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March 10, 2023

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
Attention: Document Control Desk

Dear Ms. Cindy Montgomery,

Enclosed is the 2022 Annual Operating Report required by the Technical Specifications for the Armed Forces Radiobiology Research Institute (AFRRI) Facility Operating License No. R-84, Docket 50-170.

Should you need any further technical information, please contact Mr. Andrew Smolinski at (301) 295-1288.

Mohammad Naeem, MD, FCCP, FACR
Colonel, Medical Corps, US Army
Director AFRRI

Enclosures:
As Stated

Armed Forces Radiobiology Research Institute
AFRRI TRIGA Reactor Facility

1 January 2022 - 31 December 2022

To satisfy the requirements of
U.S. Nuclear Regulatory Commission License No. R-84 (Docket No. 50-170),
Technical Specification 6.6.a.

Prepared by
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Reactor Staff

Submitted by
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2022 ANNUAL REPORT

TABLE OF CONTENTS

Introduction

General Information

Section I

Changes in the Facility Design, Performance Characteristics, Administrative Procedures, Operational Procedures, Results of Surveillance Tests and Inspections

Section II

Energy Generated by the Reactor Core and the Number of Pulses \$2.00 or Larger

Section III

Unscheduled Shutdowns

Section IV

Safety-Related Corrective Maintenance

Section V

Facility and Procedure Changes as Described in the Final Safety Analysis Report (FSAR), Changes Made Pursuant to 10 CFR 50.59 and not Submitted for Commission Approval, and New Experiments or Tests Performed During the Year

Section VI

Summary of Radioactive Effluent Released

Section VII

Environmental Radiological Surveys

Section VIII

Exposures Greater Than 25% of 10 CFR 20 Limits

2022 ANNUAL REPORT

INTRODUCTION

The Armed Forces Radiobiology Research Institute (AFRRI) reactor facility was unavailable for normal operations in the first half of 2022, pending licensing of new Reactor Operators and NRC approval of a License Amendment Request involving Technical Specification changes related to installation of a new analog/digital control system. Operating licenses were received on 21 April 2022 for three Senior Reactor Operators and one Reactor Operator, and Amendment No. 26 to Reactor Operating License R-84 was granted on 27 June 2022. In the second half of 2022 all deferred surveillances and maintenance activities were completed, including: fuel and control rod inspection; core reloading; thermal power calibration; and determination of power coefficient.

The 2022 annual reactor audit required by the reactor technical specifications was conducted on 13-14 December 2022 by Luke Gilde and Michael Hottinger from the University of Maryland reactor facility. The audit report indicated no major discrepancies were found in reactor operations, maintenance, or documentation. The audit identified some minor findings and provided suggested changes.

A comprehensive NRC inspection of reactor facility operations was conducted by Mr. Andrew Waugh and Mr. Juan Arellano from July 25-28, 2022, which included observation of the first and second startups of the reactor. The inspection resulted in no new violations or Inspection Follow-up Items (IFI), and the closure of one outstanding IFI.

There were two RRFSC membership changes during the year. There were two reactor staff arrivals and one staff departure during the year.

The remainder of this report is written in the format designated in the Technical Specifications for the AFRRI TRIGA Reactor Facility. Items not specifically required are presented in the General Information section. The following sections correspond to the required items listed in Section 6.6.a. of the Technical Specifications.

GENERAL INFORMATION

Key AFRRI personnel (as of 31 December 2022) are as follows:

1. AFRRI Director – Mohammad Naeem, COL, MC, USA
Radiation Sciences Department (RSD) Head – Andrew Cook (SRO)
Radiation Safety Officer – Jeffrey Sumlin
2. Reactor Facility Director (RFD) – Andrew Cook [Interim] (effective 24 April 2021)
3. Reactor operations personnel:
Reactor Operations Supervisor – Andrew Smolinski
Training Coordinators – Harry H. Spence and Mathieu Brener (SRO)
Maintenance Specialist – MSG Benjamin Knibbe, USA
Records Administration Specialist – Harry H. Spence
4. Other Reactor Operators:
Timothy Ayers (SRO)
Addison Guynn (RO)
5. Operator candidates:
Benjamin Knibbe, Justin Payer, Andrew Smolinski, CPT Balazs Bene, USA
6. Newly licensed operators:
Timothy Ayers (SRO), 21 April 2022
Mathieu Brener (SRO), 21 April 2022
Andrew Cook (SRO), 21 April 2022
Addison Guynn (RO), 21 April 2022
7. Additions to staff during 2022:
Andrew Smolinski, Chief, Sources Division
MAJ Andrew Ng, USA
8. Departures during 2022:
LTC Omololu Makinde, USA
9. There were two changes to the Reactor and Radiation Facilities Safety Committee (RRFSC) during 2022: Andrew Smolinski (AFRRI RSD) and Jere Jenkins (Texas A&M University) joined the RRFSC as voting members.

