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US NRC
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Washington, DC 20555-0001

26 January 2017

Subject: 2016 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. This document satisfies requirements in facility Technical Specifications (TS) 6.11.e.

The report is divided into paragraphs addressing specific items listed as requirements in the Technical Specifications.

Sincerely,

Ja Geuther

Jeffrey A. Geuther, Ph.D.
Nuclear Reactor Facility Manager
Kansas State University

Attachments:

1. Kansas State University TRIGA Mark II Reactor Annual Report, CY 2016
2. 10CFR50.59 Screening Forms

Cc: Spyros Traiforos, Project Manager, NRC
Michael Morlang, Inspector,NRC

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Kansas State University TRIGA Mark II Reactor Annual Report, CY 2016

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 facilty.

This information is transmitted in this report, in sections separated by TS clause. This report covers January 2016 – December 2016.

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 usual purposes in CY2016. Two reactor operations laboratory classes and a reactor theory laboratory class were supported, along with approximately 10 other courses with less frequent need of the reactor. In addition to the reactor operations laboratory classes, a new Nuclear Power Systems Laboratory class was developed and used the reactor facility for several laboratory experiments. 2392 visitors received access to the facility for various outreach activities, classes, and research experiments. This represents a slight increase over the previous year.

Typical funded research experiments included neutron activation analysis (NAA), neutron detector testing at beam ports, and the measurement of integral fuel element worth using the positive period method. Two new experiments were approved in 2016: Experiment 53: Void Coefficient of Reactivity Measurement, and Experiment 54: Piercing Beam Port Characterization, which provides guidance for performing Bonner sphere measurements at the piercing beam port with little or no beam collimation.

The NRC routine annual inspection was completed from August 1 – 4, 2016. No violations or inspector follow-up items were reported. (See Inspection Report No. 50-188/2016-201).

During the last quarter of 2015 the rate of water makeup to primary was noted to be higher than usual by approximately 70 gallons per week. The reactor staff identified a trickle of primary coolant water emanating from the thermal column and collecting in the reactor sump. The leak was repaired by sealing the thermal column with a gasketed aluminum plate. This seal required several further repairs during early 2016 to prevent water from leaking from bolt holes, but the leak from the thermal column has now been effectively stopped. In spite of this progress, evidence of water ingress into the reactor beam port facilities has led to the decision to apply an epoxy seal to the weld seams in the reactor tank at some point in the near future, i.e., in the next one to two years. The repair is tentatively scheduled to begin in July 2017.

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. The total MWh of operation decreased from the prior year, from 55.9 MWh to 42.1 MWh.

Table 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2016.

Month	MWh Burnup
January	0.26
February	1.44
March	2.79
April	6.38
May	1.66
June	8.71
July	6.16
August	4.94
September	1.24
October	4.65
November	2.15
December	1.70
TOTAL	**42.08**

