ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE
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February 9, 2016

Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION REGARDING THE APPLICATION FOR LICENSE RENEWAL (TAC NO. ME1587)

Sir:

By letter dated November 2, 2015, the Nuclear Regulatory Commission requested additional information necessary to allow processing of our research reactor license renewal application (License R-84, Docket 50-170). Answers to those questions are enclosed.

If you need further information, please contact Mr. Steve Miller at 301-295-9245 or stephen.miller@usuhs.edu.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge. Executed on February 9, 2016.

Stephen Miller
Reactor Facility Director

A020
NRR

REQUEST FOR ADDITIONAL INFORMATION

FOR THE LICENSE RENEWAL FOR

THE ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE

TRIGA REACTOR FACILITY

LICENSE NO. R-84

DOCKET NO. 50-170

1. NUREG-1537, Part 1, Section 13.1.2, "Insertion of Excess Reactivity," lists insertion-of excess-reactivity events, one of which is the ramp (slow) insertion of reactivity by drive motion of the most reactive control rod or shim rod, or ganged rods. Your RAI response dated April 20, 2012 (ADAMS Accession Nos. ML12122A146 and ML15296A451), as amended on September 21, 2012, (ADAMS Accession No. ML12272A303), stated that "The instantaneous insertion of $3.00 (2.1 % delta k/k) to the reactor core as a result of a worst case reactivity insertion is bounded by the analysis of the $3.50 (2.45% delta k/k) pulse limit and would not result in any adverse safety conditions within the AFRRI TRIGA core."

   Your response did not completely address a ramp insertion analyses. Provide a detailed ramp analysis identifying the maximum power level and fuel temperature experienced during the transient. Assume that the first scram, which would terminate the reactivity insertion, would fail in accordance with single failure criteria. Identify which reactor trip terminates the event and its associated response time, including the scram time of the control rods, in order to demonstrate the protection of the safety limit.

   The following information is offered in addition to the information submitted April 20,2012

   There are 2 redundant, independent power and scram channels. If the first scram channel failed, the second channel would terminate the reactivity insertion at the same power level, 1.09 MW(t). For this analysis, the 3 second period RWP is also ignored. There is a delay from the initiation of a scram to the insertion of a control rod of no more than 0.5 seconds. This is the time necessary to close relay contacts, and (in the case of a standard control rod) bleed the magnetic field from the rod drive magnetic coupling, and to bleed the air pressure (in the case of the transient rod drive.) The largest average insertion rate is the transient rod drive, 0.0997 $/sec. Starting at 1.0 MW(t), the reactor would reach the LSSS of 1.09 MW, a scram would initiate, and the control rod is assumed to continue driving out for .5 seconds, resulting in an additional reactivity insertion of $0.05, which would produce a positive period of 210 seconds. At t+.5 seconds when the insertion would be terminated and the rods all scrammed, the peak power would be 1,092,598.33 watts. The maximum temperature would be 415.66 degrees C assuming that peak power is reached immediately without delay before scramming the reactor. Similar analysis was performed for the remaining 3 control rods. (See table 2)

   Period and temperature were extrapolated from empirical data.

Table 1. (from original submitted document)

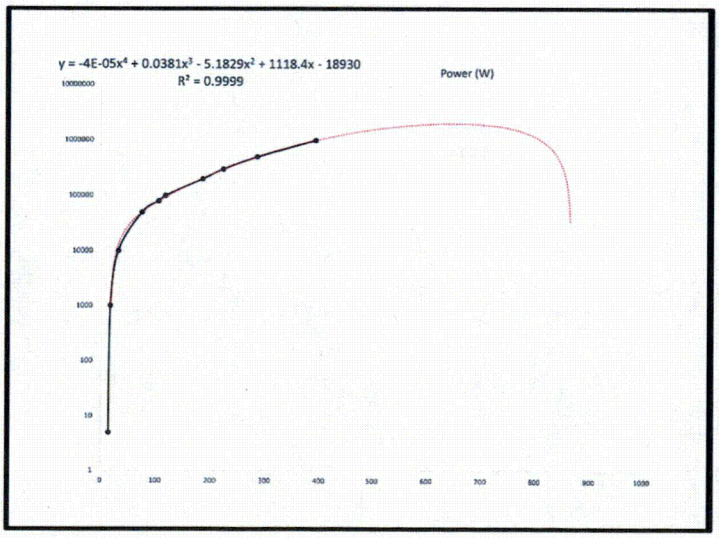
Rod	Total Worth ($)	Total Withdrawal Time (sec)	Average Insertion Rate ($/sec)
Transient	2.89	29	0.0997
Safety	2.65	39.4	0.0673
Shim	2.74	36.1	0.076
Regulating	3.01	34.8	0.0865

