OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR ADDITIONAL INFORMATION

REGARDING AMENDMENT TO FACILITY OPERATING LICENSE

THE KANSAS STATE UNIVERSITY NUCLEAR REACTOR FACILITY

LICENSE NO. R-88; DOCKET NO. 50-188

The U.S. Nuclear Regulatory Commission (NRC) staff is continuing its review of Kansas State University (KSU)'s application for amendment to Facility Operating License No. R-88, for the KSU Training, Isotopes, General Atomics (TRIGA) Mark-II Nuclear Reactor Facility, dated April 9, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12109A063), as supplemented.

In the course of reviewing KSU's application, the NRC staff has determined that additional information or clarification is required to continue its review of the application, in support of the development of its safety evaluation. The application is primarily evaluated using the appropriate regulations in Title 10 of the *Code of Federal Regulations* (10 CFR), and the following guidance:

- NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content," issued February 1996 (ADAMS Accession No. ML042430055)

- NUREG-1537, Part 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria," issued February 1996 (ADAMS Accession No. ML042430048)

- American National Standards Institute/American Nuclear Society, (ANSI/ANS)-15.1-2007 (R2013), "The Development of Technical Specifications for Research Reactors."

Requests for additional information (RAIs) 5 through 17 below are related to the proposed technical specifications (TSs) provided with KSU's application. TSs are fundamental criteria necessary to demonstrate facility safety and are required by 10 CFR 50.36 for each license authorizing operation of a production or utilization facility of a type described in 10 CFR 50.21. TSs are derived from the analyses and evaluation included in the safety analysis report (SAR) and submitted pursuant to 10 CFR 50.34. TSs for nuclear reactors will include items in the following categories: safety limits (SLs), limiting safety system settings (LSSSs), limiting conditions for operation (LCO), surveillance requirements, design features, and administrative controls. The NRC guidance for TSs is provided in NUREG-1537, Part 1, Appendix 14.1, "Format and Content of Technical Specifications for Non-Power Reactors." This guidance relies significantly on ANSI/ANS-15.1-2007. The NRC staff takes the position that the statements in these documents provide acceptable guidance to licensees and, unless acceptable alternatives are justified by the licensee, should be utilized whenever appropriate.

RAI 1

The regulations in 10 CFR 50.30(b) require that license amendment applications, and each amendment to such applications, must be executed in a signed original by the applicant or duly authorized officer thereof under oath or affirmation.

The NRC staff notes that KSU's September 23, 2017, letter (ADAMS Accession No. ML17319A305), providing a supplement to its original April 9, 2012, license amendment request (LAR), does not appear to be signed.

Provide a signed version of the September 23, 2017, supplement (or a statement that the September 23, 2017, supplement is incorporated by reference into KSU's signed response to this RAI), or justify why no additional information is needed.

RAI 2

The regulations in 10 CFR 50.34(b)(2) require that applications contain a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements; the bases, with technical justification therefor, upon which such requirements have been established; and the evaluations required to show that safety functions will be accomplished.

The guidance in NUREG-1537, Part 1, Section 4.5.1, states that licensees should provide a discussion of the safety considerations for different core configurations, including a limiting core configuration that would yield the highest power densities and fuel temperatures available with the planned fuel.

In its response to RAI 10 submitted October 5, 2016 (ADAMS Accession No. ML16291A498), KSU provides the results of core design (neutronics) calculations that are updated and corrected from those in its original LAR and its April 28, 2014, RAI responses (ADAMS Accession No. ML16200A317). The NRC staff notes that, based on the results illustrated in Figure 6 of KSU's response to RAI 10 submitted October 5, 2016, KSU's updated calculations appear to assume that the four 12 weight percent uranium (wt% U) elements are distributed at approximately equal intervals around the E-ring (previous calculations for 12 wt% U elements in the E-ring also appear to use a similar assumption, based on figures in the original LAR and the April 28, 2014, RAI responses).

However, in its response to RAI 6 submitted May 2, 2017 (ADAMS Accession No. ML17139C979), KSU states that "MCNP results transmitted in the initial LAR and in previous RAI responses indicate that 12.5 wt% (max.) fuel in the E- and F-rings will be kept below the fission heating density (i.e., power) of the 9.0 wt% (max.) elements in the B-ring, even if placed adjacent to another 12.5%-loaded element."

