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US NRC
Attn: Document Control Desk
Washington, DC 20555-0001

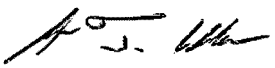
28 February 2024

Subject: 2023 Annual Operating Report for the Kansas State University TRIGA Mark II Nuclear Reactor (Facility License # R-88, Facility Docket # 50-188)

To Whom It May Concern:

This document serves as the annual operating report for the Kansas State University (KSU) nuclear reactor. The report is divided into paragraphs addressing specific items listed as requirements in the Technical Specifications 6.11e.

Sincerely,



Alan Cebula, Ph.D.
Nuclear Reactor Facility Manager
Kansas State University

Attachments:

1. Kansas State University TRIGA Mark II Reactor Annual Report, CY 2022
2. 50.59 Screening and Evaluation

Cc: Linh Tran, Project Manager, NRC
Andrew Waugh, Inspector, NRC

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Kansas State University TRIGA Mark II Reactor Annual Report, CY 2023

Introduction

The Kansas State University Nuclear Reactor Technical Specifications (TS) require a routine written report to be transmitted to the US Nuclear Regulatory Commission (NRC) within 60 days after completion of the first calendar year of operating, and at intervals not to exceed twelve months thereafter, providing the following information:

TS.6.11.e.1 - A brief narrative summary of operating experience (including experiments performed), changes in facility design, performance characteristics, and operating procedures related to reactor safety occurring during the reporting period; and results of surveillance tests and inspections.

TS.6.11.e.2 - A tabulation showing the energy generated by the reactor (in megawatt-hours).

TS.6.11.e.3 - The number of emergency shutdowns and inadvertent SCRAMs, including the reason thereof and corrective action, if any, taken.

TS.6.11.e.4 - Discussion of the major maintenance operations performed during the period, including the effects, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required.

TS.6.11.e.5 - A summary of each change to the facility or procedures, tests, and experiments carried out under the conditions of 10.CFR.50.59.

TS.6.11.e.6 - A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or before the point of such release or discharge.

TS.6.11.e.7 - A description of any environmental surveys performed outside the facility.

TS.6.11.e.8 - A summary of radiation exposures received by facility personnel and visitors, including the dates and time of significant exposure, and a brief summary of the results of radiation and contamination surveys performed within the facility.

This information is transmitted in this report, in sections separated by TS clause. This report covers January 2023 – December 2023.

TS.6.11.e.1 - A brief narrative summary of operating experience (including experiments performed), changes in facility design, performance characteristics, and operating procedures related to reactor safety occurring during the reporting period; and results of surveillance tests and inspections.

The KSU reactor remained in a shutdown state following the results of fuel inspections in CY2021. The mission of the reactor continued by supporting outreach and classroom activities. While the number of tours decreased from the previous year down to 32, the total number of visitors was increased by about 25% to 430. Although a considerable increase, tour volume remains about half of the historical volumes of over 1,000 individuals per year. Laboratories associated with the reactor facility were used to support classes within the Mechanical and Nuclear Engineering Department and researchers. A reactor laboratory course utilized radioactive sources and high purity germanium spectrometers maintained by the reactor.

Based on testing results from a system previously used in research, ultrasonic cleaning was selected as a method to address the maintenance issue resulting in the shutdown. A vendor with experience cleaning fuel bundles in the nuclear power industry was chosen to design and build a commercial cleaning system. A procedure was developed, reviewed, and approved by the Reactor Safeguards Committee to utilize the new cleaning system.

Results of monitoring water ingress into the beam port facilities show limited leaking. Experience has shown a slight increase in leakage from beam port facilities with increasing primary pool temperature above typical room temperature. With no operations above the point of adding heat, primary pool temperature was easily maintained at room temperature throughout CY2023.

Bulk shield tank and primary pool cleaning and maintenance activities continued in CY2023. Additional tools for cleaning the primary pool continue to be developed. Different methods of refurbishing the Bulk Shield Tank were investigated.

The NRC routine annual inspection was completed from April 24-28, 2023. A report dated June 5, 2023 indicating no findings of significance was received as a result of the inspection (Inspection Report No. 05000188/2023201). Concurrent with the routine inspection, the NRC conducted a security inspection. Based on the results of the security inspection, no significant security concerns or findings of non-compliance were identified (Inspection Report No. 05000188/2023202, August 1, 2023).

TS.6.11.e.2 - A tabulation showing the energy generated by the reactor (in megawatt-hours).

