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7 April 2015

**Subject: 2014 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,

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

Attachments:

1. Kansas State University TRIGA Mark II Reactor Annual Report, CY 2014
2. 10CFR50.59 Screening Forms

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

A020
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# Kansas State University TRIGA Mark II Reactor Annual Report, CY 2014

## 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 2014 – December 2014.

## 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 CY2014. 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. 2650 visitors received access to the facility for various outreach activities, classes, and research experiments.

Typical experiments included prompt gamma neutron activation analysis (PGNAA), neutron activation analysis (NAA), neutron detector testing at beam ports, and gamma irradiation with decay gammas from the reactor core. Two new experimental procedures were approved. Experiment 51 allows for the irradiation of samples in an automatic insertion / removal apparatus installed in the radial reflector well previously occupied by the rotary specimen rack. Experiment 52 provides a method of measuring the integral worth of fuel elements based on measuring the positive period of the core with all rod out and excess reactivity close to zero. Experiment 51 has been performed during CY2014; Experiment 52 has not yet been performed.

The NRC routine annual inspection was completed from June 24 – 26$^{th}$, 2014. No violations or inspector follow-up items were reported.

## 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 99.5 MWh to 48.2 MWh.

**Table 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2014.**

| Month | MWh Burnup |
|---|---|
| January | 1.4 |
| February | 2.7 |
| March | 5.4 |
| April | 8.1 |
| May | 1.3 |
| June | 3.0 |
| July | 5.9 |
| August | 0.8 |
| September | 5.1 |
| October | 5.7 |
| November | 2.8 |
| December | 5.9 |
| **TOTAL** | **48.2** |

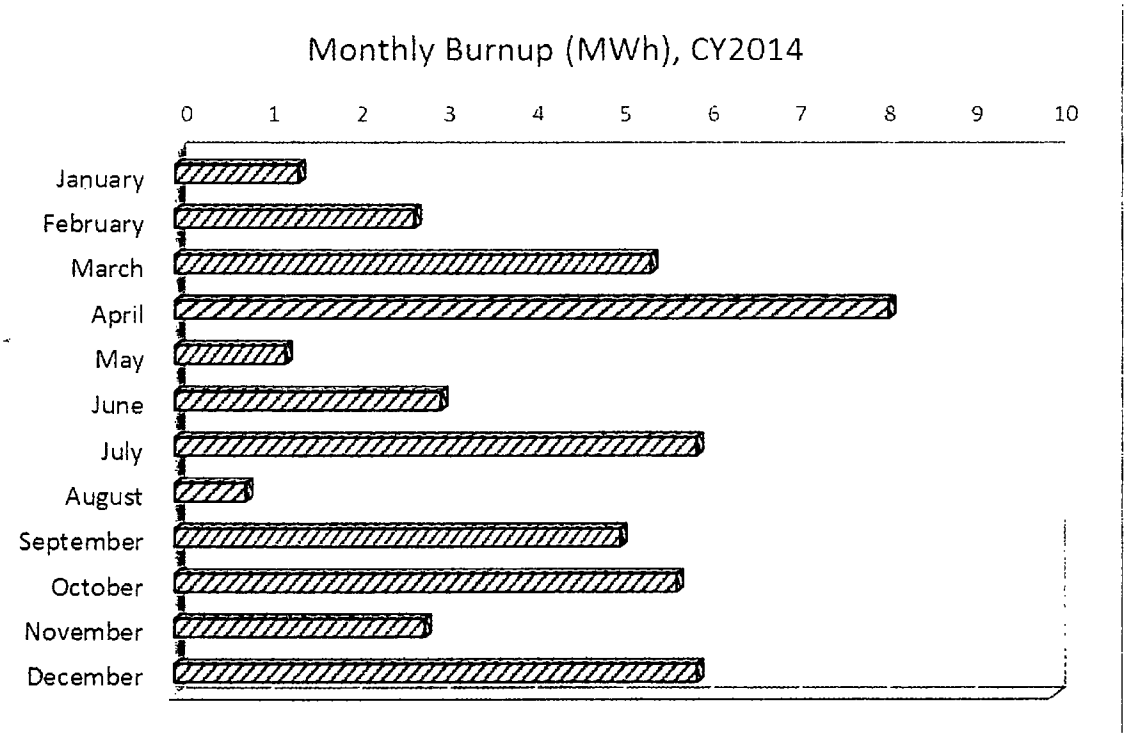


**Figure 1 - Energy generated by the KSU Triga Mark II reactor by month for CY 2014.**

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).