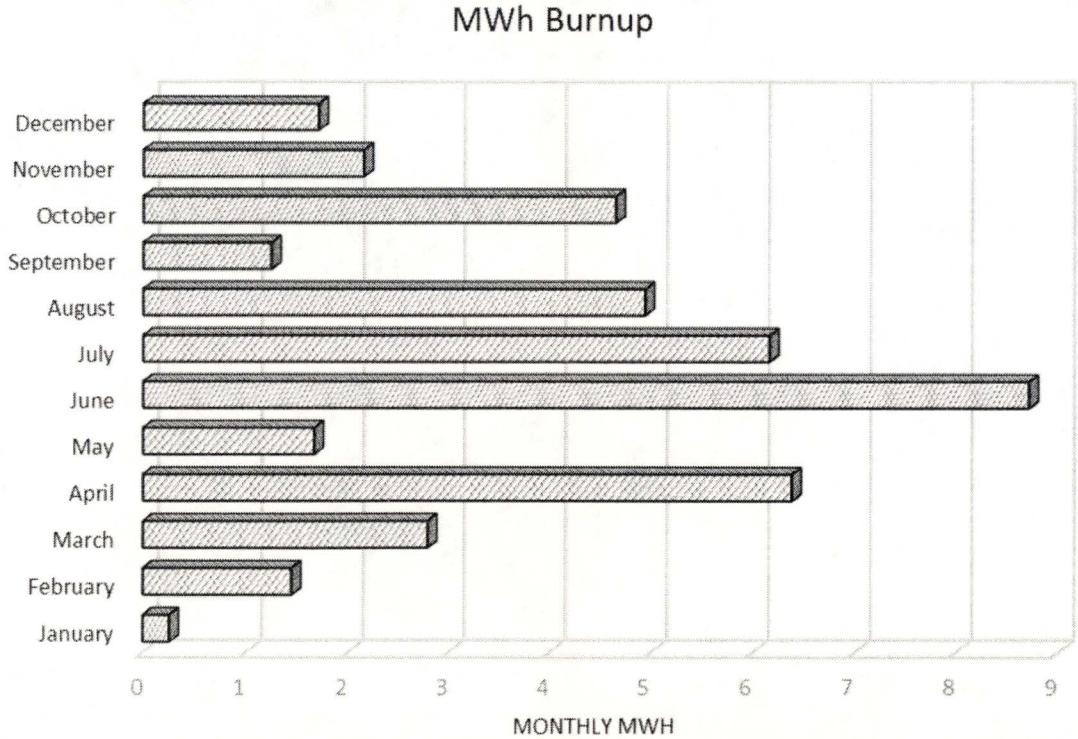

Figure 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2016.

The reactor operated for a total of 449 hours during 2016, at an average power of 94 kW. Figure 2 shows the percentage of hours of reactor operation for various purposes, i.e., research support, training, education, etc. The percentage of hours for training appears small, because operator training was often performed when the reactor was being operated for another purpose, such as research support. The plot demonstrates that the reactor is operated in accordance with our stated primary functions: education; research support (e.g., irradiation); operator training; and demonstration (e.g., tours). Compared to

CY2015, the total number of hours and percentage of time spent supporting paid research both decreased.

