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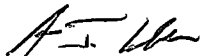
1 March 2022

**Subject: 2021 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

ADZO
NRR

Attachments:

1. Kansas State University TRIGA Mark II Reactor Annual Report, CY 2021

Cc: Linh Tran, Project Manager, NRC
Craig Bassett, Inspector, NRC

Kansas State University TRIGA Mark II Reactor Annual Report, CY 2021

Introduction

The Kansas State University Nuclear Reactor Technical Specifications (TS) require a routine written report to be transmitted to the US Nuclear Regulatory Commission 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 2021 – December 2021.

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KANSAS STATE UNIVERSITY TRIGA MARK II REACTOR ANNUAL REPORT

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 operated for its primary purposes in CY2021 and at an increased level compared to CY2020. Two undergraduate level classes were directly supported by the reactor facility. Reactor operations and applications of neutron beams laboratories were held in person. A spring reactor theory laboratory class typically supported by the facility was conducted through remote instruction. Tour activities were still reduced due to pandemic restrictions. About 230 visitors toured the facility which is much less than historical visitor volumes of over 1,000 individuals. Operating hours dedicated to training was decreased due to availability to operate and train during operations for research activities. Minimal operating hours for testing occurred due to no major maintenance issues affecting operations equipment. Primary research operations involved detector testing using beamlines, characterizing material performance following neutron irradiation, gamma irradiation of materials using the decay of fission products, and neutron radiography of a heated test loop.

The NRC routine annual inspection was completed from June 1-3, 2021. A report dated July 14, 2021 indicating no findings of significance was received as a result of the inspection (Inspection Report No. 05000188/2021201).

Water ingress into the beam port facilities is still being monitored. Maintaining primary pool temperature around room temperature has limited leak rate significantly. Bulk shield tank and primary pool cleaning and maintenance continues in preparation for refurbishing.

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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. The same data is shown as a bar chart in Figure 1. Operations varied but increased in general as the year progressed. Overall, operations were up 28% in terms of MWh burnup compared to CY2020. Operations were suspended near the end of October following removal of two fuel elements due to failed visual examination. The removal of the second element placed the core loading less than the bounding limit in the Safety Analysis Report leading to the operations suspension. Examination of fuel to replace failed elements revealed another finding that is being evaluated.

Table 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2021.

Month	MWh Burnup
January	0.74
February	0.03
March	0.02
April	1.92
May	1.38
June	1.24
July	0.64
August	2.43
September	3.86
October	2.56
November	0.00
December	0.00
TOTAL	14.82

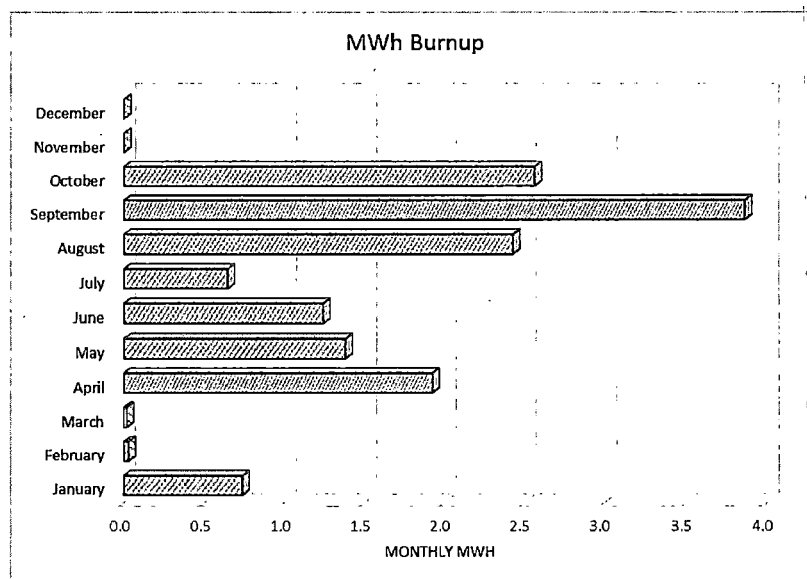


Figure 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2021.

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The reactor operated for a total of 155 hours during 2021, at an average power of 96 kW. Table 2 lists the number of hours operated and Figure 2 shows the percentage of operation for various purposes, i.e., research support, training, education, etc. Most operating hours were performed for research, classes, and maintenance. Approximately half of maintenance operations were conducted for determining control rod calibrations. Research and class operations increased about 50% compared to the previous year. The chart demonstrates that the reactor is operated in accordance with our stated primary functions: education, research support, operator training, and demonstration (e.g., tours). Tour operations were still limited as in CY2020 due to COVID-19 restrictions.

Table 2 – Operating hours grouped by purpose at the KSU TRIGA Mark II reactor for CY 2021.