Table 2. Maximum power and temperature resultant from a ramp insertion from maximum demand power assuming scram initiates .5 seconds after initiation

Rod	$(0.5 sec)	Period(sec)	P(0.5 sec)	T(0.5 sec)
Transient	0.0499	210	1,092,598.33	415.66
Safety	0.0337	320	1,091,704.46	415.48
Shim	0.0380	280	1,091,948.17	415.53
Regulating	0.0433	230	1,092,372.14	415.60

The 2nd column, $(0.5 sec), is the Average Insertion Rate ($/sec) from Table 1 multiplied by 0.5 seconds.
The 3rd column, Period(sec), is the period in seconds from the In-Hour curve.
The 4th column, P(0.5 sec), is the power in watts at 0.5 seconds from a 1.09 MW start point.
The 5th column, T(0.5 sec), is the temperature in Celsius corresponding to the in the 4th column.

Figure 1. Temperature vs. power (hottest channel) fitted to a 5th order polynomial



2. The AFRRI proposed technical specifications (TS) 4.3, "Coolant Systems," Specification a., states that "The pool water temperature, as measured near the input to the water purification system, shall be measured daily, whenever operations are planned.'1 However, there is no requirement to calibrate the thermometer. Provide a TS surveillance requirement for calibrating the temperature measurement instrument or state why it is not necessary.

   The periodicity of thermocouple and RTD probe calibration is located within the maintenance procedures. Currently, the TRIGA TRAKER requires calibration Annually, NTE 15 months.

   Temperature probes vary and the calibration frequency will vary based upon stability, the type of probe, and the manufacturer's literature. The frequency required is listed clearly in the maintenance TRIGA TRAKER and shall be performed as required. Compliance with this requirement is inspected as an integral part of the NRC inspection program.

3. The AFRRI proposed TS 4.3, "Coolant Systems," Specification b., states, in part, that conductivity of the bulk water shall be measured monthly, not to exceed 6 weeks. The basis for this TS is "Based on experience, observation at these intervals provides acceptable surveillance of limits that ensure that fuel cladding corrosion and neutron activation of dissolved materials are minimized."

   NUREG-1537, Part 1, Appendix 14.1, Section 4.3, "Coolant Systems," Item (6) "Conductivity and pH," provides guidance that the conductivity and pH should be measured weekly. Monthly measurements are permitted if the reactor is shutdown for long periods of time and/or if justification is provided in the SAR.

   The stability of conductivity within the AFRRI TRIGA pool water system has been proven by more than 5 decades of operations. Furthermore, experience demonstrates that the conductivity of the pool water not vary with reactor usage. Additionally, corrosion is an extremely slow process, making daily/weekly measurements unnecessary. NUREG-1537, Part 1, Appendix 14.1, Section 4.3, "Coolant Systems," Item (6) "Conductivity and pH," provides guidance that the conductivity and pH should be measured weekly. ***Monthly measurements are permitted if the reactor is shutdown for long periods of time*** and/or if justification is provided in the SAR. Since conductivity is not a function of usage, and NUREG-1537 permits monthly measurements, then it should be acceptable to make measurements on a monthly basis, whether or not operations are planned.

4. NUREG-1537, Part 1, Appendix 14.1, Section 3.1, "Reactor Core Parameters," Item (6)(b), "TRIGA Fuel," provides guidance that the fuel matrix should not exceed 50 percent of its initial concentration. NUREG-1537, Part 1, Appendix 14.1, Section 4.1, "Reactor Core Parameters," Item (6), "Fuel Parameters," provides guidance that the SAR should justify the surveillance method and intervals which ensure that the limit is not exceeded. Provide a TS and surveillance for burnup limit which is consistent with the guidance in NUREG-1537, Part 1, or justify why no change is necessary.

