March 8, 2010

Mr. Stephen Frantz, Director
Reed Reactor Facility
Reed College
3203 S.E. Woodstock Boulevard
Portland, OR 97202-8199

SUBJECT: REED COLLEGE - REQUEST FOR ADDITIONAL INFORMATION REGARDING THE REED COLLEGE TRIGA REACTOR LICENSE RENEWAL (TAC NO. ME1583)

Dear Mr. Frantz:

The U.S. Nuclear Regulatory Commission (NRC) is continuing the review of your application for renewal of Facility Operating License No. R-112 for the Reed College Research Reactor (RRR) dated August 29, 2007 as supplemented January 26, 2010 During our review, questions have arisen for which we require additional information and clarification. Please provide responses to the enclosed request for additional information within 60 days after the date of this letter. In accordance with Title 10 of the *Code of Federal Regulations* Part 50.30(b), your response must be executed in a signed original under oath or affirmation.

If you have any questions regarding this review, or need additional time to respond to this request, please contact me at 301-415-0894 or by electronic mail at francis.dimeglio@nrc.gov.

Sincerely,

/RA by Kathryn M. Brock for/
A. Francis DiMeglio, Project Manager
Research and Test Reactors Licensing Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-288

Enclosure:
As stated

cc w/encl: See next page

cc:

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Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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OFFICE	PRLB: PM *	PRPB: LA	PRLB: BC	PRLB: PM
NAME	AFDiMeglio	GLappert	KBrock	AFDiMeglio (KBrock for)
DATE	2/16/10	3/8/10	3/8/10	3/8/10

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OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ADDITIONAL INFORMATION

REED COLLEGE

REED RESEARCH REACTOR

LICENSE NO. R-112

DOCKET NO. 50-288

The U. S. Nuclear Regulatory Commission (NRC) staff is continuing the review of your application for renewal of Facility Operating License No. R-112, dated August 29, 2007, *Safety Analysis Report for the Reed College, Reed Research Reactor* (2007 SAR) as supplemented January 26, 2010. During our review, questions have arisen for which we require additional information and clarification. Our review conformed to the Guidelines for Preparing and Reviewing Applications for the Licensing of Non-power Reactors, NUREG 1537, Part 1 and the Interim Staff Guidance on the Streamlined Review Process for Research Reactors. Please address and provide the requested information to the following:

1. NUREG-1537, Part 1, Section 1.4, Shared Facilities and Equipment, states the applicant should consider whether the loss of any shared facilities or equipment could lead to a loss of function that would lead to an uncontrolled release of radioactive material, or if released, are analyzed and found to be acceptable. The 2007 SAR, Section 1.4 discusses this subject. However, the discussion is incomplete in that it does not include the loss of electricity and how it would affect the release of radiation should it coincide with the loss of fuel cladding integrity. Please provide this information including the loss of alarms, automatic isolation, operation of heating, ventilation, and air conditioning (HVAC) systems, etc. Please provide information concerning whether the analysis provided in Chapter 13 envelopes this condition.

2. NUREG-1537, Part 1, Section 1.5, Comparison With Similar Facilities states the applicant should use pertinent information from other reactors and this information can be used to compare the safety envelope of Reed Research Reactor (RRR) and to support analysis in appropriate chapters of the SAR. The 2007 SAR discusses this, but the information is incomplete. Please provide a comparison of the RRR to other TRIGA facilities so as to characterize the degree to which generic information or operational experience from other reactor facilities is applicable.

3. NUREG-1537, Part 1, Section 2.2, Nearby Industrial, Transportation, and Military Facilities, states information on nearby military facilities be included in the SAR. The 2007 SAR, Section 2.2 discusses industrial and transportation facilities but does not discuss military installations. Please provide information concerning the nearby military installations.

4. NUREG-1537, Part 1, Section 3.1, Design Criteria, states the applicant should identify the design criteria that are applicable to each structure, system and component that performs a safety function. The 2007 SAR, Section 3.1 briefly addresses this matter and

states “the original reactor installation in 1968 used fuel and components manufactured by General Atomics (GA), and the specifications to-which structures were built were those stated by GA. Specific design criteria were not stated. All building modifications and equipment additions were in conformance with the building codes in existence at the time.” Please provide the criteria applicable to the original design and construction and to subsequent modifications to the design and construction.

5. NUREG-1537, Part 1, Section 3.3, Water Damage, requires the applicant identify the potential for flooding which could prevent structures, systems and components from performing their safety function. The 2007 SAR, Section 3.3 states “As discussed, in Chapter 2, the flood plain of the local rivers does not come near the reactor site. However, even if flooding occurred, reactor safety would not be an issue since the core is located in a water pool.” However, this information is incomplete. Please provide information that demonstrates that should flooding occur, it will not prevent operation of the RRR safety systems.

