From:	Richard Rivera
Sent:	Wednesday, January 17, 2024 4:20 PM
To:	Rusty Towell; Lester Towell; Benjamin Beasley; Tim Head; Jordan Robison; Alexander Adams; Brazos Fitch
Cc:	Edward Helvenston; Michael Wentzel; Greg Oberson (He/Him); Mohsin Ghazali; Alexander Chereskin; Ryann Bass; Michael Balazik
Subject:	ACU MSRR PSAR Section 4.3 Audit Questions (Related to Material Degradation)
Attachments:	ACU Audit Questions 4.3-21 and 4.3-22.pdf

Dear Dr. Towell,

Attached are two questions the NRC staff has prepared for Abilene Christian University (ACU) related to the ACU Preliminary Safety Analysis Report, primarily Section 4.3, "Vessel." The NRC staff would like to discuss this question within the scope of the ACU construction permit (CP) application review Audit Plan for Chapters 4 and 6, and Section 9.6 (see audit plan dated 3/2/2023, ML23065A055), and I am providing in advance to facilitate discussion during an audit meeting to be scheduled. We will add this email, with the questions, to public ADAMS. If you have any questions, please let Edward, Mohsin, or I know.

Thank you,
Richie

Richard Rivera, MEM
Project Manager
U.S. Nuclear Regulatory Commission – HQ
NRR/DANU/UAL2
Ph. 301-415-7190
E-mail Richard.Rivera@nrc.gov

Hearing Identifier: NRR_DRMA
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Created By: richard.rivera@nrc.gov

Recipients:
"Edward Helvenston" <Edward.Helvenston@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
"Mohsin Ghazali" <Mohsin.Ghazali@nrc.gov>
Tracking Status: None
"Alexander Chereskin" <Alexander.Chereskin@nrc.gov>
Tracking Status: None
"Ryann Bass" <ryann.bass@nrc.gov>
Tracking Status: None
"Michael Balazik" <Michael.Balazik@nrc.gov>
Tracking Status: None
"Rusty Towell" <rxt01a@acu.edu>
Tracking Status: None
"Lester Towell" <ldt20a@acu.edu>
Tracking Status: None
"Benjamin Beasley" <bgb23b@acu.edu>
Tracking Status: None
"Tim Head" <tlh07b@acu.edu>
Tracking Status: None
"Jordan Robison" <jcr20b@acu.edu>
Tracking Status: None
"Alexander Adams" <axa20j@acu.edu>
Tracking Status: None
"Brazos Fitch" <bjf15a@acu.edu>
Tracking Status: None

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Audit Question 4.3-21

Abilene Christian University (ACU) Molten Salt Research Reactor (MSRR) Preliminary Safety Analysis Report (PSAR), Revision 1 (ML23319A094), Section 4.3.3, "Reactor System Structural Material," states the following:

"Weld filler ER 316 is very similar in composition to the base metal and will be used as the weld filler material, as outlined in ASME BPVC.III.5-2017 Table HBB-I-14.1(b) 'Permissible Weld Materials.' Welding procedures will comply with appropriate sections of the codes and standards."

a. Regulatory Guide (RG) 1.87, Revision 2, "Acceptability of ASME Code, Section III, Division 5, "High Temperature Reactors," does not endorse the material properties in Table HBB-I-14.10B-3 for Type 316 stainless steel (SS) base metal welded with Type 316 SS filler using processes other than gas tungsten arc welding; see RG 1.87 C.1.u.(1)(f). RG 1.87 states that "[a]pplicants wishing to use these base metal/weld metal combinations for welds made with processes other than gas tungsten arc welding may be able to demonstrate the adequacy of these [stress rupture factors] R-factors by submitting additional data." Has ACU determined that it will use gas tungsten arc welding or whether it intends to use a different process for which additional data may need to be provided? If the latter, please describe ACU's plans to submit the additional data.
b. Has ACU determined if it will use a post weld heat treatment? If so, has ACU determined how the potential impact of the post weld heat treatment on materials' properties would be accounted for in the component design?
c. It is not clear to the NRC staff what ACU means when it refers to the "appropriate sections of the codes and standards" at the end of the quoted section in the introduction of this question. For instance, the staff notes that this could be the codes and standards that are cited in ASME BPVC.III.5-2017 for ER 316. Alternatively, it could mean codes and standards for ER 316 that are not utilized by ASME BPVC.III.5-2017. The staff notes that ACU's response to audit question 5.2-4, provided via Electronic Reading Room (ERR), where it states that "[s]pecial processes like welds are intended to be performed in accordance with the AWS D1.1. structural welding code." Other explanations could be possible. Please clarify the intent of this statement and clarify which code(s) and standard(s) will be utilized.

Audit Question 4.3-22

The ACU document in the ERR titled “Degradation Mechanisms Table September 29 Revision.pdf” states that “During operation, the aim is to keep the salt under reducing conditions to mitigate corrosion… Fuel salt will be exposed to beryllium [Be] until the chemical analysis gives the desired ratios of uranium ions in salt. Beryllium will be removed once the desired ratio is achieved.” In the same report, ACU further states that “when exposed to excess beryllium and carbon in FLiBe, S316H may form intermetallic compounds like Fe-Be or Ni-Be or metal carbides over time which may degrade the mechanical behavior of SS316H,” but, according to the same document, this would affect a thin surface layer and the bulk properties would not be changed. The effect of excess Be additions on mechanical behavior of 316H SS has been demonstrated and documented (J. R. Keiser et al., “Interaction of beryllium with 316H stainless steel in molten Li_2BeF_4 (FLiBe),” Journal of Nuclear Materials, 565, 153698 (2022)).

The same document provided by ACU also states that “SS316H does have high carbon content and that is expected to lead to carbide formation at the grain boundaries. Any extra carbon from graphite may form a carburized layer at the surface… However, the bulk properties will be more affected by the carbide formation due to the carbon alloyed into SS316H. Design calculations will account for these changes.”

Concerning the management of this potential material degradation mode, ACU states in its document titled “Degradation Mechanisms Table September 29,” that “Inspection is not necessary since this is addressed in the design,” and that “[surveillance c]oupons will be characterized by using [X-Ray Diffraction] XRD and metallography on sectioned samples to detect any phase changes in SS316H.”

The following questions address this information and, as relevant, apply to both base metals and welds:

a. Describe how ACU determined that the amount of Be needed to achieve the desired redox conditions is less than the amount which would affect the bulk properties of the material.
b. ACU states in its document titled “Degradation Mechanisms Table September 29,” that beryllium addition technical specifications will be defined to preclude excess beryllium in the fuel salt. Describe how ACU will determine what amount of beryllium is excessive.
c. With respect to phase formation embrittlement (Be), ACU states that "Inspection is not necessary because this is addressed by design." Please clarify the intent of the phrase “addressed by design” in this statement. Does this refer, for instance, to component dimensions or some other means to mitigate the potential propagation of cracks that initiate in an embrittled surface layer (e.g., synergism with other surface sensitive degradation mechanisms such as fatigue)? What criteria will be used to determine whether this potential degradation mechanism is satisfactorily addressed?
d. Describe how ACU will account for the effect of additional carbon from graphite, including the potential for synergism with other surface sensitive degradation mechanisms, such as fatigue?
e. Describe how ACU determined or will it determine whether XRD and metallography are adequate methods to detect phase formation embrittlement such that potentially affected components satisfy the relevant design criteria. Will surveillance specimen locations bound all potentially affected components? Does ACU plan to implement corrective actions if surveillance coupons indicate phase formation embrittlement?