In accordance with the requirements set forth in Section 6.2.1.1 of the Technical Specifications for the AFRRI TRIGA Reactor Facility, the RRFSC consisted of the following members as of 31 December 2022.

Regular members are:

Radiation Safety Officer – Jeffrey Sumlin

Additional Appointee – Andrew Smolinski

Reactor Operations Specialist – Leo Bobek

Health Physics Specialist – Joe Pawlovich

Reactor Facility Director (Interim) – Andrew Cook

Reactor Operations Specialist – Jere Jenkins

RRFSC Chair and Director's Representative – LTC Jeffrey Brown, USA

Recorder - Harry H. Spence

Two meetings were held in 2022:

1 June

6 December

SECTION I

Changes in the Facility Design, Performance Characteristics, Administrative Procedures, Operational Procedures, Results of Surveillance Tests and Inspections

A summary of changes to the facility design, performance characteristics, administrative procedures, and operational procedures as well as the results of surveillance testing are provided in this section.

A. DESIGN CHANGES

The NRC granted license amendment request (LAR) No. 26 for the AFRRRI Triga Mark-F Operating License R-84 on 27 June 2022. The LAR included changes to the Technical Specifications related to installation of the new analog/digital control system.

Three facility modifications were performed that required 50.59 evaluations:

1. FM-001: Replacement of Soltec paper chart recorder for ventilation flow rates with Graphtec or Yokagawa digital recorders.
2. FM-002: Replacement of NP and NPP fission chambers with Uncompensated Ion Chambers
3. FSM-001: Reactor control system software modification to incorporate bug fixes identified during SAT-1 testing, improve human factors, and resolve software problems that caused two unscheduled reactor scrams.

B. PERFORMANCE CHARACTERISTICS

Subsequent to the LAR approval, the core was reloaded to the same configuration used before being unloaded for securing during the LAR approval process. A full core fuel and control rod inspection was completed with no new degraded fuel or control rods identified. Thermal power calibration and power coefficient of reactivity surveillances performed in August 2022 confirmed that core performance was in agreement with previous operational data.

C. ADMINISTRATIVE PROCEDURES

There were two new Administrative Procedures implemented in 2022:

1. 552 Facility Software Modifications
2. 553 Writing and Modifying Procedures

It should be noted that in 2022 the reactor procedures were restructured and renumbered. A comprehensive review of all procedures identified those requiring updates prior to reactor restart, and new procedures such as 552 and 553 needed for completeness and uniformity. The changes do not adversely affect reactor operations or safety. The revised procedures were approved by the RFD and reviewed by the RRFS.

D. OPERATIONAL PROCEDURES

There were several updates to the Operational Procedures during 2022 including re-numbering and reformatting:

- 001 Reactor Startup Checklist
- 002 Reactor Operations
- 003 Reactor Shutdown Checklist
- 004 Scrams, Alarms and Abnormal Conditions
- 005 Logbook
- 007 Reactor Room Safety
- 008 Movement of Core and Lead Doors
- 010 Conduct of Experiments
- 011 Reactor Exposure Room Entry
- 100 MCSA Activities
- 101 Weekly Checklist
- 102 Monthly Checklist
- 103 Quarterly Checklist
- 104 Semi-Annual Checklist
- 105 Annual checklist
- 200 Fuel Movement and Inspection
- 201 Control Rods
- 202 Control Rod Calibration and Shutdown Margin
- 206 Square Wave Reference Curve Development
- 215 Thermal Power Calibration and Power Coefficient
- 216 Low Source Interlock Test;
- 221 Primary Water RTD Test and Calibration
- 222 Pool Water Conductivity Test and calibration
- 223 Primary Water Level test and Calibration
- 253 Ventilation Flow Fault Damper Test
- 260 Facility Interlock System Test
- 291 AC Power Loss Scram Test
- 292 Watchdog Scram Test
- 293 Auto Mode Characterization

The changes do not adversely affect reactor operations or safety. The revised procedures were approved by the RFD and reviewed by the RRFSC.