The monthly total energy generated by the KSU reactor is recorded in Table 1 and shown as a bar chart in Figure 1. Normal operations remained suspended from the results of fuel inspection findings in CY2021, so the facility had zero energy generated for CY2023. A total of 20.1 hours attributed to operations occurred during 2023. All hours were at zero power and were conducted for maintenance activities such as fuel inspections. The limited operating is reflected in Table 2 and Figure 2. Not reflected in the table and figure is the use of the reactor for outreach activities. Tours were still conducted without operating the reactor and at a level comparable to CY2022.

Table 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2023.

Month	MWh Burnup
January	0.00
February	0.00
March	0.00
April	0.00
May	0.00
June	0.00
July	0.00
August	0.00
September	0.00
October	0.00
November	0.00
December	0.00
TOTAL	**0.00**

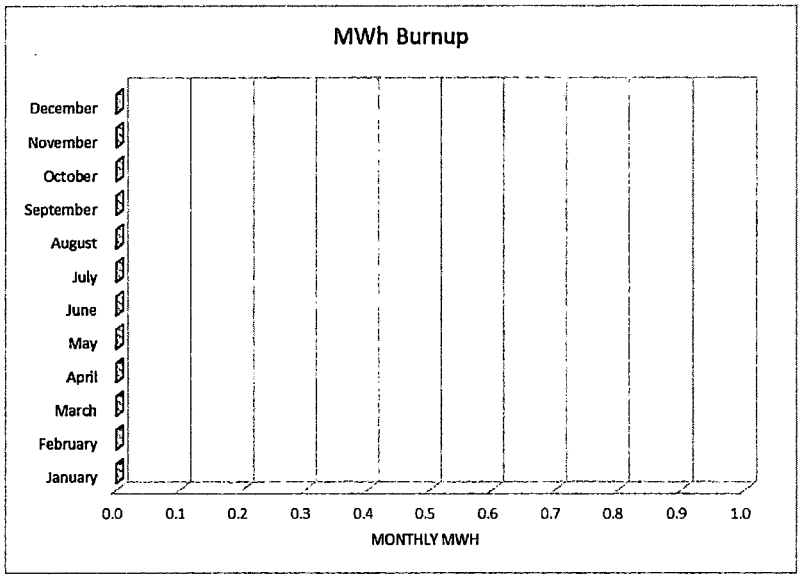

Figure 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2023.

Table 2 – Operating hours grouped by purpose at the KSU TRIGA Mark II reactor for CY 2023.

Purpose	Operating Time [hr]
Research	0
Tours	0
Classes	0
Maintenance	20.1
Training	0
Testing	0
TOTAL	**20.1**

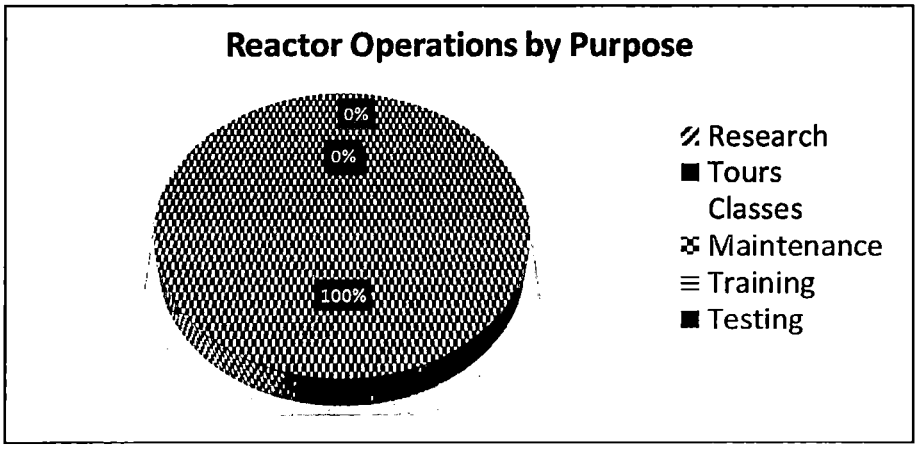

Figure 2 – KSU TRIGA Mark II operations distribution as a percentage of total hours, CY2023, based on purpose of operation.

TS.6.11.e.3 - The number of emergency shutdowns and inadvertent SCRAMs, including the reason thereof and corrective action, if any, taken.