Purpose	Operating Time [hr]
Research	52
Tours	2
Classes	33
Maintenance	57
Training	7
Testing	4
TOTAL	155

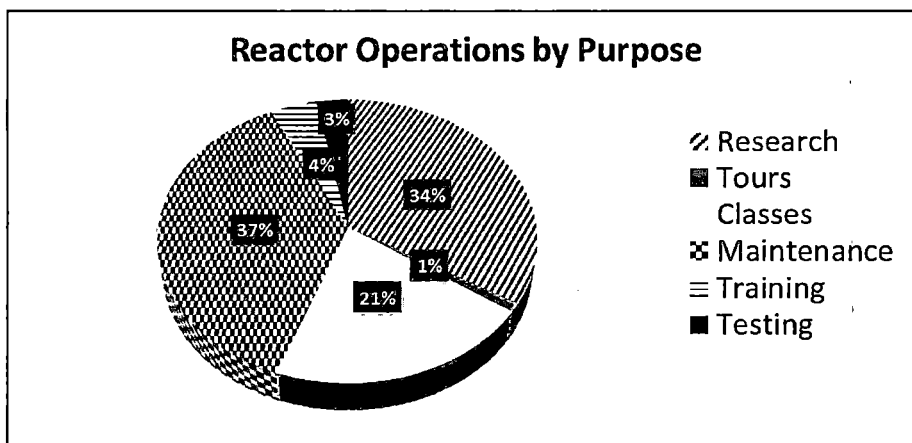


Figure 2 – KSU TRIGA Mark II operations distribution as a percentage of total hours, CY2021, based on purpose of operation.

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

For CY2021, there was a manual SCRAM for action to maintain Limiting Conditions of Operation and one inadvertent SCRAM. Table 3 summarizes the SCRAMS for CY2021 at the KSU reactor. No emergency shutdowns occurred during the time period reported. The number of inadvertent SCRAMs has remained low (CY 2020: 2, CY 2019: 6, CY 2018: 20).

Table 3 – Inadvertent SCRAMs.

Date	Action	Comments
4/2/2021	Manual SCRAM	Pool surface area radiation monitor (ARM) alarmed during reactor startup. Air monitors and 22' ARM nominal readings. Survey meter reading in use during alarm read < 1 mR/hr. Check source test of pool surface ARM revealed faulty detector. Detector replaced and calibrated.
8/17/2021	Period SCRAM	Operator (trainee) error

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 CY2021 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 CY2021:

- Pool surface ARM detector module replaced with same make and model.
- Transient control rod decoupled from rod drive due to low air pressure. Pulse rod drive cylinder cleaned, and pulse rod piston rod cleaned and lubricated.
- Safety control rod position potentiometer bumped during transient control rod drive maintenance causing shift in reading. Potentiometer adjusted to pre-maintenance reading. Actual UP and DOWN position not affected. Calibration not affected.
- Regulating control rod magnet ON light failed to illuminate. Troubleshooting showed that the switch allowed motion enough to prevent activation. Switch more securely fastened. Retest SAT.
- Leak detected in reverse osmosis makeup water system due to incorrect fittings. Replaced with correct components. No leaks detected following repair.
- Air compressor aftercooler fitting broke due to overtightening. Aftercooler replaced.
- Shim control rod magnet ON lightbulb replaced.
- Primary cleanup loop ion exchange resin and particulate filter replaced.
- Primary cleanup loop filter housing gasket (bottom) and ion exchanger strainer (outlet) rubber washer replaced.

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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 facility changes occurred during CY2021.

Experiment 50 – Gamma Irradiation was revised to update dose estimation, allow for variable operation time before shutdown, increase decay time following operation, implement editorial changes, and add precautions for contamination.

Experiment 56 – Packed Bed Vapor Void Fraction Imaging was reviewed and approved by Reactor Safeguards Committee.

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 and total activity of liquid effluent were calculated prior to discharge, showing both to be below the limits in 10CFR20. 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	<=Bkg	4.73E6	<=Bkg
Beta-emitters	1.3E-11	4.73E6	6.3E-5

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.

Radiation surveys of the operations boundary at full power revealed dose rates (gamma and neutron) slightly above background readings. The maximum dose rate of 0.4 mrem/hr at the operations boundary while operating at full power was the same as

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CY2020 and less than the ALARA goal. Two thermoluminescence dosimeters (TLD) are placed at the operations boundary for environmental/area monitoring monthly. Table 5 summarizes the monthly TLD measurements for CY2021. Reports for September through December monitoring periods have not been received. All monthly dose measurements at the confinement boundary were reported as zero mrem. Three of the eight control room door dose measurements were reported above zero. Note control room door readings above minimal did not correlate with operations. Energy production in January, February, and July varied drastically (Table 1) while dose reported remained the same 2 mrem. Also note for the highest operating month for which reports were received (August), the control room door reported zero mrem for the monitoring period. Overall, reported values for the control room door area monitor remain very low.

Table 5 – Environmental and Area Monitor Monthly Doses 1/1/2021 - 8/31/2021. NR – Not Reported

Month	Control Room Door	Reactor Confinement (South)
	[mrem]	[mrem]
January	2	0
February	2	0
March	0	0
April	0	0
May	0	0
June	0	0
July	2	0
August	0	0
September	NR	NR
October	NR	NR
November	NR	NR
December	NR	NR
TOTAL	6	0

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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.