Given the discussion in KSU's response to RAI 6 submitted May 2, 2017, compared to the information in the LAR and previous RAI responses, it is not clear whether KSU's core design calculations consider the possibility of 12 wt% U elements being located near or adjacent to each other, or only consider 12 wt% U elements to be spaced at intervals from other 12 wt% U elements. The NRC staff notes that placing 12 wt% U elements adjacent to each other, or clustered together, in the E- and/or F-rings could result in higher power densities in those elements than if the elements were spaced at approximately equal intervals around the E- or F-ring.

Clarify whether KSU's core design calculations for its LAR, as supplemented, considered the possibility of 12 wt% U elements being near or adjacent to each other. If such situations were considered, discuss whether the maximum peaking factors in the 12% fuel elements in the E- and/or F-rings remained below the maximum peaking factor in 8.5 wt% U fuel in the B-ring. If such situations were not considered, provide calculations showing that placing 12 wt% U elements adjacent to each other or clustered together would not cause peaking factors in the 12 wt% U fuel to exceed the B-ring peaking factor, or discuss why such calculations are not necessary. Alternatively, discuss why no additional information is required.

RAI 3

The regulations in 10 CFR 50.34(b)(2) require that applications contain a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements; the bases, with technical justification therefor, upon which such requirements have been established; and the evaluations required to show that safety functions will be accomplished.

The guidance in NUREG-1537, Part 1, Chapter 13, describes the types of research reactor accidents that licensees should analyze. These accidents include insertion of excess reactivity accidents. NUREG-1537, Part 1, Section 13.1.2, states that insertion of reactivity events include the rapid (or step) insertion of reactivity (e.g., due to rapid removal of a control rod or rods, rapid insertion of a fuel element into the core, or experiment malfunction), and the ramp insertion of reactivity (e.g., due to drive motion of a control rod or rods). NUREG-1537, Part 1, Section 13.2, describes how accidents should be analyzed, and states that licensees should base accident scenarios on a single initiating malfunction.

KSU's LAR, as supplemented, references analyses of a $3.00 pulse discussed in its license renewal SAR, as supplemented (and previously reviewed and approved by the NRC as documented in the NRC staff's March 13, 2008, safety evaluation report (SER) (ADAMS Accession No. ML080580284)), and states that the $3.00 reactivity insertions previously analyzed would bound any inadvertent insertion of reactivity, for existing cores or proposed cores with 12 wt% U fuel.

a. The NRC staff notes that the existing analysis for a routine $3.00 pulse assumes that the reactor is initially at zero or very low power, such that the initial fuel temperature is low (27 degrees Celsius (degrees C) (81 degrees Fahrenheit (degrees F))). However, while routine pulses are typically performed from low power, when the fuel temperature is low, a rapid inadvertent insertion of reactivity (e.g., due to an experiment failure) could occur while the reactor is operating at full steady-state power and the initial fuel temperature is much higher. Existing KSU TS 3.6.3 limits the worth of any reactor experiment, or total worth of any 2 or more related experiments, to $2.00. The NRC staff notes that it is not clear whether a rapid insertion of up to $2.00 of reactivity from failure or unplanned removal of experiment(s) when the reactor is operating at full steady-state power (and the fuel is initially at its maximum calculated steady-state temperature) would be bounded by the $3.00 pulse analysis. Therefore, provide an analysis demonstrating that a rapid $2.00 reactivity insertion during full power steady-state reactor operation would not cause a safety limit to be exceeded, or justify why no additional information is required.