As shown in Table 3, there were no inadvertent SCRAMs in CY2023 and no emergency shutdowns occurred during the time period reported. The number of inadvertent SCRAMs has remained low (CY 2022: 1, CY 2021: 2, CY 2020: 2, CY 2019: 6, CY 2018: 20).

Table 3 – Inadvertent SCRAMs.

Date	Action	Comments
None		

TS.6.11.e.4 - Discussion of the major maintenance operations performed during the period, including the effects, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required.

Various system maintenance was performed throughout CY2023 for part failure due to normal wear and tear. No effects on the safe operation of the reactor were observed. The following is a summary of all major maintenance activities during CY2023:

- Control rod limit switch maintenance
  - Shim Rod limit switch (rod down actuator) adjusted to restore drive function
  - Pulse rod down microswitch adjusted to restore Air Light function
- Cooling tower fan belts replaced
- Continuous Air Monitor vacuum pump vanes broke during power outage. Vanes replaced using repair kit.
- Crane inspection
- Rotary Specimen Rack moved from Bulk Shield Tank (BST) to dry storage location within reactor bay to allow BST refurbishment work
- Sump level sensor wires resoldered and protected with heat shrink covering
- Ultrasonic fuel cleaning system tested with model fuel rod. Testing included working through logistics of system setup including pump-filter skid and generator power adjustment.

TS.6.11.e.5 - A summary of each change to the facility or procedures, tests, and experiments carried out under the conditions of 10.CFR.50.59.

All maintenance activities involved replacing malfunctioning components with same make and model equipment. No changes in facility or experiments occurred during CY2023. A new procedure was approved by the Reactor Safeguards Committee to allow ultrasonic cleaning of stainless-steel clad fuel elements.

TS.6.11.e.6 - A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or before the point of such release or discharge.

Per procedure, the concentration of liquid effluent was calculated prior to discharge, along with an estimate of the total activity. After discharge, the total activity released was determined based on actual volume discharged. Values are verified to be below the limits in 10CFR20 before discharge. Table 4 summarizes the average concentration and total activity released.

Table 4 – Summary of radioactive effluent (water)

Isotope	Avg. Concentration (Ci / mL)	Total Volume (mL)	Total Activity Released (Ci)
Alpha-emitters	3.2E-11	3.46E6	1.11E-10
Beta-emitters	1.69E-5	1.00E7	1.69E-4
Cs-137	6.4E-15	6.58E6	4.21E-8

TS.6.11.e.7 - A description of any environmental surveys performed outside the facility.

Radiation surveys are performed within and around the facility to verify that radiation levels remain safe when at full-power operation. These surveys indicate that the dose rate (gamma and neutron) at the reactor dome does not exceed the hourly dose limit to members of the public of 2 mrem/hr, as set forth in 10CFR20, which indicates that the outside dose cannot exceed this limit.

Since no high-power operations took place during CY2023, all radiation surveys of the operations boundary were at zero power. Gamma and neutron dose rates for all environmental surveys at the operations boundary revealed dose rates at background readings. Two thermoluminescence dosimeters (TLD) are placed at the operations boundary for environmental/area monitoring monthly. Table 5 summarizes the monthly TLD measurements for CY2023. All monthly dose measurements at the confinement boundary were reported as zero mrem.

Almost half (5 of 12) control room door area monitor measurements were reported above minimum. Reactor staff TLDs are stored at the same location as the area monitor. As shown in Figure 3, reported doses for reactor staff tend to be elevated in months when the area monitor at the control room door reports above the minimum level. Overall, reported values for the control room door area monitor remain very low.

Table 5 – Environmental and Area Monitor Monthly Doses 1/1/2023 - 12/31/2023.

Month	Control Room Door [mrem]	Reactor Confinement (South) [mrem]
January	0	0
February	0	0
March	10	0
April	0	0
May	2	0
June	7	0
July	1	0
August	0	0
September	0	0
October	0	0
November	3	0
December	0	0
TOTAL	**23**	**0**