6. NUREG-1537, Part 1, Section 3.5, Systems and Components, states the applicant should identify the bases or design features of the electromechanical systems that are used to ensure safe operation and shutdown of the reactor during all conditions. The 2007 SAR, Sections 3.5 and 3.6 provide some information on this topic but do not provide information on the design features of the control rods (e.g., fail safe in the event of loss of power) or the systems associated with reactor operation and safety (e.g., power level scrams, interlocks to limit reactivity insertion). Please provide the design for electromechanical systems and components required for operation, shutdown and to maintain shutdown.

7. NUREG-1537, Part 1, Section 4.2.1, Reactor Fuel, states the applicant should describe the fuel elements used in the reactor including detailed design information. References should be provided to demonstrate that the design basis assures that integrity of the fuel is maintained under all conditions assumed in the safety analysis. The description should also include information necessary to establish limiting conditions beyond which fuel integrity would be lost. The 2007 SAR, Sections 1.3.3, 4.2.4 and 4.2.5 which provide some information are incomplete. Please discuss the differences in fuel length for the aluminum and stainless steel clad fuel utilized in the core and the implications of these differences on analysis. In addition, please address mechanical forces and stresses, corrosion and erosion of cladding, hydraulic forces, thermal changes and temperature gradients, and internal pressures from fission products and the production of fission gas. Include in the analyses the impact of radiation effects, including the maximum fission densities and fission rates that the fuel is designed to accommodate.

8. NUREG-1537, Part 2, Section 4.2.2 states the control rods should be sufficient in number and reactivity worth to comply with the 'single stuck rod' criterion; that is, it should be possible to shut down the reactor and comply with the requirement of minimum shutdown margin with the highest worth scrammable control rod stuck out of the core. The control rods should also be sufficient to control the reactor in all designed operating modes and to shut down the reactor safely from any operational condition.

   The control rods, blades, followers (if used), and support systems should be designed conservatively to withstand all anticipated stresses and challenges from mechanical,

hydraulic, and thermal forces and the effects of their chemical and radiation environment.

The control rods should be designed so that scramming them does not challenge their integrity or operation or the integrity or operation of other reactor systems.

The 2007 SAR, Sections 4.2.7, 4.2.8 and 4.2.9, while providing some of this information, is incomplete. The SAR does not provide the worths of the 3 RRR control rods. Please provide calculated and measured control rod worths under all conditions of operation. Please determine if control rod withdrawal insertion limitation limits (rod position vs. power) are necessary to preserve assumptions in the departure from nucleate boiling ratio (DNBR) analysis.

9. NUREG-1537, Part 1, Section 4.2.3, Neutron Moderator and Reflector, states the applicant should describe reflectors and moderators designed into the core and their special features. The 2007 SAR, Sections 4.2.2 and 4.2.6 RRR provides a discussion of the radial reflector and the graphite reflector elements; however, it does not provide any information pertaining to the naturally circulating water which is also a moderator/reflector. Please provide a description of the water moderator and reflector and an assessment of the function and importance of the moderator and the effect of loss of moderator on the behavior of the reactor core during operations.

10. NUREG-1537, Part 1, Section 4.2.4 Neutron Startup Source, states the applicant should describe the neutron source used for reactor startup. The 2007 SAR, Section 4.2.10 provides a description of the neutron source holder only. Please review the cited requirement and then supply a revised description of the neutron source in use at RRR including the following:

- type of neutron source including information on neutron startup material
- type of nuclear reaction
- energy spectra of neutrons
- source strength
- interaction of the source and holder, while in use, with the chemical,
- thermal, and radiation environment
- design features that ensure the function, integrity, and availability of the source

11. NUREG-1537, Part 1, Section 4.2.5, Core Support Structure, states the applicant should describe structural performance of the core support structure under all reasonable conditions. Furthermore, it is required that the design basis, operational analysis and safety considerations should be provided for each reactor component placed on the grid plate. The 2007 SAR, Sections 4.21 and 4.23, while providing some of this information, are incomplete. Please provide information demonstrating the adequacy of the core support structure under flooded and empty tank conditions to support all required components under all operating conditions.

12. NUREG-1537, Part 1, Section 4.3, Reactor Tank or Pool, states the applicant should describe the reactor tank and associated components and provide assurances regarding those components to perform their intended function free from any problems associated

with chemical interactions, failure of penetrations and welds that could lead to loss of coolant, and to propose TS that impose limiting conditions. In addition, the applicant should assess the possibility of uncontrolled leakage of contaminated coolant and should discuss detection, preventive and protective measures. The 2007 SAR, Section 4.1, while providing some of this information (e.g., a physical description), is incomplete. Please provide information regarding loss of water through failure in the tank including detection methods and consequences, chemical compatibility of components, resistance to corrosion, suitability of penetrations below the normal coolant level, and propose TS applicable to these topics.

