., analysis, preliminary assumptions, and material properties) for the following statements in 6.2.4: "The stainless steel is capable of withstanding, without failure, the direct contact of approximately 1.5 tons of hot fuel salt falling on it and collecting at the bottom of the RTMS," and "In the event heater power is lost, the RTMS and the components inside will slowly cool. This cooldown period is long enough for the fuel salt to drain."
6.2-6	K. Song	3/24/2023	6.2.4	NRC staff requests ACU provide preliminary analysis as part of the audit for the statement "The utility of the RTMS is demonstrated in the Chapter 13 MHA analysis." Although the system is utilized in Chapter 13, information in the PSAR is insufficient for the staff to understand how the RTMS heat removal capability is assumed to function when relied upon (e.g., system configuration, assumed heat transfer characteristics).
6.2-7	K. Song	3/24/2023	6.2.4	It is not clear from the information presented in PSAR 6.2.4 how the RTMS meets the DC 72 function (heat retention) under accident conditions (which accidents, capability of insulation). ACU should provide additional context regarding the conditions under which the RTMS is credited to retain heat (e.g., keep the salt liquid) and which the RTMS removes heat. A preliminary analysis, including any assumptions, should be provided as part of the audit.
6.2-8	K. Song	3/24/2023	6.2.4	PSAR Section 6.2.4.3 states the RTMS is independently supported by the reactor loop. Provide clarification if this statement refers to the thermal management aspect (e.g. salt temperature control) or mechanical function.

PSAR Review Information Needs for Chapter 6, Section 6.3, "Compliance with Design Criteria"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
6.3-1	S. Jones	3/24/2023	6.3	No information was provided regarding technical specifications that may be needed for ESF or manual isolation of fuel salt storage tanks. ACU should provide context on why these are not present, or plan to add these to the list of variables for preliminary TS in Chapter 14.

PSAR Review Information Needs for Chapter 9, Section 9.6, "Gas Management System"

Item #	Reviewer(s)	Date Sent to ACU (Accession No.)	PSAR Chapter or Topic	Question
9.6-1	A. Chereskin	3/24/2023	9.6	ACU should describe how the design of the GMS is planned to meet each of the applicable ACU MSRR DC.
9.6-2	A. Chereskin	3/24/2023	9.6	Clarify where portions of the GMS and cover gas system are located. What subsystems and components are located inside the reactor enclosure, reactor cell, and outside of these buildings? Clarify what components in the GMS are safety related.
9.6-3	A. Chereskin	3/24/2023	9.6	PSAR Section 9.6.1 states that one of the design bases for the GMS is to maintain integrity to limit dose releases. ORNL/TM-2020/1478 Section 9.6 states that the GMS should be able to withstand any pressure transients in the reactor system. Provide the design basis and preliminary postulated accident temperatures and pressures, or bounding assumptions, if transient analysis details are not available to demonstrate that the GMS can maintain boundary integrity under all postulated conditions. Additionally, describe the pressure relief functions mentioned in PSAR Section 9.6.2.
9.6-4	A. Chereskin	3/24/2023	9.6	PSAR Section 9.6.1 states that one of the design bases is to support reactor protection system (RPS) functions. Provide context as to which RPS functions the GMS supports. Explain how the GMS performs the pressure equalization safety function.
9.6-5	A. Chereskin	3/24/2023	9.6	It appears that PSAR Section 9.6, "Gas Management System," does not specifically discuss storage and removal of tritium and section 9.6.3 states that only iodine, xenon, and krypton will enter the scrubber beds. How does the GMS handle tritium storage, removal, and processing so that dose limits are not exceeded during normal operations or a postulated accident? Additionally, how does the GMS handle decay products from iodine, xenon, or krypton?
9.6-6	A. Chereskin	3/24/2023	9.6	PSAR Section 4.3 references certain construction codes that will be used for components in the reactor system but doesn't specify which codes are used for what components/subsystems. ACU should specify the construction codes that will be used for the GMS and why the chosen codes are appropriate given the safety significance of the GMS system and components.
9.6-7	A. Chereskin	3/24/2023	9.6	ORNL/TM-2020/1478 Section 9.6 states that the GMS should be designed to ensure there are adequate decay heat removal mechanisms to ensure a credible failure would not lead to loss of fuel system boundary integrity, and Section 9.6.1 of the ACU MSRR PSAR, "Design Basis," states the GMS is designed to remove decay heat. Section 9.6.2 states decay heat will be "appropriately managed." However, there is no description of how this will be achieved. Describe how decay heat is removed from the GMS to ensure that there is no loss of the fuel system integrity boundary.
9.6-8	A. Chereskin	3/24/2023	9.6	ACU MSRR PSAR Section 9.6.2 states that hydrogen will be used in the GMS. ORNL/TM-2020/1478 Section 9.6 states that the GMS should be designed so that acceptable concentrations of constituents (includes processing, storing, and recombination of reactive gases) are maintained. Describe how the design of the GMS allows for appropriate processing, storage, and recombination, if necessary, of reactive gases.
9.6-9	A. Chereskin	3/24/2023	9.6	ACU PSAR Section 9.6 states that actinides are not gaseous and so criticality in the GMS is prevented, although there was evidence from the MSRE that a fuel salt mist may be deposited within the off-gas system. ORNL/TM-2020/1478 Section 4.7 specifies that an analysis should be provided to demonstrate that no single failure can result in criticality outside the active reactor core. Given these considerations, how is inadvertent criticality in the GMS prevented?
9.6-10	A. Chereskin	3/24/2023	9.6	ORNL/TM-2020/1478 4.7 states that the maximum release of hazardous chemicals should not exceed applicable regulatory criteria including effects on workers in the facility. Describe how hazardous materials such as F_2 or HF are scrubbed from the GMS in order to ensure releases don't exceed applicable regulatory criteria.
9.6-11	A. Chereskin	3/24/2023	9.6	ORNL/TM-2020/1478 Section 9.6 states that the GMS should have systems to assess the required purity or concentrations of contained gases. Provide context regarding how corrosive impurities (e.g. air, moisture) in the gas system will be monitored to ensure the appropriate fuel salt redox potential is maintained.