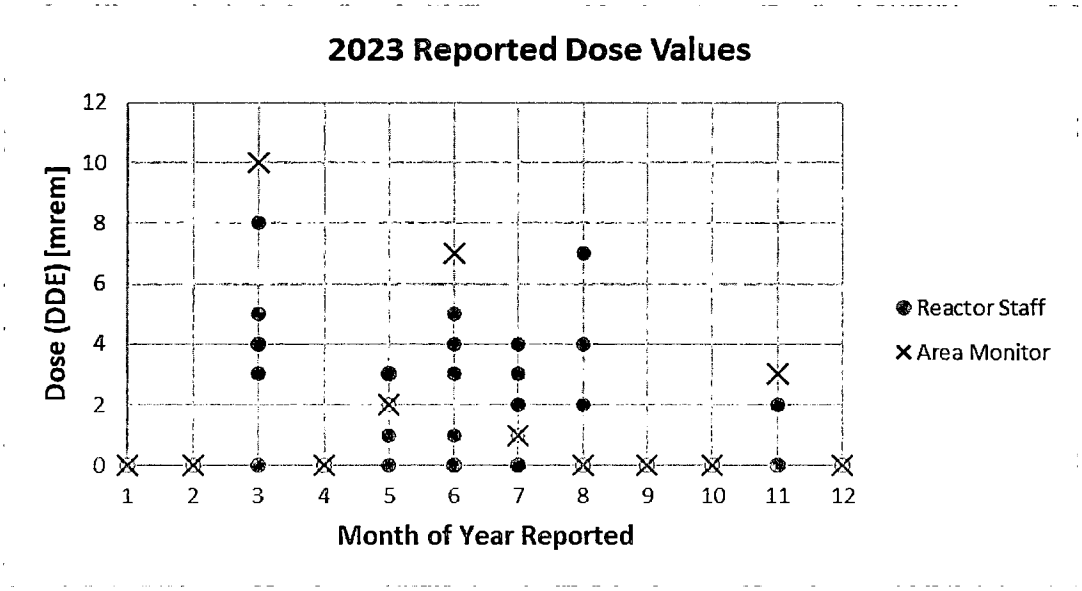

Figure 3 – Comparison of reported doses for reactor staff (whole-body) and area monitor by month (CY2023).

TS.6.11.e.8 - A summary of radiation exposures received by facility personnel and visitors, including the dates and time of significant exposure, and a brief summary of the results of radiation and contamination surveys performed within the facility.

Monthly whole body dose reports have been received from the dosimetry vendor for monitoring periods January to December 2023 along with quarterly extremity reports for first through fourth quarter 2023 monitoring periods. A total of 12 individuals were monitored at some point during 2023.

Table 6 shows the distribution of cumulative worker doses based on the reports available. Overall, no staff exceeded 20 mrem total for a reported whole-body dose. The average dose equivalents were 8 mrem deep dose equivalent (DDE), 8 mrem lens dose equivalent (LDE), and 9 mrem shallow dose equivalent (SDE). The maximum for an individual was 18 mrem DDE, 19 mrem LDE, and 19 mrem SDE.

The average max extremity dose for the year was 85 mrem and the maximum was 111 mrem. The fourth quarter extremity report showed unusual values considering no significant change in staff activities and no accompanying increase in whole body monitoring for October to December. Elevated reported values for the fourth quarter were observed for other groups monitored on campus. The university's radiation safety office is investigating the irregularity. Excluding the 4th quarter report, extremity monitoring had an average of 15.6 mrem and a maximum of 54 mrem for an individual. Overall, values are well below ALARA goals and similar to previous years.

Table 6 - Summary of total occupational dose received by KSU reactor workers from 1/1/2023 – 12/31/2023.

mrem	DDE	LDE	SDE	Max Extremity
[0, 10]	10	9	8	0
(10, 20]	2	3	4	0
(20, 30]	0	0	0	0
(30, 40]	0	0	0	0
(40, 50]	0	0	0	0
(50,100]	0	0	0	9
(100,150]	0	0	0	3
(150,200]	0	0	0	0

Visitor dose at the KSU TRIGA reactor facility is measured using self-reading pocket ion chamber dosimeters, with an indication range from 0-200 mR. Self-indicated pocket dosimeter readings suffer from imprecision due to parallax error, sometimes resulting in negative values or readings above the true value. Figure 4 summarizes the distribution of visitor exposures recorded. For a total of 496 visitor dose records, over 87% of the visitor dose records are at 1 mR or less. Records above 2 mR occurred sporadically within large groups of visitors where the bulk of readings were 1 mR or less indicating error in reading.