13. NUREG-1537, Part 1, Section 4.4, Biological Shield, states the applicant should describe the biological shied employed to ensure doses are in conformance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20. The 2007 SAR does not provide a characterization of the biological shield. Please provide a description of the biological shielding employed at RRR including consideration of concrete, tank structure and pool water.

14. NUREG-1537, Part 1, Section 4.5, Nuclear Design, states the applicant should discuss normal operating conditions, reactor core physics parameters and operating limits. The discussion should include a discussion of the complete, operable core; control rod worths; kinetic parameters; excess reactivities; shut down margins; and flux distribution or all planned configurations for the life of the core.

    The 2007 SAR, Subsection 4.6.1 states:

    > *"General Atomics utilized a mixed core of stainless steel and aluminum-clad fuel from 1960 when they were first authorized to use a limited number of stainless steel clad together with aluminum-clad elements until cessation of operations. The mixture was authorized as long as fuel temperature in the mixed aluminum and stainless steel core did not exceed 550 C (1022 F). … Consequently, since a mixed core of aluminum and stainless steel was used in the Mark I reactor for more than 35 years at a thermal power greater than the RRR reactor, it is concluded that the health and safety of the public will not be endangered by operating with mixed stainless steel and aluminum fuel."*

    The GA reactor cited was analyzed and licensed based on particular neutronic and thermal-hydraulic conditions pertinent to that reactor. RRR needs to establish the basis for incorporating the GA conclusions into the RRR SAR.

    In addition:

    The 2007 SAR, Subsection 4.6.2.1 (Excess Reactivity) discusses limiting RRR to +$3.00 of core reactivity to prevent excessive fuel temperatures. However, the excess reactivity of RRR has not been established in the SAR.

    The 2007 SAR, Subsection 4.6.2.2 (Shutdown Margin) lists the shutdown margin Technical Specification requirement. However, the ability to meet this requirement is not presented in the SAR.

The 2007 SAR, Subsection 4.6.2.3 (Reactivity Limits on Experiments) states that limiting reactivity insertions from experiments to -$1.00 will prevent sudden removals from causing excessive fuel temperatures. However, there is no analysis demonstrating this in the SAR.

The 2007 SAR, Subsection 4.6.3 (Stainless Steel Clad Fuel) assumes that there is no neutronic difference between the aluminum and the stainless steel clad fuel. However, there is no analysis establishing this and the stainless steel clad fuel meat is longer by 1 inch and stainless steel is neutronically different from aluminum

Please provide the information that addresses the stated points and that provides core physics parameters consistent with the NUREG citation.

15. NUREG-1537, Part 1, Section 4.5.2, Reactor Core Physics Parameters, states the applicant should describe reactor core physics parameters that determine operating characteristics as they are influenced by reactor design including:

- methods used to neutronically characterize the RRR,
- uncertainties required to apply calculated results to the RRR operation,
- methods to calculate kinetics parameters,
- coefficients of reactivity applicable to the RRR,
- comparisons with measurements to demonstrate the effectiveness of the methods employed, and
- changes in reactivity coefficients that result from changes to core configurations.

The 2007 SAR, Section 4.6, does not provide this information. Please provide this information regarding methods, uncertainties, comparisons and all required technical parameters.

16. NUREG-1537, Part 1, Section 4.5.3, Operation Limits, states that the applicant should describe operating limits including those nuclear design features necessary to ensure safe operation and shutdown, namely:

- temperature coefficients or reactivity, void coefficients, Xe-Sm worths, power coefficients (if not otherwise accounted for), and the influence of experiments,
- minimum control rod worths and stuck rod worths for all allowed core conditions,
- transient analysis of an uncontrolled rod withdrawal,
- shutdown margin calculations for limiting core conditions, and
- technical specification implemented to ensure safe operation.

The 2007 SAR, Section 4.6 describes some of these limits but is incomplete. Please provide information specific to the RRR regarding methods, uncertainties, comparisons and all technical parameters as identified in NUREG 1537.

NUREG-1537, Part 1, Section 4.6, Thermal-Hydraulic Design states the applicant should describe operating limits on cooling conditions necessary to prevent fuel overheating and to ensure that fuel integrity will not be lost under any reactor conditions including

accidents. Technical characteristics are that the DNBR limit of 2 is never violated and flow instability may not contribute to a loss of fuel cooling under any conditions. The 2007 SAR, Section 4 does not provide this information. Please provide information regarding methods, uncertainties, and results of a DNB analysis showing that the safety limits proposed will never violate the limits stated. Please provide information concerning restrictions on pool temperature, inlet temperature, adequacy of bottom grid geometry, spacer geometry, and nuclear issues such as peaking factors, rod insertion limits, delay times, and measurement uncertainties affecting DNB analysis.

17. NUREG-1537, Part 1, Section 5, Reactor Coolant Systems, states the applicant should demonstrate that the system can remove the fission and decay heat from the fuel during reactor operation and decay heat during reactor shutdown. The 2007 SAR Section 5 describes the reactor coolant systems but is incomplete because it does not discuss the capability of the systems. Please provide a discussion of the capability of the cooling systems.