Dose reports have been received from the dosimetry vendor for January to August 2021 monthly monitoring periods. In addition to delays in reporting, monthly dosimeter for November was not exchanged until 2022. The dosimeter for the November monitoring period was worn until an exchange was possible. Overall, no staff exceeded 20 mrem total for a reported whole-body dose (Jan.-Aug.). Table 6 shows the distribution of worker doses based on eight months of reports available. The average deep dose equivalent was 5 mrem with a maximum of 12 mrem. The lens dose equivalent also had an average of 5 mrem and a maximum for an individual of 12 mrem. Shallow dose equivalent average was 6 mrem with a maximum of 12 mrem. Extremity monitoring had an average of 23 mrem and a maximum of 77 mrem for an individual. The maximum cumulative deep dose was associated with a worker who was also monitored in another location outside the facility. Overall, values are well below ALARA goals.

Table 6 - Summary of total occupational dose received by KSU reactor workers from 1/1/2021 - 8/31/2021.

mrem	DDE	LDE	SDE	Max Extremity
[0, 10]	8	8	7	3
(10, 20]	1	1	2	1
(20, 30]	0	0	0	3
(30, 40]	0	0	0	0
(40, 50]	0	0	0	1
(50,100]	0	0	0	1
(100,150]	0	0	0	0
(150,200]	0	0	0	0

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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 3 summarizes the distribution of visitor exposures recorded. For a total of 229 visitor dose records, over 95% of the visitor dose records are at 1 mR or less.

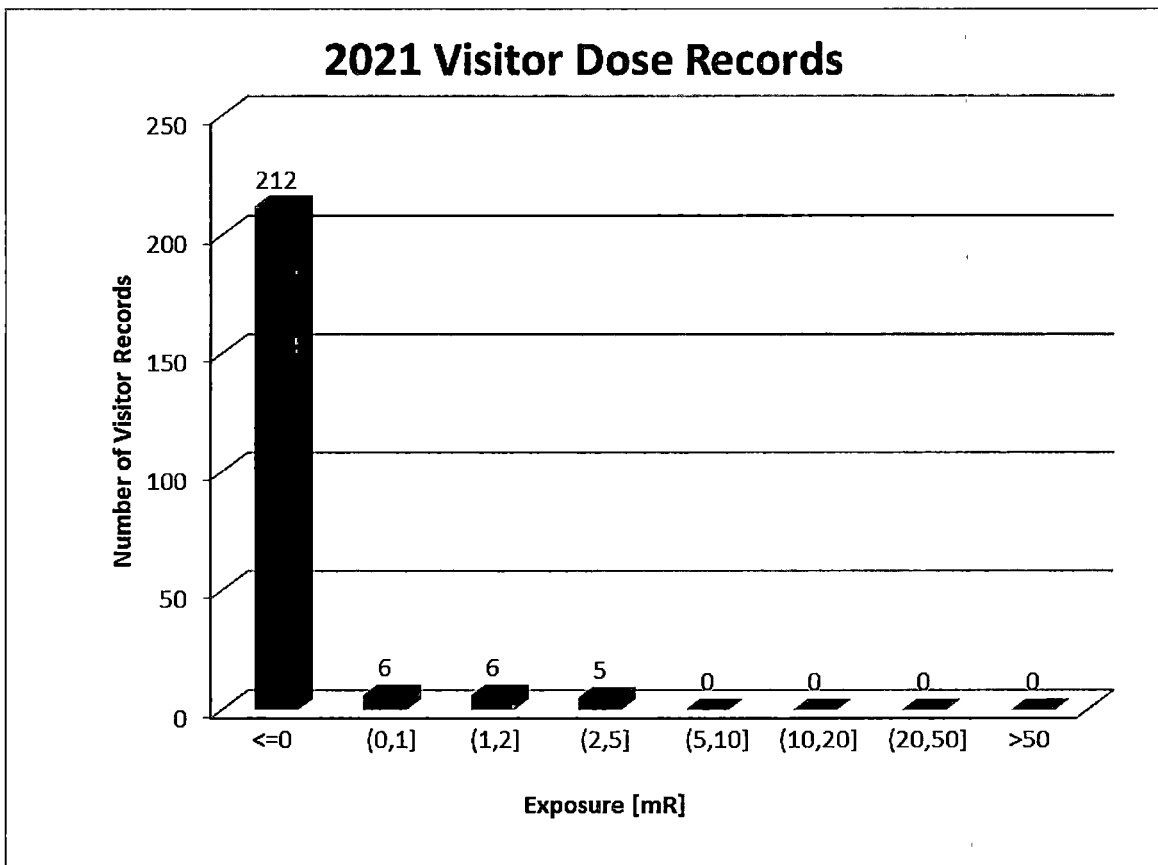


Figure 3 - Visitor exposure records from CY 2021.

All monthly radiation and contamination surveys conducted at the facility in 2021 were nominal, and no action levels were exceeded.

This concludes the 2021 Annual Report for the Kansas State University TRIGA Mark II Nuclear Reactor.