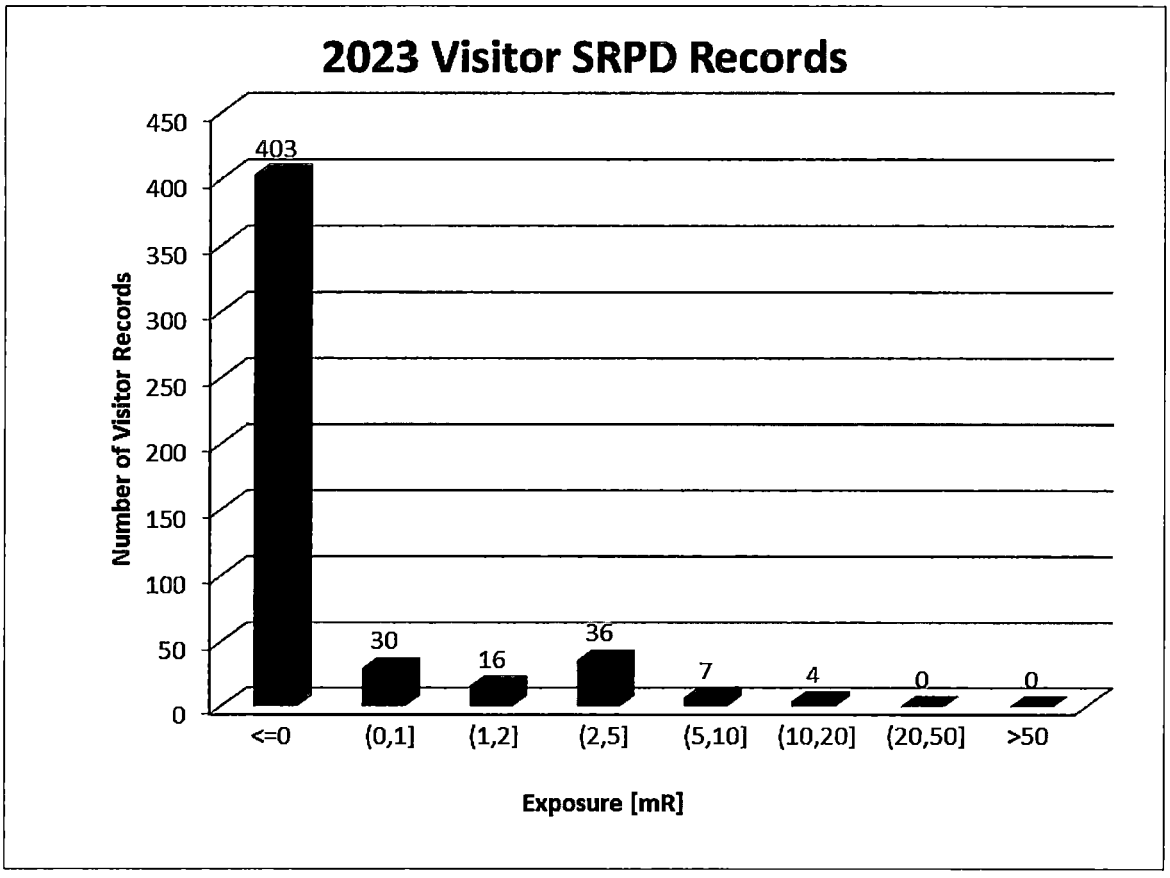

Figure 4 - Visitor self-reading pocket dosimeter (SRPD) records from CY 2023.

All monthly radiation and contamination surveys conducted at the facility in 2023 were nominal, and no action levels were exceeded.

This concludes the 2023 Annual Report for the Kansas State University TRIGA Mark II Nuclear Reactor.

Date: 11/29/2023

Title: Procedure 30 – Fuel Element Cleaning and Inspection

Performer: Alan Cebula

Description: Procedure 30 provides a method for ultrasonic cleaning of stainless steel clad TRIGA fuel elements and the subsequent inspection.

SCREENING – The following guidance provides criteria to screen the proposed change from further assessing the need for NRC review.

SSC Affected	**SSC Design Function**	**Failure Mode(s)**	**Accident Scenario(s)**
Fuel Cladding	Cladding integrity – fission product retention	Fuel element cladding failure	Fuel element failure

Safety Analysis and Accident Response/Mitigation	YES	NO
Decrease SSC design function reliability when failure would initiate accident		x
Decrease SSC design function reliability when failure would affect accident mitigation		x
Reduce redundancy, reliability, or defense in depth		x
Add or delete an automatic or manual design function of an SSC		x

Human Interface	YES	NO
Convert an automatic feature to manual or vice versa		x
Adversely affect ability to perform required actions		x
Adversely affect time response of required actions		x

Interface Outside of the Proposed Change	YES	NO
Degrade seismic or environmental qualification		x
Affect method of evaluation used to establish design basis or safety analysis		x
Introduce unwanted or previously unreviewed system or material interaction	x	
(Not described in SAR) indirect effects on electrical distribution		x
(Not described in SAR) indirect effects on structural integrity		x
(Not described in SAR) indirect effects on environmental conditions		x
(Not described in SAR) indirect effects on other SAR design functions		x

EVALUATION - If the change does affects (1) a design function of SSC, (2) a method of performing or controlling design function, or (3) evaluation for demonstrating the design function will be accomplished, as indicated by one or more YES answers in the "Screening" section, complete the applicable tables below.