18. NUREG-1537, Part 1, Section 5.2, Primary Coolant System, states the primary coolant should provide a chemical environment that limits corrosion of fuel cladding, control and safety rod surfaces, reactor vessels, and other essential components. The 2007 SAR, Section 5.2 describes components of a system to control coolant conductivity and pH without describing the objectives stated. Please provide and justify the value of electrical conductivity and pH that is used for controlling and maintaining chemical environment in the primary coolant system.

19. NUREG-1537, Part 1, Section 5.3, Secondary Coolant System, states the applicant should discuss the secondary coolant system recognizing that some non-power reactors are designed with secondary coolant systems that will not support continuous reactor operation at full licensed power. This is acceptable, provided the capability and such limiting conditions as maximum pool temperature are analyzed in the SAR and included in the TS. The 2007 SAR, Section 5.3, while discussing the secondary coolant system, inadequately discusses the capabilities of the secondary coolant system and the bases of the TS on maximum pool temperature. Please provide information on heat load as it pertains to the secondary coolant system and review Technical Specification 3.8 which states that the basis for the pool temperature limit is protection of the resin beds and does not address the limits on pool temperature.

20. NUREG-1537 guidance states in Section 5.4, Primary Coolant Cleanup System, the applicant needs to ensure that when operating the system, exposure and release of radioactivity do not exceed the requirements of 10 CFR Part 20 and are consistent with the facility ALARA program. The 2007 SAR, Section 5.2.4 does not address the consistency of the cleanup system with the ALARA program. Please provide information that operation of the cleanup system does not challenge the commitment of the ALARA program of RRR.

21. NUREG 1537, Part 1, Section 5.5, Primary Coolant Makeup Water System, states the applicant needs to ensure that: the makeup water system or plan should include provisions for recording the use of makeup water to detect changes that indicate leakage or other malfunction of the primary coolant system. The 2007 SAR, Sections 5.26 and 5.4, while discussing aspects of the detection system, is incomplete in that it does not

provide information concerning the provisions or plans to indicate leakage or other malfunction of the primary coolant system. Please provide information concerning provisions and plans to detect abnormal leakage in the primary system.

22. NUREG-1537, Part 2, Section 5.6, Nitrogen-16 Control System, states the applicant should confirm the amount of nitrogen-16 (N^{16}) predicted by the SAR analysis at the proposed power level and the potential personnel exposure rates, including exposures from direct radiation and airborne N^{16}. The 2007 SAR, Section 5.5, describes the N^{16} control system but provides no information on confirmation of effectiveness and exposure rates. Please provide information concerning the amount of N^{16} produced during operation at full power and the resulting personnel exposures.

23. NUREG-1537, Part 1, Section 9.1, Heating, Ventilation, and Air Conditioning Systems, states the applicant should consider modes of operation and features of the HVAC system designed to control (contain or confine) reactor facility atmospheres, including damper closure or flow-diversion functions, during the full range of reactor operation. The 2007 SAR, Section 9.1, describes the general features of the HVAC system but does not describe how isolation is initiated, the set-points used, or the TS governing the use and testing of the system. Please provide information concerning the HVAC and address the above.

24. NUREG-1537, Part 2, Section 9.2. Handling and Storage of Reactor Fuel, states the applicant should consider the methods, analyses, and systems for secure storage of new and irradiated fuel that will prevent criticality (k_{eff} not to exceed 0.80) under all conditions of moderation during storage and movement. The 2007 SAR, Section 9.2 states that the spacing in the rack is sufficiently far apart to prevent accidental criticalities. However, analysis supporting this statement is not provided or referenced. Please provide this information for the fuel rack design.

25. NUREG-1537, Part 1, Section 9.3, Fire Protection Systems and Programs, states the applicant needs to discuss fire protection systems and plans that would affect reactor safety systems. The 2007 SAR, Section 9.3, discusses this issue. However, there is no discussion of the sources of fire or expected outcomes that would affect safety systems. Fire barriers protecting safety systems are not discussed. Please provide information regarding fire sources and outcomes consistent with the guidance.

26. NUREG-1537, Section 9.7, Other Auxiliary Systems, states the applicant should discuss auxiliary systems that are not fully described in other sections that are important to the safe operation and shutdown of the reactor, and to the protection of the health and safety of the public, the facility staff, and the environment. The 2007 SAR, Section 9.7.1, discusses a reactor bay crane. However, there is no discussion regarding prohibiting the movement of heavy objects over the reactor core. Nor is there discussion regarding operating procedures, load testing and required maintenance and surveillances of the crane. Please provide information relating to crane limitations (if any) and procedures for using and parking the crane.