b. The NRC staff notes that the existing KSU TSs do not establish any specific limit on the rate at which reactivity may be inserted into the core during steady-state operation. Additionally, the existing KSU TSs do not require that a short period scram be operable when the reactor is operating. The NRC staff notes that a control rod malfunction could cause a ramp insertion of reactivity that, in the absence of any short period scram, could cause the reactor core to reach an unacceptably high power level and temperature, given the time it could take the reactor to be shut down by one of the 2 existing TS-required high power scrams if the transient started from low power, considering the instrument delay and time it would take control rods to insert into the core once a scram occurred. The NRC staff notes that this type of transient could, potentially, bound any potential rapid (step) reactivity insertion transient or pulse. Therefore, provide an analysis demonstrating that any ramp reactivity insertion, starting from any power level, with the reactor in its most restrictive initial condition, would not cause a safety limit to be exceeded (including due to a loss of flow stability); or, justify why no additional information is required.

c. KSU's existing analysis for an inadvertent $3.00 pulse that occurs during reactor operation (although, as discussed in the NRC staff's March 13, 2008, license renewal SER, there is an interlock preventing pulsing when reactor power is above 10 kilowatts-thermal (kWth), there is no TS requirement for this interlock) assumes that the peak reactor fuel temperature prior to the inadvertent pulse is 150 degrees C (302 degrees F). This temperature is based on a steady-state reactor power of approximately 100 kWth (well below the full licensed power). This is because KSU determined that, given that existing TS 3.1.3(1) limits maximum excess reactivity to $4.00, and the maximum allowed pulse is $3.00, the remaining $1.00 of excess reactivity would only allow the reactor to be operated up to a steady-state power of approximately 100 kWth.

   Given that, in its LAR, as supplemented, KSU provided updated steady-state thermal-hydraulic analyses, it is not clear whether the inadvertent pulse analysis in KSU's license renewal SAR, as supplemented (including the 150 degrees C (302 degrees F)) initial peak fuel temperature assumption), remains valid. Additionally, although KSU analyzed a scenario in which the reactor is operating at the highest power possible with $1.00 of excess reactivity, and the reactor is pulsed with the remaining $3.00 of excess reactivity, it is not clear whether this scenario would bound other possible combinations of reactivity for reactor operation and inadvertent pulsing. For example, the reactor could be operated at the maximum power level possible with $1.50 of excess reactivity, and the remaining $2.50 of allowed excess reactivity could be inserted in an inadvertent pulse.

   Therefore, discuss whether KSU's existing inadvertent pulse analysis is still valid for a scenario in which the reactor is operating at the highest power possible with $1.00 of excess reactivity, and the reactor is pulsed with the remaining $3.00 of excess reactivity. If it is no longer valid, provide an updated analysis that is based on the results of the updated steady-state thermal-hydraulic analyses in the LAR, as supplemented. Additionally, provide analyses, also based on the updated thermal-hydraulic analyses, demonstrating that other combinations of operation and pulsing (e.g., an inadvertent $2.50 pulse when the reactor is operating with $1.50 of excess reactivity) would be bounded by the inadvertent $3.00 pulse scenario (or other analyzed scenarios), or would otherwise not cause a safety limit to be exceeded. Alternatively, justify why no additional information is required.

RAI 4

(See also RAI 18 in relation to this RAI.)

The regulations in 10 CFR 50.34(b)(2) require that applications contain a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements; the bases, with technical justification therefor, upon which such requirements have been established; and the evaluations required to show that safety functions will be accomplished.

The guidance in NUREG-1537, Part 1, Section 4.5.1, states that licensees should present information on core geometry and configurations, including the limiting core configuration (LCC) (the core yielding the highest power density and fuel temperature using the fuel specified for the reactor), and other proposed operating core configurations that are demonstrated to be encompassed by the safety analysis of the LCC.

In its response to RAI 5 submitted May 2, 2017, KSU provided core design (neutronics) analyses to demonstrate the acceptability of its proposed new TS 3.4.3(3), which would allow reactor operation with any 1 control rod inoperable and fully inserted. KSU's calculations consider a core with all fresh 9.0 wt% U fuel elements and all rods fully withdrawn, and then consider how the peaking factor would change when each of the 4 control rods is fully inserted.

However, the core with all rods withdrawn that KSU considered appears to be a less limiting (lower peaking factor) core than the core considered for KSU's limiting core design calculations submitted in its October 5, 2016 RAI responses. Therefore, although KSU's calculations in its response to RAI 5 submitted May 2, 2017, show that having 1 rod inoperable and fully inserted would not cause a peaking factor to exceed 1.65 (the peaking factor calculated in KSU's bounding core design calculations submitted in its October 5, 2016 RAI responses), the calculations in RAI 5 submitted May 2, 2017, may not be based on a bounding core configuration.