9.6-12	A. Chereskin	3/24/2023	9.6	ORNL/TM-2020/1478 Section 9.6 states that the GMS should provide periodic monitoring for long-term accumulation of fissionable material in the system. Section 9.6.4 includes monitoring for scrubber bed activity, but it isn't clear if this can be used to monitor accumulation of fissionable material throughout the GMS as this only appears to monitor one component and doesn't seem to discriminate between fission products and fissionable material. Describe how fissionable material in the GMS is planned to be monitored.
9.6-13	A. Chereskin	3/24/2023	9.6	The GMS uses He which is much less dense than ambient air. What are the consequences of air ingress in sub-systems such as the primary salt tanks which can't drain to the RTMS?
9.6-14	A. Chereskin	3/24/2023	9.6	ACU MSRR DC 73 requires provisions to prevent or mitigate plugging of gas lines due to salt solidification which could prevent the safety related (SR) function of pressure equalization. Additionally, ORNL/TM-2020/1478 Section 9.6 states that monitoring should be provided for hazardous chemicals and fission products to detect build-up, clogging, and leaks. PSAR Section 9.6.3 states hazardous chemicals and fission products will be monitored for plugging and leaks, but doesn't describe how this will be accomplished. Describe how plugging of gas lines, or leaks are prevented or mitigated, and demonstrate that the GMS can provide pressure equalization during a postulated accident, and perform any other required safety functions.
9.6-15	A. Chereskin	3/24/2023	9.6	DC 74, NUREG-1537, and ORNL/TM-2020/1478 stipulate that an analysis should be provided that demonstrates if the gas characteristics are changed, that it will not impact safe shutdown. The GMS performs the SR function of pressure equalization. If the characteristics of the gas are changed, can pressure equalization be achieved? Demonstrate that events such as air leaks do not inhibit the ability of the GMS to perform its SR functions.
9.6-16	A. Chereskin	3/24/2023	9.6	If the fuel salt is drained to the drain tank or RTMS in a postulated accident, is the GMS still credited to perform its function to retain radionuclide gases from the drain tank or RTMS? Provide context as to the preliminary expected GMS function during these events.
9.6-17	A. Chereskin	3/24/2023	9.6	How is the GMS piping isolatable as described in Section 9.6.3?
9.6-18	A. Chereskin	3/24/2023	9.6	Describe how fission product partitioning between the fuel salt and the gas space is determined. The thermochemistry of the salt will determine whether certain fission products exist in solution or as a vapor and could increase the quantity of radionuclides available for release from the GMS.
9.6-19	A. Chereskin	3/24/2023	9.6	Integrity of the GMS boundary: a) ACU MSRR DC 42 requires inspection of containment atmosphere cleanup systems and DC 43 requires testing of containment atmosphere cleanup systems. PSAR Section 9.6.5, "Technical Specifications, Testing, and Inspection," only states that a surveillance program is established to ensure barrier integrity. Does the program referenced in PSAR Section 9.6.5 include periodic inspection of important components and functional testing? b) It appears the ACU MSRR DC 51, "Fracture prevention of containment boundary," is missing from the evaluation in Section 9.6. It appears the GMS forms part of the containment boundary as it is needed to retain gaseous fission products generated in the fuel salt. This DC requires the containment be designed with margin to ensure probability of rupture is minimized and to account for material properties, stresses, and flaws. Clarify whether ACU MSRR DC 51 applies to the GMS and, if so, describe how it is met. c) ORNL/TM-202/1478 Section 4.7 contains an evaluation finding that the applicant designed the system to be compatible with the chemical environment to which it will be exposed. ACU should demonstrate that the 316H and associated weld filler material is compatible with the gases to which it can be exposed (e.g. HF at different concentrations/temperatures, H_2 which can cause cracking/embrittlement, Helium embrittlement, temperature, dose) as well as the volatile fission products and fuel salt mist that can deposit in the GMS, or describe what measures will be in place to preclude adverse interactions. d) ACU should provide context regarding the interaction between gaseous fission products and the GMS boundary (e.g., by increasing temperature, cracking, or deposition causing blockage of gas pathways) e) ACU should describe preliminary measures regarding how the GMS will account for thermal stresses and thermal fatigue (e.g., thermal cycling) and what data will be used to design for these effects.