27. NUREG-1537, Part 2, Section 10.1, Summary Description, states the applicant should discuss:

- limiting experimental characteristics (e.g., reactivity, contents)
- monitoring and control of the experiments and the interaction between the experiment and the reactor control and safety systems
- design requirements for the experiment and the review and approval process.

The 2002 SAR, Section 10.1 presents a summary description. However, the information provided is not in sufficient detail to enable conclusions to be drawn regarding the safe operation of the experimental facilities. Please provide a description of the principal features of the experimental and irradiation facilities including experimental limitations

28. NUREG-1537, Part 1, Section 10.2, Experimental Facilities, states the applicant should discuss the experiment safety system and the functional interface between the experimental safety system and the reactor protection system. The 2007 SAR, Section 10.2 discusses the experimental facilities. However, the discussion only addresses physical features and does not provide any information regarding safety, assurance of independence, or compliance with requirements. Please provide information regarding the interface between reactor safety systems and experiment safety systems. Provide information on design requirements and how the design requirements are met.

29. NUREG-1537, Part 1, Section 10.3, Experiment Review, states the experiment review committee should have the appropriate scope of responsibility, including the review of procedures that pertain to the use of experimental facilities. The 2007 SAR, Section 10.3 does not state this authority for the Reactor Review Committee and the scope of the Committee's review appears to be limited. Please provide information on the Committee's authority to review and approve procedures including procedures for the experimental facilities.

30. NUREG-1537, Part 1, Section 11.1.1, Radiation Sources, states that the applicant should present the best estimates of the maximum annual dose and the collective doses for major radiological activities during the full range of normal operations for facility staff and members of the public. The doses shall be shown to be within the applicable limits of 10 CFR Part 20. The 2007 SAR, Section 11.1.1.1 provides calculations, using maximizing assumptions, that result in values greater than the applicable limits in 10 CFR Part 20, Appendix B. Please provide the results of best estimate calculations that demonstrate compliance with 10 CFR Part 20, Appendix B.

31. NUREG-1537, Part 1, Section 11.1.2, Radiation Protection Program, guidance states program procedures need to establish clear lines of responsibility and clear methods for radiation protection under normal and emergency conditions. Also, procedures should be organized and presented for convenient use by operators and technicians at appropriate locations, and should be free of extraneous material. The 2007 SAR, Section 11.1.2, provides a description of the program and, the attached Radiation Protection Plan, references procedures used for various activities concerning radiation protection. However, the other NUREG-1537, Part 1 attributes cannot be established from review of the SAR. Please provide information which shows that clear lines of responsibility and clear methods for radiation protection are established for normal and emergency conditions.

32. NUREG-1537, Part 1, Section 11.1.2, Radiation Protection Program, and Section 11.1.5, Radiation Exposure Control and Dosimetry, guidance states the radiation protection program records management system should include records such as ALARA program records, individual occupational dose records, monitoring and area control records, monitoring methods records, and training records. The 2007 SAR, Section 11.1.2 provides a description of the program including management, administration, and training. Section 11.1.5 provides information regarding exposure records. However, the other required attributes have not been discussed. Please provide information concerning the maintenance of records and that demonstrate acceptance with the above criteria.

33. NUREG-1537, Part 2, Section 11.1.4, Radiation Monitoring and Surveillance, states the bases of the methods and procedures used for detecting contaminated areas, materials, and components should be clearly stated. The 2007 SAR provides the surveillance frequency for contamination as biweekly for the reactor bay, control room, and facility. Section 5 of the RRR Administrative Procedures for Handling, Storage, and Disposal of Radioactive Material indicates that the operator shall keep a record of the radiation level of the specimen when removed from the reactor. However, the procedures do not address possible contamination of the sample. Please provide any additional bases or methods that are used for detecting contaminated materials and components, including the measures taken to ensure experimental samples being removed have not become contaminated.

34. NUREG-1537, Part 1, Section 11.1.4, Radiation Monitoring and Surveillance, states the bases of the methods and procedures used for detecting contaminated areas, materials, and components should be clearly stated. The 2007 SAR, Section 11.1.4 provides a brief discussion of monitoring equipment and Table 11.10 of the 2002 SAR provides a listing of typical monitoring equipment. However, the methods and procedures used for detecting contaminated areas, materials, and components cannot be learned from the information provided. Please provide information on the methods and procedures for sampling and monitoring air, liquids, solids, and reactor radiation beams and effluents.

35. NUREG-1537, Section 11.1.6, Contamination Control, states the contamination control program should include provisions to avoid, prevent and remedy the occurrence and spread of contamination. The 2007 SAR, Section 11.1.6 provides the most likely sites of contamination and the measures taken to minimize the spread of contamination. This section also states that staff and visiting researchers are trained on the risks of contamination and techniques for avoiding, limiting and controlling contamination. However, contamination of personnel is not addressed. Please describe the means for addressing personnel contamination, if it should occur.