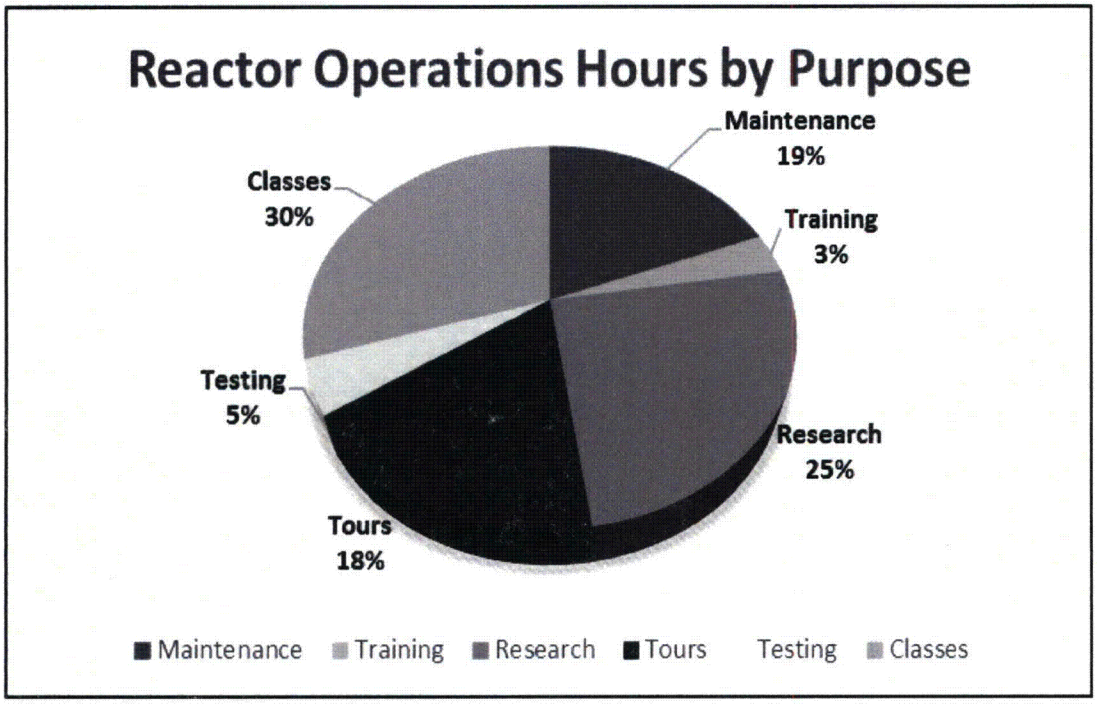


**Figure 2 - KSU reactor hours, based on purpose of operation.**

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

Inadvertent SCRAMS and Emergency Shutdowns

| Date | Action | Comments |
|---|---|---|
| 6/13/14 | Period scram | Due to noise spike when pumps energized |
| 11/13/14 | Period and HV scram | Cause unknown – thought to be spurious |

## 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:

- Installation of a secondary water chemistry control system;
- Installation of a water radiation monitor;
- Replacement of the secondary water holding tank (i.e., surge tank);
- Replacement of the primary water pump;
- Installation of the intra-reflector irradiation system (IRIS) for Experiment 51.

## 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.

- Replacement of water radiation monitor with new unit;
- Addition of "slow starts" to primary and secondary water pumps to avoid noise spikes on nuclear instruments;
- Temporary replacement of NPP-1000 Percent Power channel power meter with external analog meter;
- Replacement of primary water pump;
- Replacement of control room radiation monitor / evacuation monitor.

None of the above changes were determined to have a significant impact on the safety analysis. Copies of the 10CFR-50.59 screening checklists that were performed to accept the changes are attached to this report.

## 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.

On five occasions the contents of the reactor bay sump were discharged to the sanitary sewer. 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 | 6.11E-11 | N/A | 1.78E7 | 1.09E-3 |
| $^{3}H$ | 7.01E-12 | 1.00E-02 | | 1.25E-04 |
| $^{14}C$ | 5.57E-12 | 3.00E-04 | | 9.91E-05 |
| $^{32}P$ | 3.70E-12 | 9.00E-05 | | 6.58E-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 facilty.

A table showing the number of workers receiving given amounts of dose is presented below. Note that no worker received a shallow dose equivalent, deep dose equivalent, or lens dose equivalent in excess of 100 mrem. This shows that the facility radiation protection program has continued to be successful in keeping occupational doses as low as reasonably achievable.

**Table 2 - Summary of total occupational dose received by KSU reactor workers from 1/1/2014 - 12/31/2014.**

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

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.