KSU's calculations in its response to RAI 5 submitted May 2, 2017, also consider the effect on peaking factor of adding a single 12.3 wt% U element to the core (in position E-10) when each control rod is fully inserted, and show that the peaking factor would not still exceed 1.65, but these calculations may also not be bounding given the core configurations assumed, including the use of only a single 12.3 wt% U element (instead of the 4 that would be allowed) and the location of that element.

Based on the above, the NRC staff notes that KSU's calculations do not appear to adequately demonstrate that any permissible core configurations, with up to four 12 wt% U fuel elements, and any 1 control rod fully inserted, would be bounded by KSU's limiting core design calculations. Therefore, provide additional calculations demonstrating that reactor operation with up to four 12 wt% U fuel elements located in any permissible locations, and any 1 control rod inoperable and fully inserted, will not result in a safety limit being exceeded. The calculations should assume that the reactor is operated at the full licensed power of 1,250 kWth, even when 1 control rod is fully inserted, because although the inserted rod would reduce reactivity and could limit the power level that could be achieved, other core changes (e.g., addition of experiments) could compensate for some of this reduction in reactivity. Alternatively, justify why no additional information is required.

RAI 5

In its LAR supplement dated November 30, 2018 (ADAMS Accession No. ML18347A209), KSU provided a marked-up copy of the KSU reactor TSs, which includes KSU's proposed changes. However, the NRC staff notes that this copy of the proposed TSs appears to include changes that are not discussed in the LAR, as supplemented. Additionally, the change bars on this copy of the TSs do not appear to correspond exactly to all locations where changes have been made compared to the current TSs of record (i.e., some locations marked with change bars do not appear to have been changed, and vise-versa).

Provide marked-up TS change pages that only include changes that are specifically discussed and analyzed, as applicable, in the LAR, as supplemented; or, discuss and provide a basis for, as applicable, each change that is indicated in the change pages, including minor formatting or editorial changes. Additionally, provide marked-up TS change pages with change bars that show all locations where changes have been made compared to the current NRC-approved TSs of record (the NRC staff recommends that KSU only submit copies of those TS pages on which changes are proposed; a complete copy of the TSs including the pages with no changes does not need to be submitted). Alternatively, justify why no additional information is required.

RAI 6

In its LAR, as supplemented, KSU proposed to add TS 3.4.3(3) (and associated action statement TS 3.4.4.B), which would require operable control rods. However, although the title of current TS 3.4 includes "Control Rod Operability," the "Applicability" and "Objective" for current TS 3.4 only appear to address measuring and safety system channels, and do not address control rods. Propose a revised "Applicability" and "Objective" for current TS 3.4 such that they would be applicable to all specifications in proposed TS 3.4, or justify why no change is required.

RAI 7

The NRC staff notes that the current KSU reactor TSs, in general, use all capital letters to denote terms that are defined in the TS definitions (Section 1 of the TSs). However, the proposed TSs do not appear to use this formatting uniformly. For example (not an exhaustive list), proposed TS 3.4.4.B uses the term "control rod," which is defined in Section 1 of the TSs, but it is not in all capital letters, and proposed TS 5.1.3(1) uses "shall," but it is not in all capitals. Revise the proposed TSs (for any TSs in which changes are proposed) to consistently use all capital letters to denote defined terms, or justify why no change is required.

RAI 8

In its LAR, as supplemented, KSU proposed to add new TS 3.8.3(4), which would limit the reactor pool temperature to 37 degrees C (99 degrees F) when there is an experiment installed in an interstitial flux wire port. KSU stated that it proposed this limit (which is less than the 44 degrees C (111 degrees F) limit in proposed TS 3.8.3(1) when the ports are empty) because the presence of an experiment in these holes may reduce the temperature at which bulk boiling will occur. However, the LAR, as supplemented, does not appear to provide any basis or analysis supporting the specific choice of 37 degrees C (99 degrees F). Provide an adequate basis for the 37 degrees C (99 degrees F) limit in proposed new TS 3.8.3(4), or justify why no additional information is required.