36. NUREG-1537, Part 1, Section 13.1.1, Maximum Hypothetical Accident, guidance states the applicant needs to present a methodology for reviewing the systems and operating characteristics of the reactor facility that could affect its safe operation or shutdown. The methodology should be used to identify limiting accidents, analyze the evolution of the scenarios, and evaluate the consequences. The 2007 SAR, Section 13.2.1 discusses the Maximum Hypothetical Accident (MHA) and provides the method and assumptions used to estimate potential consequences from an MHA and discusses compliance with

10 CFR Part 20. However, the discussion is not complete and requires further clarifications.

Please provide the following information:

a. Provide the approach used in determining the average thermal reactor power over 40 years.

b. Given a thermal power of 250 kw operating 8 hours per day, 5 successive days, provide the method to show the average utilization (kw-hr/day) indicated in the SAR.

c. In Chapter 4 Section 4.2.4 and in Figure 4.4 of the 2002 SAR, fuel rods with various Uranium 235 (U^{235}) contents have been described. In addition, the U^{235} content of fuel rods will vary because of burn-up. This would indicate the presence of different power level per rod, affecting the estimate for a peak rod power level. Provide clarification on the method used for assigning a peaking factor of 2.

d. Subsection 13.2.1.2, Radionuclide Inventory Buildup and Decay, describes a power level and number of fuel rods that is inconsistent with those provided in the preceding subsection. Please clarify.

e. Subsection 13.2.1.2 contains a subsection, Data from ORIGEN Calculations. The text refers to values in Appendices A and B where as there are Appendices A through F in this section. Please clarify.

f. In Chapter 13, Appendix B, the heading indicates an ORIGEN input for irradiation at “1 watt 8 hours per day for 5 days”. Should this be irradiation at “1 kw 8 hours per day for 5 days?” Please clarify.

g. In Chapter 13, Appendix D, the heading indicates an ORIGEN input for irradiation at “1 watt 8 hours per day for 5 days”. Should this be irradiation at “1 kw 8 hours per day for 5 days?”

h. In Chapter 13, Appendix E, there is confusion concerning the number of fuel rods. Please clarify.

i. In Chapter 13, Appendices E and F, it is not clear how the values are produced from those provided in Appendices C and D. Please provide an example of the method used. In addition, the headings for data presented in Appendices E and F do not appear to be correct. Please clarify.

j. Chapter 13, Table 13.5 provides values in the third column (A, activity (μCi)) of the released curies. Discuss the method used to determine these values. It appears that the values given in this column are 2.5 times less than those given in Tables 13.3 and 13.4. Please clarify.

37. NUREG-1537, Part 1, Chapter 13, Accident Analysis, states the applicant needs to present a methodology for reviewing the systems and operating characteristics of the reactor facility that could affect its safe operation or shutdown. The methodology should be used to identify limiting accidents, analyze the evolution of the scenarios, and evaluate the consequences. The 2007 SAR, Section 13.2.3 presents an analysis of the LOCA and provides radiation dose rates in Tables 13.6 and 13.9 after extended operation at 250 kw and 1 MW respectively. The values in Table 13.9 at various times after shutdown are smaller than those in Table 13.7 for same times after shutdown. Please clarify this discrepancy.

38. NUREG-1537, Part 1, Chapter 13, Accident Analysis, states the applicant needs to describe the mathematical models and analytical methods employed, including assumptions, approximations, validation, and uncertainties. The 2007 SAR, Section 13.2.5 provides a descriptive analysis involving control rod worths whose origins and relationship to the RRR have not been established, and whose worths are combined additively without justification. Section 13.2.5 discusses the Experiment Malfunction accident and assumes a $1.00 reactivity worth for the experiment. It should be established that the experiment reactivity worth is a negative value and failure in the experiment introduces positive reactivity. The means for combining the worths need to be clearly presented. Please provide a revised presentation of the information.

39. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish technical specifications (TS) that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. NUREG-1537, Part 1 provides guidance regarding TS in Appendix 14.1. The 2007 SAR, Chapter 14 presents proposed TS for the operation of the RRR. However, they do not incorporate all of the guidance (e.g., required action, completion time). Please consider proposing TS following the guidance of Appendix 14.1.

40. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The licensee shall select appropriate safety criteria, establish a Safety Limit (SL) and then establish an associated Limiting Safety System Setting (LSSS) that will ensure that the SL is not exceeded. The 2007 SAR, Chapter 14, TS 2.0, establishes the SL at 300 kw when operating with aluminum clad fuel elements in the core. The associated LSSS is also set at 300 kw which will not ensure that the SL is not exceeded. Please provide clarification and justification for setting both limits at the same value.