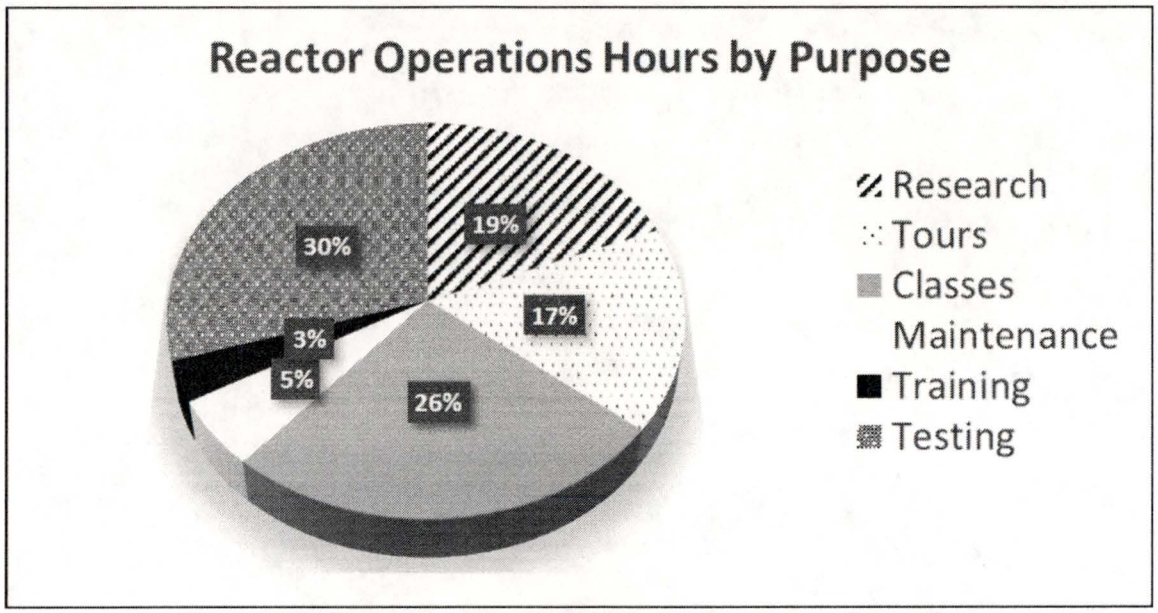

Figure 2 - KSU reactor hours, CY2016, based on purpose of operation.

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

The following table documents the inadvertent SCRAMS for CY 2016 at the KSU reactor. This table does not include single dropped rods. There were occasions when rods dropped, but not due to a reactor trip. There were no emergency shutdowns. Note that the period scrams due to transient rod motor noise occur when the other rods are bottomed and the transient rod is being raised during a startup. In other words, the reactor is at very low power when those scrams occur.

Inadvertent SCRAMS and Emergency Shutdowns

Date	Action	Comments
1/24/16	Period scram	Due to transient rod motor noise
2/12/16	Period scram	Source interlock clear, but the AmBe startup source was not fully seated.
3/11/16	Period scram (2)	Due to transient rod motor noise
4/18/16	Period scram	Operator error
8/16/16	Period scram	Due to transient rod motor noise
10/17/16	Scram	Console mode select switch was set to invalid mode.

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.

No major maintenance operations affected the safe operation of the reactor. The following major maintenance activities occurred:

- Completed water leak repair on thermal column.
- Replaced CAM with new unit comprised on parts from Thermo AMS-4.
- Repaired leak in HVAC air handler unit.
- Replaced magnehelic differential pressure gauge with Dwyer Mk II manometer.

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

The following changes were carried out under 10CFR-50.59:

- The magnehelic differential pressure gauge in the control room was replaced with a manometer.
- The continuous air monitor was replaced with a newer model based on Thermo AMS-4 components.
- The thermal column seal (aluminum plate and gasket) were evaluated using the 50.59 process.

The screening forms for these changes are attached.

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 radioisotope inventory and concentration were calculated prior to discharge, showing both to be well below the limits in 10CFR-20:

Isotope	Avg. Concentration (Ci / mL)	Limit* (µCi / mL)	Total Volume (mL)	Total Activity Released (Ci)
Alpha-emitters	0.00E+00	N/A	8.39E+06	5.00E-02
^{3}H	3.23E-11	1.00E-02		2.80E-04
^{14}C	8.45E-12	3.00E-04		8.30E-05
^{32}P	4.20E-12	9.00E-05		4.80E-05

*10CFR-20, App.B

The only other discharges beyond the facility boundary were HVAC condensate discharges to the sanitary sewer. Since the Kansas State University average water usage is 750,000 gallons per day, it is nearly impossible to exceed 10CFR20 limits for effluent concentration at the KSU reactor. HVAC condensate water is never circulated through or

near the reactor core and historically radiation levels in HVAC condensate are near background levels.

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

Monthly radiation surveys are performed within the facility to verify that radiation levels remain safe when at full-power operation. These surveys indicate that the dose rate at the inside surface of the reactor dome does not exceed the hourly dose limit to members of the public of 2 mR / h, as set forth in 10CFR-20, which indicates that the outside dose cannot exceed this limit.

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.

A table showing the number of workers receiving given amounts of dose is presented below. The total is given through the end of November, since the dosimetry results for December have not been received yet.