RAI 9

In its LAR, as supplemented, KSU proposed to add new TS 3.8.3(4), and an associated action statement which is designated as new TS 3.8.4.B. However, the NRC staff notes that proposed TS 3.8.4 appears to contain 2 items designated "B." Additionally, while proposed TS 3.8.3(4) is the fourth of the 4 specifications listed under proposed TS 3.8.3, the corresponding proposed TS 3.8.4.B is the second of 4 action statements listed under proposed TS 3.8.4.

Revise proposed TS 3.8.4 to correct the apparent editorial error, and clarify which action statement in proposed TS 3.8.4 corresponds to proposed TS 3.8.3(4) (for example, by re-designating the second action statement under proposed TS 3.8.4 as proposed TS 3.8.4.D, and moving it to the end of the list of action statements under proposed TS 3.8.4, if appropriate). Alternatively, justify why no change is required.

RAI 10

In its LAR, as supplemented, KSU proposed to add new action statement TS 3.8.4.B, which would state:

[CONDITION]	[REQUIRED ACTION]	[COMPLETION TIME]
B. Bulk water temperature exceeds 37°C with an experiment installed in an interstitial flux wire port.	B.1 ENSURE the reactor is SHUTDOWN AND B.2 Reduce bulk water temperature to less than 37°C. OR B.3 Remove experiment from flux wire port	B.1 IMMEDIATE B.2 IMMEDIATE B.3 IMMEDIATE

However, the NRC staff notes that the "and/or" logic in the center column of the action statement appears to be ambiguous. It is not clear whether both of items B.1 and B.2, *or* only item B.3, are required, or whether item B.1 *and* either item B.2 or item B.3 is required. Proposed a revised TS 3.8.4.B which clarifies the "and/or" logic, or justify why no change is required.

RAI 11

Proposed LCO TSs 3.8.3(1) and 3.8.3(4) would impose limits on the bulk water temperature of the reactor pool. However, the proposed KSU reactor TSs do not appear to include an existing or proposed surveillance requirement for pool temperature. Propose a surveillance TS for pool temperature, or justify why no change is required.

RAI 12

In its response to RAI 2 submitted May 2, 2017, KSU proposed to add new TS 3.10, which would impose requirements on maximum steady-state power level and power level scram points. KSU stated that the purpose of the new TS 3.10 is, in part, to address the issue that the current reactor console instruments are not capable of reading up the full licensed power limit of 1,250 kW(th).

KSU's response to RAI 2 submitted May 2, 2017, also stated that "the upgraded control console instrumentation planned for installation in January 2018 is capable of reading 1.25 MW of power." Additionally, in a public meeting with the NRC staff on November 7, 2017 (see ADAMS Accession No. ML17319A064), KSU stated that it expected to complete its control console upgrade in 2018.

It is not clear to the NRC staff whether the upgraded control console instrumentation has been installed, or what the status of the planned installation is, or whether the KSU reactor instrumentation is still the original instrumentation discussed in KSU's response to RAI 2 submitted May 2, 2017. Discuss the status of the instrumentation upgrade, or justify why no additional information is required.

RAI 13

In its LAR, as supplemented, KSU proposed to add new TS 3.10.3(2), which would state, "[a] required reactor power level scram is set to a value no greater than 1,250 kWth." In its response to RAI 2 submitted May 2, 2017, KSU stated that the purpose of the new TS 3.10 is, in part, to address the issue that the current reactor console instruments are not capable of reading up the full licensed power limit of 1,250 kW(th). Additionally, KSU's corresponding action statement for proposed TS 3.10.3(2), which is found in proposed TS 3.10.4.B, requires that if "[a] required reactor power level scram is set to a value above 1,250 kWth or above the maximum readable value on a required channel," KSU must "[a]djust reactor power level scram setpoint to a readable value less than or equal to 1,250 kWth."