41. NUREG-1537, Part 1, Chapter 14, Technical Specifications states the applicant should establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The licensee shall select appropriate safety criteria, establish a SL and then establish an associated LSSS that will ensure that the SL is not exceeded. The important parameter for a TRIGA reactor is the fuel rod temperature. The SL should be established based on the maximum permissible temperature of the fuel rod. The LSSS should be set so that the SL will not be exceeded under all

conditions of operation. The 2007 SAR, Chapter 14, TS 2.0 establishes the SL and the LSSS using reactor power with no correlation of this power to fuel temperature. Please provide fuel rod temperatures at the power levels established for the SL and LSSS

42. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR, Chapter 14 in several sections of the TS refers back to sections of the SAR that do not exist, do not have the stated information discussed, or do not provide the requisite analysis required to validate the information in the Technical Specification.

For example:

Technical Specifications 2.1.5, “Bases” states:

“Safety Analysis Report, Section 3.5.1 (Fuel System) identifies design and operating constraints for TRIGA fuel that will ensure cladding integrity is not challenged.”

Technical Specifications 2.2.5, “Bases” states:

“Analysis in the Safety Analysis Report, 4.5.3, demonstrates fuel centerline temperature does not exceed 600oC at power levels approximately 1.25 MW with bulk pool water temperature at approximately 100 ^{o}C.”

Technical Specifications 3.1.5, “Bases” states:

“Safety Analysis Report Section 13.2 demonstrates that a $3.00 reactivity insertion from critical, zero power conditions leads to maximum fuel temperature of 250 ^{o}C, well below the limit.”

Technical Specifications 3.2.5, “Bases” states:

“Calculations in Chapter 4 assuming 500 kW operation and 83 fuel elements demonstrate fuel temperature limits are met.”

These calculations or sections do not appear in the SAR. Please provide the information supporting these statements in the TS.

43. NUREG-1537, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR, Chapter 14, TS 3.14, Actions, presents required actions for various TS violations. However, it is incomplete in that it does not include conditions, required actions and completion time for the rate of reactivity insertion by control rod motion (i.e. no greater than 0.12% delta k/k/second. In addition, it states the limitations on experiments are found in Section 3.8 which is incorrect. Please provide this additional information and corrections.

44. NUREG-1537, Part 1, Chapter 14, Technical Specifications states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. NUREG 1537, Part 1 provides guidance regarding TS in Appendix 14.1.

Appendix 14.1 suggests that the maximum scram time should be specified for each scrammable rod and the specification should ensure that the drop times are consistent with the SAR analysis of reactivity required as a function of time to terminate a reactivity addition event accounting for measurement and calculational uncertainties.

The 2007 SAR, Chapter 14, TS 3.4.3, Specification, there is the statement, "Control rods are capable of 90% of full reactivity insertion from the fully withdrawn position in less than 1 second" but an associated action statement has not been included if the control rods fail to meet the specification.

Please provide information concerning why this has not been included. Additionally, automatic scram conditions are usually established, with associated actions, for reactor operations outside of the normal operating mode or normal conditions, (e.g. scram at 110% of full licensed power or reactor tank coolant level below a specified normal operating value).

Conditions such as those described above are not clearly stated in the TS section of the application with associated required Surveillance Requirements and Actions. Please provide the missing information.

45. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. Water level monitors for the reactor tank would provide information concerning possible tank leakage. The 2007 SAR, Chapter 14 does not include TS (Limiting Conditions for Operations (LCO) and/or Surveillance Requirements (SR)) for monitoring the water level and water additions to the tank. Please propose TS on reactor tank water level and water addition monitors which would provide assurance for early detection of a possible leak in the reactor tank.

46. NUREG 1537, Part 1, Chapter14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR Chapter 14, TS 4.4.5 (BASES), it is stated that "the power level scram in not credited in the analysis, but provides assurance that the reactor is not operated in conditions beyond the assumptions used in the analysis (Table 13.2.1.4)." Neither the Table nor the analysis referenced could be located in the 2007 SAR. In addition, Section 13 of the SAR discusses accident analysis and does not normally provide a basis for a TS on the required measuring channels during operation. Please correct the TS.

47. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR, Sections 1.3.5.2, 3.5 and 9.1 state that if radioactive material releases associated with reactor operations occur, a controlled ventilation system minimizes exposure to reactor personnel and the public. Ventilation exhaust from the reactor room will shift to a filtered exhaust upon a manual signal or on high radioactivity of the air in the room and the function shall be tested semi-annually. However, a SR has not been established for testing the Gaseous Effluent Control System to ensure that it functions correctly when needed. Please propose a SR or provide a justification as to why one is not necessary.

48. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR, Chapter 14, TS 3.5 provides a LCO for the reactor bay ventilation system. The objective stated is to ensure that exposures to the public resulting from gaseous effluents released during normal operation and accident conditions are within limits. However, the LCO is incomplete in that it does not establish the conditions under which the ventilation system operates in the various modes possible. In addition, the discussion in the bases is incomplete. Please propose a TS limiting the operation of the ventilation system for normal and accident conditions.