Table 2 - Summary of total occupational dose received by KSU reactor workers from 1/1/2016 - 11/30/2016. (Data for December 2016 is not yet available).

mrem	DDE	LDE	SDE
(0, 10]	2	2	2
(10, 20]	2	2	1
(20, 30]	0	0	1
(30, 40]	3	2	0
(40, 50]	1	2	1
(50,100]	2	1	4
(100,150]	1	2	2

Visitor dose at the KSU TRIGA reactor facility is measured using Civil Defense self-indicating pocket 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.

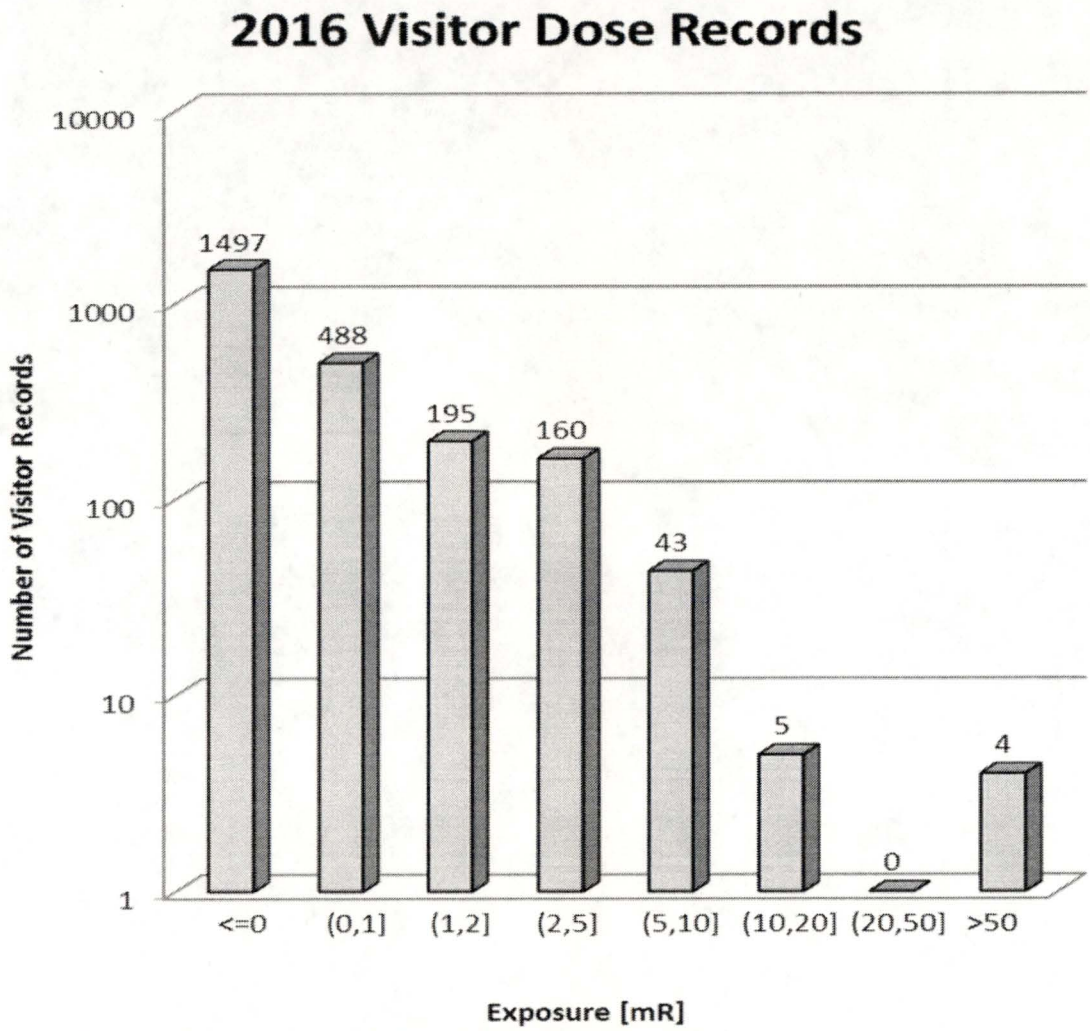

Figure 3 - Visitor exposure records from CY 2016.

