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April 30, 2024

Docket No. 50-610

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Abilene Christian University Construction Permit Application
Response to Request for Additional Information 2

On December 21, 2023, the Nuclear Regulatory Commission issued two Requests for Additional Information (RAIs) to Abilene Christian University related to the construction permit application for the Molten Salt Research Reactor (ML23348A196). The response to RAI 2 is provided below and is supplemented in the Enclosure. PSAR changes associated with the response to RAI 2 will be submitted with Revision 2 of the PSAR.

Response to RAI 2

RAI 2a. Provide additional information regarding how ACU is utilizing pre-existing data to demonstrate conformance with these design bases referenced above, for instance, to preclude the possibility that certain degradation phenomena will occur or to assess the extent or rate of progression for certain degradation phenomena when its potential occurrence cannot be excluded. This includes, for instance, the conclusion that 5 dpa for SS316 components will be acceptable, and determinations about the potential for specific degradation mechanisms that may be caused by interactions with the MSRR environment (e.g., thermal aging, environmentally assisted cracking, helium embrittlement, etc.). Please identify what pre-existing data will be used, and how the data will be applied. Also, please identify the criteria that have been or will be used to determine that the data adequately represent or bound the materials and operating conditions of the MSRR.

Response: MSRR Degradation Management Program

In order to ensure that degradation mechanisms are being properly managed throughout detailed design, construction and operation of the MSRR, ACU is developing a Degradation Management Program (DMP). The DMP will manage and mitigate the effects of specific degradation mechanisms for safety related SSCs whose failure could adversely affect component performance.

The DMP will consider design characteristics, design margins, fabrication processes, operating and transient conditions, plant- and industry-specific experience, results of examinations, component service history, degradation mechanisms, and vendor's recommendations regarding the service of SSCs. The criteria used to identify, evaluate, and mitigate the susceptibility of selected SSCs to applicable degradation mechanisms shall be specified in the DMP documentation. The DMP will develop specific mitigation strategies to each relevant degradation mechanism for SSCs in the scope of the program. For a larger summary of this program, see Appendix A. During detailed design and construction, the DMP will be used to ensure that the mitigation strategies are incorporated into the design and construction, and that the basis for each strategy remains valid. This will be documented as part of the program.

Once construction is complete, the DMP will be used to implement and maintain any monitoring and NDE required during operation.

<u>Degradation Mechanism Assessment: Pre-existing data</u>
ACU has conducted (and is continuing) a literature survey on topics of degradation phenomena relevant to the design and operation of the MSRR as part of the degradation mechanism assessment in the DMP. Upon initial review of data and literature, ACU performed a qualitative assessment to determine relevant information about: the effect of a particular degradation mechanism (e.g. embrittling behavior, cracking, corrosion); potential mitigation strategies; and the extent of relevant research and data about a particular degradation mechanism.

Secondly, if applicable, ACU obtains quantitative information from the literature such as: data regarding a change in material performance for specific properties; data about the extent of the degradation (e.g. crack length, depth of affect); and data about the conditions of the environment which allows (or prevents) a particular degradation mechanism.

To make useful determinations about the potential for a degradation mechanism in the MSRR, ACU looked specifically for the following attributes: record of the mechanism in similar applications; driving physics of the degradation; whether or not the MSRR supports the same conditions; how different is the MSRR from the applications of interest; what is the effect of the degradation on the material performance; can either the mechanism or its effect be mitigated; is that mitigation effect definitive enough; and the consequence to safety if failure from that degradation mechanism were to occur. If similar applications have not recorded the degradation mechanism or if the MSRR does not have the same conditions necessary to support the degradation mechanism or the effect of the degradation to the system can be mitigated by typical design and construction; ACU can preclude the degradation mechanism in the design of the MSRR. If the degradation mechanism cannot be precluded, then ACU's DMP will select appropriate mitigation strategies.

Clarification of 5 DPA

In PSAR Revision 1 Section 4.3.5, ACU makes the statement,

"Considering that MSRR is a low-pressure system, and that the fuel salt chemistry will be tightly controlled to minimize corrosion susceptibility, we expect that up to 5 dpa for SS316 components will be acceptable."

Based on a SCALE neutronics model developed from a preliminary design, 5 dpa is five times higher than the conservative bounding dose values expected in ACU's MSRR. Since this is not an accurate or useful value for the MSRR, ACU will remove it from the PSAR and provide updated text. In the same section of the PSAR, ACU states that the maximum damage will be on the order of 1 dpa. Based on preliminary calculations, 1 dpa is a conservative bounding value for damage to all 316H components in the MSRR, and twice as much as the expected dose to pressure boundary components.