49. NUREG-1537, Part 1, Chapter 14, Technical Specifications states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. In the 2007 SAR, Sections 14, TS 2.2.4 and 3.2.4, it is stated in the Actions-Required Action section that if the SL or LCO is exceeded then the operator has the option of reducing the power level to the SL or LCO limit. These TS are in direct conflict with TS 6.8 and 6.9 which specify the action to be taken in the event a safety limit is exceed and in the event of a reportable occurrence. Please correct the TS.

50. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. In the 2007 SAR, Section 14, TS 3.3 and 3.4.3, Measuring Channels and Safety Channel and Control Rod Operability there is a specification that states:

    "(2) There is a neutron-induced signal on the STARTUP CHANNEL"

    Table 1 of the same Section lists the Minimum Measuring Channel Complement. However Table 1 does not list the "STARTUP CHANNEL" as one of the required measuring channels that must be operable prior to actual reactor startup. Please correct this omission.

51. NUREG-1537, Part 1, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the

SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR, Chapter 14, does not provide TS concerning the requirement for interlocks. As an example, there is no TS requiring an interlock to prevent reactor startup if there is not a neutron induced signal on the start up channel. Please propose TS which include specifications for all the interlocks required for operation.

52. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. The 2007 SAR Chapter 14, Section 14, TS 3.8.3 it is stated that:

(1) Water temperature at the exit of the reactor pool shall not exceed 55ºC with flow through the primary cleanup loop
(2) Water conductivity shall be less than 2 micro-siemens/cm
(3) Water level above the core shall be at least 5 meters above the top of the core

However, there is no discussion of where the parameters in (1) and (2), above are monitored and by whom. In addition, the surveillance frequency for parameter (2) is confusing because it states that it will be measured daily and at least once every four weeks. Technical Specification Amendment #8 states that the new criteria for reactor pool water temperature is 48 ^{o}C for Parameter (1). Clarify the discrepancies identified and provide the information requested above.

53. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. From the Tables, it appears that the “CHANNEL TEST of Percent Power Safety Circuit SCRAM” and the “Reactor power level MEASURING CHANNEL, CHANNEL TEST” are the same thing with different surveillance frequencies (refer to TS 4.2.2, and 4.3.2). Please clarify the SR including what daily means (e.g., does daily mean each day before startup.

54. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. There are many terms in the TS that refer to “TEST”, “CHECK”, or “CALIBRATION”, that are used interchangeably (refer to TS 4.5.2, and 4.3.2). The terms are defined in Chapter 14, TS 1.0. However, the terms are not always consistently applied, leading to confusion. Please clarify the usage of the terms.

55. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff.

The 2007 SAR, Chapter 14, TS 3.6.5, it is stated that:

"Specifications 3.6(1) and 3.6(2) are conservatively chosen to limit reactivity additions to maximum values that are less than an addition that could cause the fuel temperature to rise above the limiting safety system set point (LSSS) value. The temperature rise for a $1.00 insertion is known from previous license conditions and operations and is known not to exceed the LSSS."

Please provide the documented analysis to support the statement.

56. NUREG-1537, Part 1, Chapter 14, Technical Specifications, states the applicant needs to establish TS that will provide reasonable assurance that the facility will function as analyzed in the SAR without endangering the environment or the health and safety of the public and the facility staff. NUREG 1537 guidance states in Section 14, 4.1 that the shutdown margin needs to be determined semiannually (every 6 months). In the 2007 SAR, the licensee has not provided actual RRR core reactivity and control rod worths. It is therefore, difficult to understand how this requirement is being met. Please provide the procedure for determining shutdown margin and an example from RRR records showing how this procedure has been implemented.

57. NUREG-1537, Part 1, Section 16.1 states the applicant should consider how a component or system was used in the past and evaluate the continued serviceability considering aging, wear, etc. and also to consider the suitability of items procured from other facilities. The 2007 SAR, Section 16.1, Prior Use of Reactor Components, the licensee described the depletion of the original fuel, receipt of fuel assemblies from Berkley University, and some damage to the RRR fuel inventory. Also described is the receipt of control rods from Cornell University. However, there is no discussion of the aging of components or the effect of the used components upon the ability of RRR to continue to safely operate. Furthermore, there is no discussion regarding the suitability of items supplied from other universities for use by RRR. Please provide an analysis of component aging to ensure that systems and components important to safety continue to be appropriate for use. Please provide a discussion of the safety evaluations performed on the previously utilized fuel rods and control rods, before they were placed into service at Reed.

58. NUREG-1537, Part 1, Section 12.9, Quality Assurance, provides guidance on Quality Assurance for research reactors. The 2007 SAR, Section 12.9 discusses quality assurance (QA). However the discussion is incomplete in that it does not include how QA will apply to replacements, modifications and changes to systems having a safety related function. Nor does it discuss how QA will be applied to the required audit function of the Reactor Review Committee. Please address these deficiencies.