Does the change result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final SAR (as updated)?	YES	NO
		x

Accident	***Potential Impact on Accident Frequency***
Reactivity Addition	N/A
LOCA	N/A
Fuel Handling	N/A

Does the change result in more than a minimal increase in the likelihood of occurrence of a malfunction of an SSC important to safety previously evaluated in the final SAR (as updated)?	YES	NO
		x

Affected SSC	***Potential Impact on Likelihood of Malfunction***
N/A	N/A

Does the change result in more than a minimal increase in the consequences of an accident previously evaluated in the final SAR (as updated)?	YES	NO
		x

Accident	***Potential Impact on Accident Consequences***
Reactivity Addition	N/A
LOCA	N/A
Fuel Handling	N/A

Does the change result in more than a minimal increase in the consequences of a malfunction of an SSC important to safety previously evaluated in the final SAR (as updated)?	YES	NO
		x

Affected SSC	***Potential Impact on Consequences of Malfunction***
N/A	N/A

EVALUATION – continued

Does the change create a possibility for an accident of a different type than previously evaluated in the final SAR (as updated)?	YES	NO
		x

Accident Description (Including Likelihood and Consequences)
N/A

Does the change create a possibility for a malfunction of an SSC important to safety with a different result than any previously evaluated in the final SAR (as updated)?	YES	NO
		x

Accident	***Affected SSC***	***Result***
Reactivity Addition	N/A	N/A
LOCA	N/A	N/A
Fuel Handling	N/A	N/A
Other	N/A	N/A

Does the change result in exceedance or alteration of a design basis limit for a fission product barrier as described in the SAR (as updated)?	YES	NO
		x

Category	***Reference/Text***	***Value***
Design Basis Limit	N/A	N/A
Analysis	N/A	N/A
Approach to Limit	N/A	N/A

Does the change result in departure from a method of evaluation described in the final SAR (as updated) used to establish design bases or in the safety analysis?	YES	NO
		x

Category	***Reference/Text***	***Value***
Design Basis	N/A	N/A
New Analysis	N/A	N/A
Comparison	N/A	N/A

Comments: The ultrasonic cleaning device was designed, manufactured, and safety qualified by a commercial company with extensive experience applying ultrasonic cleaning methods to commercial power reactor fuel. Design and manufacturing of the system is based on technology developed and used for over two decades in the power industry and is adapted to clean TRIGA fuel. Safety testing extended methods used in prior fuel cleaning qualification programs to stainless steel TRIGA fuel [1]. Manufacturer testing conclusions show no concerns for material integrity for cleaning exposures up to 120 minutes [2,3].

Fuel element failure accident (Maximum Hypothetical Accident) in the Safety Analysis Report does not credit any type of device or force as a cause of the accident. Based on the safety qualification provided by the manufacturer, this device does not pose any more likelihood of increasing the occurrence of the Maximum Hypothetical Accident than normal fuel movement and inspection operations.

References:
[1] Dominion Engineering, Inc. Memo M-208-2301-00-02, Rev. 0
[2] Dominion Engineering, Inc. Letter L-208-2301-00-01, Rev. 1
[3] Dominion Engineering, Inc. Memo M-208-2301-00-01, Rev. 0

APPROVAL – According to Technical Specifications, Section 6.2(b)4, the Reactor Safeguards Committee is responsible for determining "whether changes in the facility as described in the safety analysis report (as updated), changes in the procedures as described in the final safety analysis report (as updated), and the conduct of tests or experiments not described in the safety analysis report (as updated) may be accomplished in accordance with 10 CFR 50.59 without obtaining prior NRC approval via license amendment pursuant to 10 CFR Sec. 50.90."

Date of RSC approval: 11/29/2023

Method of RSC approval: Voice Vote 5 aye including RSO, 0 nay

Attach appropriate records of RSC approval (e.g., email ballots or meeting minutes) to this form.