   Tech Spec 3.7 e., FUEL PARAMETERS will be added

   e. The burnup of the uranium-235 in the UZrH fuel matrix shall not exceed 50 percent of the initial concentration.

The AFRRI core contains 87+3 elements. The quantity of uranium 235 contained within a standard 8.5 weight percent TRIGA fuel element is known. From 1964 through 2016, AFRRI has logged approximately 42 MWD on the current core. Assuming 1gm of fuel is consumed per MWD of operation, 42 grams of uranium 235 has been consumed. Assuming that the burn rate continues into the future, we will reach 50 percent burnup in 2140 years.

In addition, analysis shows that at approximately 80 MWD, excess reactivity will have diminished to the point where we will no longer be able to maintain power and will be forced to either recore or shut down, so that the issue of burnup is self-limiting.

Table 4.8 From chapter 4 of the SAR demonstrates excess reactivity loss as a function of burnup.

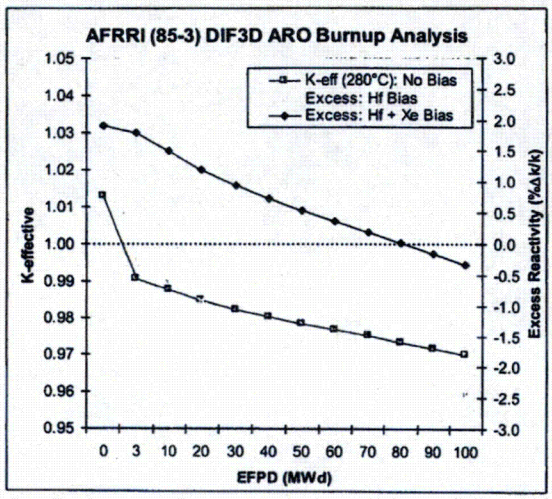


Figure 4-8 The excess reactivity as a function of burnup for 85-3 Core

5. The AFRRI proposed TS 1.25 "Reference Core Condition," provides a value of $0.30 for Xenon reactivity. Given that the reactivity required to satisfy the AFRRI shutdown margin (SOM), TS 3.1.3, "Reactivity Limits," Specification b., is $0.50, in the Reference Core Condition, the resulting SOM reactivity could be as low as $0.20. This is not consistent with the guidance in NUREG-1537, which provides a value of $0.50 SOM reactivity.

   Provide justification for proposed TS 1.25, "Reference Core Condition," by proposing a TS 3.1.3, "Reactivity Limits," Specification b., SOM reactivity limit that is consistent with the SOM guidance in NUREG-1537, revise TS 1.25 "Reference Core Condition," or demonstrate that control rod worth can be determined by within $0.20.

   The definition of Reference Core Condition will be changed to read … "worth of Xenon is negligible (<$0.01)."

6. Your letter dated March 30, 2015 (ADAMS Accession No. ML15093A099), revising your TS deleted TS 3.8, "ALARA." Your TS 6.1.2, "Responsibility," states "The Radiation Safety Officer shall implement a radiation protection program at AFRRI that satisfies the

requirements of 10 CFR Part 20." Provide a justification for the deletion of TS 3.8.

10CFR20 requires that every licensee maintain an ALARA program. 10CFR20 requirements must be met regardless of the Technical Specifications, and also apply to the other AFRRI licenses, making the citation in the TS redundant and superfluous.

7. AFRRI proposed TS. 3.3, "Coolant Systems," state the following: "The reactor shall not be operated above a thermal power of 5 kW when the purification system inlet water temperature exceeds 60°C;" however, your thermal hydraulic analysis was performed at 45°C. Provide a thermal hydraulic analysis at 60°C, or modify your TS to be consistent with the thermal hydraulic analysis previously provided. Provide justification for the 5kW power limit when water temperature is above 60°C or remove the limit from the TS.