The NRC staff notes that proposed TS 3.10.3(2) requires that a power level scram be set at or below 1,250 kW(th) (the maximum licensed power of the KSU reactor), but does not appear to require that a power level scram also be set below the highest readable value of the scram channel. Therefore, the NRC staff notes that proposed TS 3.10.3(2) does not appear to be consistent with the purpose of proposed TS 3.10 (as discussed in KSU's response to RAI 2 submitted May 2, 2017), or with proposed action statement TS 3.10.4.B. The NRC staff also notes that existing TS 3.4.3(1) requires that 2 power level scram channels be operable, but proposed TS 3.10.3(2) only appears to require that 1 of the required scrams be set to an appropriate value. Additionally, the NRC staff notes that proposed TS 3.10.3(2) uses the language "is," which appears to be inconsistent with the existing TS definition of "shall" to denote a requirement.

Revise proposed TS 3.10.3(2) to be consistent with the stated purpose of proposed TS 3.10, and with proposed TS 3.10.4.B; to clearly require that both of the 2 power level scrams required by existing TS 3.4.3(1) be set to an appropriate value; and to be consistent with the TS definition of "shall." Alternatively, justify why no change is required.

RAI 14

Proposed new TS 3.4.3(3) would require that "[a] minimum of three CONTROL RODS must be OPERABLE. Inoperable CONTROL RODS must be fully inserted." The NRC staff notes that proposed TS 3.4.3(3) uses the language "must" (2 instances), which appears to be inconsistent with the existing TS definition of “shall” to denote a requirement. Revise proposed TS 3.4.3(3) to be consistent with the TS definition of “shall,” or justify why no change is required.

RAI 15

Proposed new action statement TS 3.10.4.B, in the “COMPLETION TIME” column, appears to contain an extraneous “AND” that is inconsistent with the “COMPLETION TIME” columns for other existing and proposed action statement TSs. Revise proposed TS 3.10.4.B to correct the apparent editorial error by deleting the “AND,” or justify why no change is required.

RAI 16

Proposed new TS 3.10.3(2) would impose a requirement for the maximum setpoint of required reactor power level scrams (existing TS 3.4.3(1) requires that 2 reactor power level scrams be operable). However, the existing or proposed KSU TSs do not appear to include any surveillance TS to verify the operability of these required scrams, which could be needed to ensure that a safety limit is not exceeded if, for example, an unplanned reactivity transient occurred. Provide an appropriate surveillance TS for the operability of these scrams, or justify why no change is required.

RAI 17

Proposed new TS 5.1.3(3) would state:

> A maximum of four fuel elements with greater than 9.0 weight percent uranium may be installed in the core. These elements shall only be placed in lattice positions in the E- and F-rings of the core that meet the following condition: using a properly scaled top-view drawing of the reactor core grid plate, a line segment drawn from the center of any lattice position populated with a control rod or a water channel to the candidate lattice position must intersect the boundary of at least one additional lattice position.

Provide the following, or discuss why no additional information or TS changes are required:

a. Proposed TS 5.1.3(3) would require that 12 wt% U elements be placed in core positions not adjacent to “a water channel.” However, the NRC staff notes that it is not clear whether “water” channels mean only empty channels, or also other channels that are not “empty” but do not contain fuel (e.g., the neutron source holder position, or an experiment position such as a pneumatic transfer position). Revise proposed TS 5.1.3(3) to clarify what is meant by “a water channel.”

b. Proposed TS 5.1.3(3) would provide criteria that would determine whether a lattice position would be considered to be adjacent to a control rod or a water channel, for the purposes of determining whether 12 wt% U fuel would be allowed in the lattice position. However, the NRC staff notes that the criteria appear to be ambiguous because it is not clear if the line segment would be drawn from “the center of any lattice position populated with a control rod or a water channel” to the center of the candidate position, or to any point on the candidate position. Revise proposed TS 5.1.3(3) to clarify which lattice positions would be considered to be adjacent to a control rod or water channel. To help ensure clarity, the NRC staff also recommends that KSU provide examples of locations where TS 5.1.3(3) would allow or not allow 12 wt% U fuel to be placed, based on a scale drawing of the grid plate.

c. The NRC staff notes that proposed TS 5.1.3(3) uses the language “must,” which appears to be inconsistent with the existing TS definition of “shall” to denote a requirement. Revise the “must” language in proposed TS 5.1.3(3) to be consistent with the TS definition of “shall.”