All radiation surveys and contamination surveys conducted at the facility in 2016 were nominal.

This concludes the 2016 Annual Report for the Kansas State University TRIGA Mark II Nuclear Reactor.

TITLE	***Install Al / gasket seal over thermal column***	DATE	1/5/2016
DESCRIPTION	Install ¼" Al 6061 plate with gasket seal, screwed into Al on perimeter of thermal column on outside (between graphite and door). Purpose is to prevent water that is leaking into the TC from getting out to the sump.		

SCREENING: The following guidance provides criteria to screen the proposed change from further assessing need for NRC review. If the change does not affect (1) a design function of SSC, (2) a method of performing or controlling design function, (3) evaluation for demonstrating the design function will be accomplished, then it is not necessary to continue the evaluation.

SSC Affected	**SSC Design function**	**Failure Mode(s)**	**Accident scenario(s)**

SAFETY ANALYSIS & ACCIDENT RESPONSE/MITIGATION	YES	NO
Decrease SSC design function reliability when failure would initiate an accident		X
Decrease SSC design function reliability when failure would mitigate accident		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 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 an unwanted or previously unreveiwed system or material interaction		X
(Not described in SAR) indirect effects on electrical distribution		X
(Not described in SAR) indirect effects 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

COMMENTS:

PERFORMED BY: _____Geuther_____ DATE __1/5/2016_____

If any of the above answers are YES, then proceed to the EVALUATION section.

TITLE	*CAM Replacement*	DATE	3/1/2016
DESCRIPTION	Replace Tech Associates MFT-5 CAM with Eberline AMS-4 iodine		
Detector head module.			

SCREENING: The following guidance provides criteria to screen the proposed change from further assessing need for NRC review. If the change does not affect (1) a design function of SSC, (2) a method of performing or controlling design function, (3) evaluation for demonstrating the design function will be accomplished, then it is not necessary to continue the evaluation.

SSC Affected	SSC Design function	Failure Mode(s)	Accident scenario(s)
NA	NA	NA	NA

SAFETY ANALYSIS & ACCIDENT RESPONSE/MITIGATION	YES	NO
Decrease SSC design function reliability when failure would initiate an accident		X
Decrease SSC design function reliability when failure would mitigate accident		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 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 an unwanted or previously unreveiwed system or material interaction		X
(Not described in SAR) indirect effects on electrical distribution		X
(Not described in SAR) indirect effects 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

COMMENTS:

PERFORMED BY: J A Geuther DATE: 3/1/2016

If any of the above answers are YES, then proceed to the EVALUATION section.

TITLE	***Replace DP Gauge with manometer***	DATE	9/28/16
DESCRIPTION	Replace magnehelic differential pressure gauge with Dwyer Mk II		
manometer. This change will make the measurement of differential pressure easier and			
will eliminate the need to calibrate the gauge.			

SCREENING: The following guidance provides criteria to screen the proposed change from further assessing need for NRC review. If the change does not affect (1) a design function of SSC, (2) a method of performing or controlling design function, (3) evaluation for demonstrating the design function will be accomplished, then it is not necessary to continue the evaluation.

SSC Affected	**SSC Design function**	**Failure Mode(s)**	**Accident scenario(s)**

SAFETY ANALYSIS & ACCIDENT RESPONSE/MITIGATION	YES	NO
Decrease SSC design function reliability when failure would initiate an accident		X
Decrease SSC design function reliability when failure would mitigate accident		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 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 an unwanted or previously unreveiwed system or material interaction		X
(Not described in SAR) indirect effects on electrical distribution		X
(Not described in SAR) indirect effects 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

COMMENTS:

PERFORMED BY: _____Geuther_____ DATE 9/28/2016

If any of the above answers are YES, then proceed to the EVALUATION section.