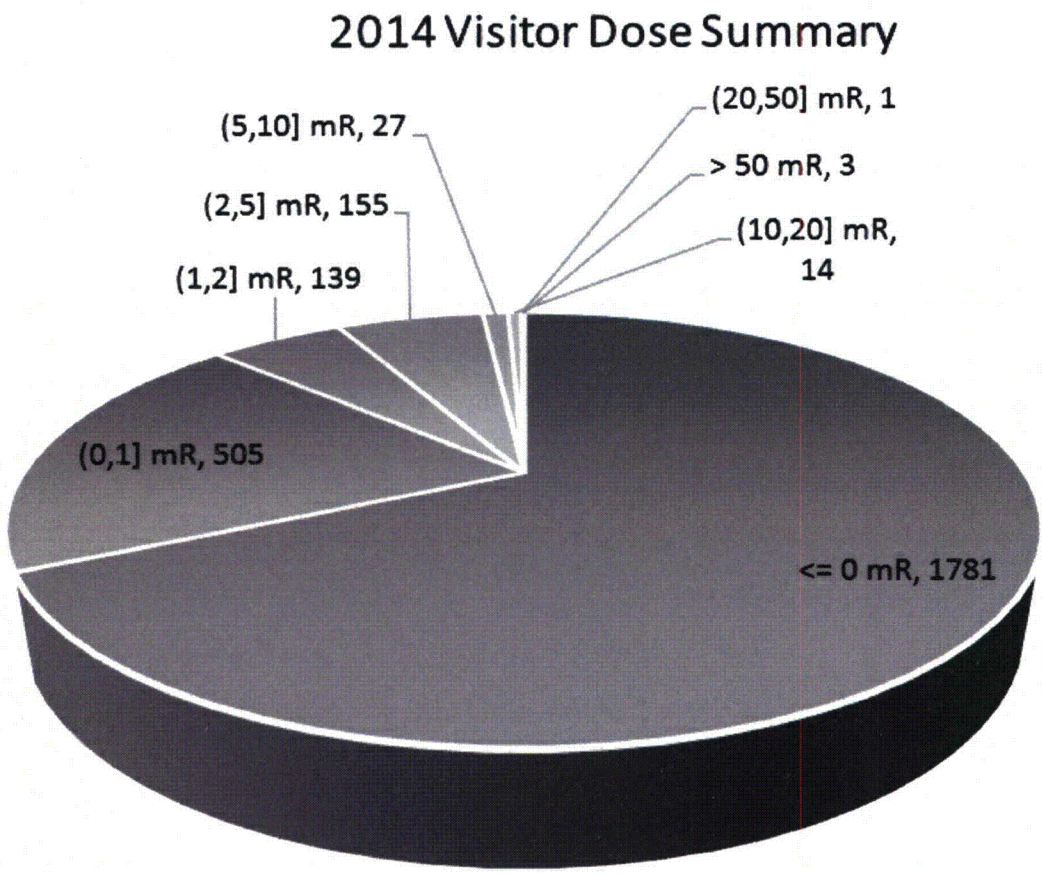


**Figure 3 - Visitor dose records from CY 2014.**

All radiation surveys and contamination surveys conducted at the facility in 2014 were nominal.

This concludes the 2014 Annual Report for the Kansas State University TRIGA Mark II Nuclear Reactor.

| TITLE | *Secondary Pump* | DATE | 1/7/2014 |
|---|---|---|---|
| DESCRIPTION | Replace Bell & Gossett 7.5 HP 2 in. inlet, 1.5 in. outlet, 220 V 3 ph. centrifugal pump with Gould 3 ph. 7.5 HP, 2 in. inlet, 1.5 in. outlet, 220 V centrifugal pump | | |

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: 1/7/2014

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

| TITLE | ***Control Room Rad Monitor*** | DATE | 5/5/2014 |
|---|---|---|---|
| DESCRIPTION | Replace old Victoreen Vamp control room radiation monitor with a | | |
| Ludlum 375 monitor. | | | |
| | | | |

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: 5/5/2014

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

| TITLE | ***Water Radiation Monitor*** | DATE | 5/5/2014 |
|---|---|---|---|
| DESCRIPTION | Replace old (currently uninstalled) water rad monitor with a Thermo- | | |
| Eberline system. | | | |
| | | | |

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: New system will have both local and remote readouts – old system just had remote readout. Water rad monitor is mentioned in SAR but not required by Tech Specs. Old system was broken and has not been in use for several years.

PERFORMED BY: J A Geuther DATE: 5/5/2014

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

| TITLE | *Pump slow start* | DATE | 10/8/2014 |
|---|---|---|---|
| DESCRIPTION | Add slow starts to primary and secondary pumps in order to avoid noise spikes in Nis when pumps are cycled on. | | |

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) |
|---|---|---|---|
| Primary / Secondary pumps | 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: 10/8/2014

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

Pumps are not required to be on during operation and credit is not taken for pumps in any of the SAR accident scenarios. In 6 seconds, the expected time for the slow start to take, the reactor tank can heat by about 0.1°C at 1250 kWth.

| TITLE | *Temporary replacement for NMP1000 % Power meter* | DATE | 12/5/2014 |
|---|---|---|---|
| DESCRIPTION | Replace GA MM9102-1 analog percent power meter with GA NM 7303-4 analog percent power meter while MM9102-1 is being repaired. This component dislays NMP-1000 percent power. | | |

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) |
|---|---|---|---|
| Primary / Secondary pumps | 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: 12/5/2014

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