   TS 3.3 will be modified to read "The reactor shall not be operated above a thermal power of 5 kW when the core outlet temperature exceeds 60°C;" The temperature rise across the core at full power is approximately 15°C . This modification will ensure that water at the core inlet will not exceed 45°C while the reactor is operating at 1.0 MW

8. The AFFRI proposed TS 4.0, "Surveillance Requirements" states that "any surveillance requirements that cannot be performed due to a reactor outage shall be performed prior to resuming normal reactor operations." Specify which requirements fall into this category or justify why it is not necessary.

   As the technical specifications state, no maintenance will be deferred unless an outage prevents maintenance from being performed. Since all possible equipment failures which could affect the reactor include items that have not yet occurred and yet more items that are out of the reactor facility's control (i.e. power failure), a comprehensive and all inclusive list of all possible failures of equipment within and external to the facility is also not practical.

   We can list several examples of failures that could prevent completion of a maintenance item for example only; Console computer failure for example would prevent fuel measurement because we cannot monitor reactivity changes with the console down. Similarly, there are a myriad of calibrations that cannot be completed if the control console (CSC or DAC) are not fully functional such as NM1000, NP, NPP, Fuel Temperature, etc.

   Surveillance requirements are inspected during the normal inspection cycle and anomalies will be noted in the facility logs.

9. ANSI/ANS 15.1-2007, Section 6.2.3, "Review Function," states "A written report or minutes of the [review] findings and recommendations of the review group shall be submitted to Level 1 and the review and audit group members in a timely manner after the review has been completed." Your TS Section 6.2.4, "Review Function," does not have such a requirement. Your Section 6.2.3.5, "Minutes," states that "Minutes of the previous meeting should be available to regular members at least one week before a regular scheduled meeting," however, in TS 6.2.1.1.a.1, the Level 1 is not a regular member. Explain the procedures by which the Level 1 is provided review findings in a timely manner.

   TS 6.2.3.5 will be modified to read:

   "a. Draft minutes of the previous meeting should be available to regular members at least

one week before a regular scheduled meeting, "

"b. Once approved by the committee, final minutes will be submitted to level one management for review."

10. The AFFRI proposed TS 6.3, "Procedures," specifies, in part, "written instructions for certain activities shall be approved by the Reactor Facility Director and reviewed by the RRFSS," but does not indicate if the procedures are required to be used and followed to ensure effective procedure adherence. Revise TS 6.3 to include instructions for using these procedures or justify why no change is necessary

    TS 6.3 shall be modified to read as follows:

    Original text:

    Written instructions for certain activities shall be approved by the Reactor Facility Director and reviewed by the RRFSS. The procedures shall be adequate to ensure safe operation of the reactor, but shall not preclude the use of independent judgment and action as deemed necessary. These activities are as follows:

    Modified text:

    Written instructions for certain activities shall be approved by the Reactor Facility Director and reviewed by the RRFSS. The procedures shall be adequate to ensure safe operation of the reactor, but shall not preclude the use of independent judgment and action as deemed necessary. Operating procedures shall be used for the following items:

14. The AFRRI proposed TS 6.4, "Review and Approval of Experiments," provides requirements for new experiments or experiments not included in a Routine Reactor Authorization. However, the TS does not include a review in accordance with TS 3.6, "Limitations on Experiments." Revise TS 6.4 to add the review requirements associated with TS 3.6, or justify why no changes are necessary.

    Current Text:

    Before issuance of a reactor authorization, new experiments shall be reviewed for radiological safety and approved by the following:

    a. Reactor Facility Director

    b. Health Physics Department

    c. Reactor and Radiation Facilities Safety Subcommittee (RRFSS)

Prior to its performance, an experiment shall be included under one of the following types of authorizations:

a. Special Reactor Authorization for new experiments or experiments not included in a Routine Reactor Authorization. These experiments shall be performed under the direct supervision of the Reactor Facility Director or designee.

b. Routine Reactor Authorization for approved experiments safely performed at least once. These experiments may be performed at the discretion of the Reactor Facility Director and coordinated with the Health Physics Department, when appropriate. These authorizations do not require additional RRFSS review.

c. Reactor Parameters Authorization for routine measurements of reactor parameters, routine core measurements, instrumentation and calibration checks, maintenance, operator training, tours, testing to verify reactor outputs, and other reactor testing procedures. This shall constitute a single authorization. These operations shall be performed under the authorization of the Reactor Facility Director or the Reactor Operations Supervisor.