E. RESULTS OF SURVEILLANCE TESTS AND INSPECTIONS

All maintenance and surveillance tasks during 2022 were accomplished as normally scheduled during the year, including those tasks involving the reactor fuel, instrumentation, control rod drives, and other related components that had been deferred during the instrumentation upgrade.

There was one reactor malfunction, and 28 corrective maintenance items identified during 2022. Refer to Section IV below.

The 2022 annual reactor audit required by the reactor technical specifications was conducted on 13-14 December 2022 by Luke Gilde and Michael Hottinger from the University of Maryland reactor facility. The audit report indicated no major discrepancies were found in reactor operations, maintenance, or documentation. There were six minor findings identified in the audit:

1. Signature or Initial lines should be filled out on all procedures and not left blank.
2. Fuel Inspection requirements should be included in the schedule of surveillance procedures.
3. When skipping steps in procedures, the relevant step should be crossed out and the change initialed along with a brief explanation to make it clear that it was not skipped accidentally.
4. Include a memo summarizing the changes made, methods, and results of the acceptance

testing in the documentation for future software modifications.

5. Document the testing performed to investigate scrams and unscheduled shutdowns.
6. Improve radiological control procedures for working in and around the Exposure Rooms.

Procedural changes to address all findings have been implemented.

A routine NRC inspection of reactor facility operations was conducted by Mr. Andrew Waugh and Mr. Juan Arellano from 25-28 July 2022. The inspection resulted in no new violations or Inspection Follow-up Items (IFI), and the closure of one outstanding IFI. The results of the inspection are documented in “ARMED FORCES RADIOBIOLOGY RESEARCH INSTITUTE – U.S. NUCLEAR REGULATORY COMMISSION SAFETY INSPECTION REPORTNO. 05000170/2022201,” dated August 24, 2022.

SECTION II

Energy Generated by the Reactor Core and the Number of Pulses \$2.00 or Larger

Month	Kilowatt-Hours
Jan	0.0
Feb	0.0
Mar	0.0
Apr	0.0
May	0.0
Jun	0.0
Jul	0.0
Aug	2,140.8
Sep	0.0
Oct	0.0
Nov	5,075.6
Dec	5,811.7
TOTAL	13,028.1

Total energy generated in 2022: 13028.1 kWh

Total energy on fuel elements: 1,171,874.8 kWh

Total energy on FFCRs*: 439,077.1 kWh

Total pulses this year \geq \$2.00: 0

Total pulses on fuel elements \geq \$2.00: 4,219

Total pulses on FFCRs* \geq \$2.00: 107

Total pulses this year: 0

Total pulses on fuel elements: 12,201

Total pulses on FFCRs*: 2,436

*Fuel-followed control rods

SECTION III

Unscheduled Shutdowns

There were 7 unscheduled shutdowns during 2022:

1. 1 Aug - AC power loss scram during operation
2. 24 Aug - Scram initiated by switching from auto to manual rod control (see Section IV)
3. 29 Aug - AC power loss scram during operation
4. 29 Aug - Scram initiated by switching from manual to auto rod control (see Section IV)
5. 5 Dec - Safety channel high power scram while moving core
6. 22 Dec - Reactor manually shut down due to control rod limit switch malfunction
7. 27 Dec - Facility Interlock System scram due to closing lead doors while operating

None of the unscheduled shutdowns were reportable events, and no operating limits were exceeded. The AC power loss scrams were caused by a periodic self-test of the console UPS. The scrams initiated by changing control rod modes were caused by a software deficiency that is described in the next section. The safety channel high scram was due to an artificially high (conservative) detector reading due to its placement in the reactor tank and core position, and did not result in an actual overpower condition. Power was approximately 80% (800kW) at the time of the scram.

SECTION IV

Safety-Related Corrective Maintenance

There was one reactor malfunction in 2022: on two occasions a software deficiency caused the reactor to scram when switching between manual and automatic rod control. The issue was addressed in Corrective Maintenance item CM 22-004 and corrected as part of a software update in October 2022.

There were 28 corrective maintenance items identified in 2022, 6 of which were safety-related.