d. Proposed TS 5.1.3(3) would state that up to four fuel elements with greater than 9.0 wt% U may be placed in the core. However, the NRC staff notes that the proposed TSs, including proposed TS 5.1.3(3), would not appear to specifically prohibit more than four elements with greater than 9.0 wt% U from being placed in the core. Revise proposed TS 5.1.3(3) to clarify that more than four elements with greater than 9.0 wt% U shall not be placed in the core, consistent with the existing TS definitions and the analyses provided in the LAR, as supplemented.

RAI 18

The regulations in 10 CFR 50.34(b)(2) require that applications contain a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements; the bases, with technical justification therefor, upon which such requirements have been established; and the evaluations required to show that safety functions will be accomplished.

The guidance in NUREG-1537, Part 1, Section 4.5.1, states that licensees should present information on core geometry and configurations, including the LCC, and other proposed operating core configurations that are demonstrated to be encompassed by the safety analysis of the LCC. The guidance in NUREG-1537, Part 1, Section 4.6, states that licensees should present information on the thermal power density distribution in the fuel and heat fluxes into the coolant of each channel and along the channel, derived from fuel loading and neutron flux characteristics.

Figure 2 of KSU’s response to RAI 1 submitted May 2, 2017, provides a plot of the heat flux along the axial length of the hot fuel element. This is the heat flux profile used in KSU’s updated steady-state thermal-hydraulic analyses. Additionally, page 4-22 of the updated pages of KSU’s SAR for its reactor, which KSU submitted with its LAR supplement dated November 30, 2018, states that the updated thermal-hydraulic analysis used “an appropriate axial power profile.”

However, it is not clear how this axial power profile and corresponding heat flux profile assumed for the updated thermal-hydraulic calculations were determined, and whether or why they are appropriately conservative and bounding. Discuss how the axial power and heat flux profiles were determined and why they are appropriate for any calculations in which they are used (including analyses supporting KSU’s ability to operate the reactor with one rod inoperable and fully inserted (see RAI 4)), or justify why no additional information is required.

RAI 19

The regulations in 10 CFR 50.34(b)(2) require that applications contain a description and analysis of the structures, systems, and components of the facility, with emphasis upon performance requirements; the bases, with technical justification therefor, upon which such requirements have been established; and the evaluations required to show that safety functions will be accomplished.

The guidance in NUREG-1537, Part, 1, Chapter 13, describes the types of research reactor accidents that licensees should analyze. These accidents include loss-of-coolant accidents (LOCAs).

In its response to RAI 7 submitted April 28, 2014, KSU discussed its justification for its determination that the LOCA analysis in its license renewal SAR, as supplemented, would continue to be bounding for existing cores or proposed cores with 12 wt% U fuel. KSU stated that its existing LOCA analysis would continue to be bounding because the maximum fission product density, and therefore decay heat and temperature, in the core would not increase beyond what was assumed for the LOCA analysis in the license renewal SAR, as supplemented.

However, the NRC staff noted that the existing LOCA analysis appears to use certain methodologies and assumptions which may not be appropriate and/or bounding. Specifically, the existing analysis assumes that the thermal resistance of the fuel cladding and gap is negligible, which may not be realistic. The existing analysis also appears to assume that the initial fuel temperature is at ambient when the LOCA occurs, which may not reflect maximum reactor fuel temperatures for normal operation. Additionally, the existing analysis only appears to consider the fuel temperature immediately after the LOCA occurs. The NRC staff notes that, for an instantaneous LOCA occurring simultaneously with reactor shutdown, the reactor fuel generally increases for some period of time following the LOCA due to the decay heat produced in the fuel; therefore, the peak fuel temperature may occur after some time has elapsed since the LOCA.

Therefore, provide an updated LOCA analysis that uses appropriate assumptions and methodologies, and is bounding for existing cores or proposed cores with 12 wt% U fuel. Alternatively, discuss why the existing LOCA analysis would continue to be bounding, considering its methodologies and assumptions discussed above; or, justify why no additional information is required.