Substantive (> $0.25) changes to previously approved experiments shall be made only after review by the RRFSS and after approval (in writing) by the Reactor Facility Director or designated alternate. Minor changes that do not significantly alter the experiment (<$0.25) may be approved by the Reactor Operations Supervisor. Approved experiments shall be carried out in accordance with established procedures.

Revised Text:

Before issuance of a reactor authorization, new experiments shall be reviewed for radiological safety and approved by the following:

a. Reactor Facility Director

b. Health Physics Department

c. Reactor and Radiation Facilities Safety Subcommittee (RRFSS)

Prior to its performance, an experiment shall be included under one of the following types of authorizations:

a. Special Reactor Authorization for new experiments or experiments not included in a Routine Reactor Authorization. These experiments shall be performed under the direct supervision of the Reactor Facility Director or designee.

b. Routine Reactor Authorization for approved experiments safely performed at least once. These experiments may be performed at the discretion of the Reactor Facility Director and coordinated with the Health Physics Department, when appropriate. These authorizations do not require additional RRFSS review.

c. Reactor Parameters Authorization for routine measurements of reactor parameters, routine core measurements, instrumentation and calibration checks, maintenance, operator training, tours, testing to verify reactor outputs, and other reactor testing procedures. This shall constitute a single authorization. These operations shall be performed under the authorization of the Reactor Facility Director or the Reactor Operations Supervisor.

Substantive (> $0.25) changes to previously approved experiments shall be made only after review by the RRFSS and after approval (in writing) by the Reactor Facility Director or designated alternate to ensure that the change does not impact compliance with TS. 3.6, LIMITATIONS ON EXPERIMENTS. Minor changes that do not significantly alter the experiment (<$0.25) may be approved by the Reactor Operations Supervisor. Approved experiments shall be carried out in accordance with established procedures.

15. Pursuant to 10 CFR 50.33(f) (2), "[t]he applicant shall submit estimates for total annual operating costs for each of the first five years of operations of the facility." Since the information included in the previous correspondence was for the period of fiscal years (FYs) 2013 through 2018, please provide the following additional information:

a) Projected operating costs of the AFRRI facility for each of the FY2016 thru FY2021 (the first five year period after the projected license renewal). If the cost estimates have not changed since the previous submittal for the period of FY2013 through FY2018, please so state.

Cost estimates have not changed since the previous submittals for the period of FY2013 through FY2018

b) Has the source(s) of funding to cover the operating costs for FYs 2016 to 2021 changed since the August 13, 2010, submittal?

The source of funding has not changed.

16. By letter dated August 13, 2010, you provided an updated decommissioning cost estimate for the facility that was developed using NUREG/CR-1756, "Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors." The decommissioning cost estimate was $14.831 million in 2011 dollars. The cost estimate summarized costs by labor, radioactive wastes disposal, energy, and a 25-percent contingency factor.

(a) Please indicate if the basis for how the cost estimate was developed has changed. If NUREG/CR-1756 is still the basis, please so state.

The basis for how the cost estimate was developed is still NUREG/CR-1756

(b) Please indicate if there are any changes to the means of adjusting the cost estimate and associated funding level periodically over the life of the facility.

There have been no changes to the means of adjusting the cost estimate and associated funding level over the life of the facility

17. AFRRI provided a Statement of Intent (SOI), dated August 11, 2010, stating that "[f]unding will be sought from the [U.S.] Department of Defense in accordance with established programming and budgeting procedures," per 10 CFR 50.75(e)(1)(iv).

(a) Please indicate if there have been any changes to the SOI and if decommissioning funding obligations of the AFRRI facility continue to be backed by the full faith and credit of the U.S. Government.

There has been no change to the SOI. Decommissioning funding obligations of the AFRRI facility continue to be backed by the full faith and credit of the U.S. Government.