1. CM 22-004: Spurious scrams occurred when switching between manual and auto rod control modes. The cause was traced to an unnecessary command in the ControlKeys.bas file. The file was edited to remove the command.
2. CM 22-011: Spurious de-energizing of the NPP scram relay during zero-power pulse testing, resulting in pulse data not being captured. Pulsing is procedurally restricted until a solution is found.
3. CM 22-015: During startup k-excess measurement was inconsistent with previous values. Rod position indication for the Safety Rod was found to be off by 100 units. A set screw on the potentiometer drive gear was replaced, and a linearity check of rod position vs. indication was completed satisfactorily.
4. CM 22-017: NPP indication 73% (high) while at 3 kW in core position 250. Installed a spacer and repositioned the NPP detector, and performed new thermal power calibration

- and power coefficient determination in core positions 250 and 500.
5. CM 22-019: Transient Rod failed to move during performance of startup checks. The motor was disassembled and a set screw was found to be backed out. The set screw was tightened, the motor reassembled and tested satisfactorily.
 6. CM 22-023: While performing scram tests during startup checks, the Pool Low scram would not clear. An acrid odor was detected in the reactor room, and investigation found a burned out spot on the scram logic board where a chip had overheated. The scram logic board was replaced with an identical board, and the system was tested by performing the Scram Tests from General Atomics Site Acceptance Tests (SAT-1).

SECTION V

Facility and Procedure Changes as Described in the Final Safety Analysis Report (FSAR), Changes Made Pursuant to 10 CFR 50.59 and not Submitted for Commission Approval, and New Experiments or Tests Performed During the Year

A. FACILITY CHANGES AS DESCRIBED IN THE FSAR

There were three facility modifications were performed that required 50.59 evaluations:

1. FM-001: Replacement of Soltec paper chart recorder for ventilation flow rates with Graphtec or Yokagawa digital recorders.
2. FM-002: Replacement of NP and NPP fission chambers with Uncompensated Ion Chambers
3. FSM-001: Reactor control system software modification to incorporate bug fixes identified during SAT-1 testing, improve human factors, and resolve software problems that caused two unscheduled reactor scrams.

B. PROCEDURE CHANGES AS DESCRIBED IN THE FSAR

The reactor administrative and operating procedures were restructured and renumbered in 2022. A new procedure change form and formalized 10CFR50.59 screening process were introduced, aligned with recently NRC-endorsed NEI 21-06 Rev1 guidance, to ensure all procedure changes were properly reviewed, validated and approved by appropriate personnel, and that all procedure changes were screened for the necessity to perform a 10CFR50.59 safety evaluation. Procedure updates that were needed to complete deferred surveillances and maintenance, and all others needed for reactor restart were prioritized. A list of procedures put in force in 2022 under the new structure and screening process are listed in Sections 1.C and 1.D.

C. NEW EXPERIMENTS OR TESTS

No new experiments or tests were performed during the reporting period that were not encompassed by the FSAR.

SECTION VI

Summary of Radioactive Effluent Released

A. Liquid Waste: The reactor produced no liquid waste during 2022.

B. Gaseous Waste: There were no particulate discharges in 2022.

The total activity of Argon-41 discharged in 2022 was 2.71 curies. The estimated effluent concentration from the release of Argon-41 represents 1.24% of the constraint limit for unrestricted areas (10 CFR 20.1101(d) and Table 2, Appendix B, 10 CFR 20).

Quarterly:	Jan - Mar 2022	0.00 Ci
	Apr - Jun 2022	0.00 Ci
	Jul - Sep 2022	1.19 Ci
	Oct - Dec 2022	1.52 Ci

C. Solid Waste: All solid radioactive waste material is transferred to the AFRI byproduct license; none was disposed of under the R-84 reactor license.

SECTION VII

Environmental Radiological Surveys

All environmental sampling of soil and vegetation yielded radionuclide levels within the background range. The radionuclides that were detected were those expected from natural background and from long-term fallout from nuclear weapons testing.

The calculated annual dose, due to Argon-41 release to the environment for 2022, was 0.124 millirem (mrem) at the location of maximum public exposure. The maximum exposure is calculated at a location 91 meters from the release point as described in the FSAR. Exposure to the general population at the boundary of the Naval Support Activity Bethesda is significantly less due to the diffusion of Argon-41 in the atmosphere. The constraint limit for exposure to the public established under 10 CFR 20.1101(d) is 10 mrem per year. The exposure dose was calculated using COMPLY code, level 2, which is the most conservative level of COMPLY. Emissions due to reactor operations were 0.124 mrem, or 1.24% of the 10 mrem constraint limit, for the entire year.

The reactor in-plant surveys, specified in Health Physics Procedure (HPP) 3-2, all resulted in readings that were less than the action levels specified in HPP 0-2.

SECTION VIII

Exposures Greater than 25% of 10 CFR 20 Limits

There were no doses to reactor staff personnel or reactor visitors greater than 25% of 10 CFR 20 occupational and public radiation dose limits.