Pre-existing data on corrosion
There is a large amount of corrosion data from the flow-loop experiments at ORNL during the MSRE and MSBR programs, as well as other published data on FLiBe. The corrosion rate for purified FLiBe with fuel is expected to be less than 10 microns per year [1]. Corrosion under redox control can be controlled to even lower values. According to the flow-loop experiment data as well as recent published data, the corrosion rate with the addition of Be to molten FLiBe is expected to be around 2 microns per year [1]. The initial MSRR salt will be purified and the molten salt will be kept under reducing conditions by the addition of active Be. Based on the expected corrosion rate as well as the corrosion allowance in design of various components, these components are not anticipated to need replacement during the operation of the MSRR.

References:

[1] J.R. Keiser, J.J. DeVan, and D.L. Manning, The Corrosion Resistance of Type 316 Stainless Steel to Li2BeF4, ORNL/TM-5782, 1977

RAI 2b. If it is necessary for ACU to acquire additional data to demonstrate the adequacy of the reactor system design, describe the scope of such data acquisition activities and state the purpose of any testing to be undertaken, how the data will be applied, and the schedule for acquisition of those data. Also, identify the criteria that will be used to determine that the data adequately represent or bound the materials and operating conditions of the MSRR.

Response: ACU will perform environmental compatibility testing which will examine samples of materials planned to be in contact with the MSRR fuel salt under different conditions expected during the lifetime of the MSRR. The scope of the environmental compatibility testing is described in Appendix B. ACU plans to complete the environmental compatibility testing before submitting the operating license application for the MSRR. Testing will investigate general corrosion by selective dissolution of active elements. That mechanism is strongly dependent on the redox potential of salt and impurities. Corrosion control in molten salt relies on the chemistry of the salt, with an emphasis on redox control of salt rather than formation of a passivating oxide layer. Therefore, the main concerns are selective oxidation and dissolution of alloying elements due to the presence of oxidants in the salt. Damage mechanisms that rely on corrosion can then be mitigated by managing selective corrosion in the molten salt environment. Further, the DMP will be used to address other degradation phenomena not limited to corrosion mechanics.

The resultant data will be used to determine the corrosion reaction kinetics, corrosion rates and tolerance, environmental influence on corrosion, and the withdrawal schedule for the material research coupons as part of the MSRR's research mission (the mentioned coupons are not part of a surveillance program). Data gained from the environmental compatibility testing will be used to verify conclusions drawn from literature.

Additionally, ACU's DMP is an active program that will incorporate and address data in an ongoing process. As the MSRR detailed design develops, the DMP will continue to be updated and used for evaluating any need for mitigation measures regarding degradation to SSCs within its scope. If the DMP identifies a need to conduct additional research, then ACU will plan and conduct the research as indicated by the DMP.

RAI 2c. If ACU will rely on in-service methods (e.g., periodic surveillance or inspection) to confirm that the reactor boundary system and RTMS integrity will be maintained over the operating life, please describe the approach including stating the criteria that ACU will use to determine the scope of the in-service methods, how pre-existing or to-be-acquired data will be used to inform the application of methods (e.g., techniques and frequency), and the criteria that ACU will use to demonstrate that the methods can adequately detect degradation prior to the loss of capacity for the affected components to perform their intended functions.

Response: ACU will mitigate degradation mechanisms by use of design, fabrication techniques, and operational strategies, when possible. The DMP will identify, if present, combinations of SSCs and degradation phenomena which cannot be mitigated by design, fabrication, or operational measures. In these cases, the DMP will identify appropriate monitoring and non-destructive examinations, or mitigation strategies to be implemented during the service life of the MSRR. These monitoring, NDE, or other strategies will be identified as part of the development of the detailed design and will be provided with the operating license application.

If there are further questions, please contact Benjamin.Beasley@acu.edu or Brazos.Fitch@acu.edu.

Recognizing that the responses above and the enclosures provide preliminary design information and that the final design may differ, I declare under penalty of perjury that the information is true and correct.

Executed on April 30, 2024.

Rusty Towell

Rusty Towell, PhD
Director of NEXT Lab

Enclosure: Appendices to RAI 2 Response

cc: Richard Rivera, Project Manager, NRR Advanced Reactor Licensing Branch 2
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