NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
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March 31, 2015

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attn.: Document Control Desk

Subject: Annual Report, Docket No. 50-20, License R-37, Technical Specification 7.7.1

Gentlemen:

Forwarded herewith is the Annual Report for the MIT Research Reactor for the period from January 1, 2014 to December 31, 2014, in compliance with paragraph 7.7.1 of the Technical Specifications issued November 1, 2010, for Facility Operating License R-37.

Sincerely,

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EL/st

Enclosure: As stated

cc: USNRC – Senior Project Manager
Research and Test Reactors Licensing Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

USNRC – Senior Reactor Inspector
Research and Test Reactors Oversight Branch
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Office of Nuclear Reactor Regulation

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MIT RESEARCH REACTOR
NUCLEAR REACTOR LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ANNUAL REPORT

to

United States
Nuclear Regulatory Commission
for
the Period January 1, 2014 – December 31, 2014

by

REACTOR STAFF

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MIT RESEARCH REACTOR

ANNUAL REPORT TO

U. S. NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JANUARY 1, 2014 – DECEMBER 31, 2014

INTRODUCTION

This report has been prepared by the staff of the Massachusetts Institute of Technology Research Reactor for submission to the United States Nuclear Regulatory Commission, in compliance with the requirements of the Technical Specifications to Facility Operating License No. R-37 (Docket No. 50-20), Paragraph 7.7.1, which requires an annual report that summarizes licensed activities from the 1st of January to the 31st of December of each year.

The MIT Research Reactor (MITR), as originally constructed and designated as MITR-I, consisted of a core of MTR-type fuel, enriched in uranium-235, cooled and moderated by heavy water in a four-foot diameter core tank that was surrounded by a graphite reflector. After initial criticality on July 21, 1958, the first year was devoted to startup experiments, calibration, and a gradual rise to one megawatt, the initially licensed maximum power. Routine three-shift operation (Monday-Friday) commenced in July 1959. The authorized power level for MITR-I was increased to two megawatts in 1962 and to five megawatts (the design power level) in 1965.

Studies of an improved design were first undertaken in 1967. The concept which was finally adopted consisted of a more compact core, cooled by light water, and surrounded laterally and at the bottom by a heavy water reflector. It is under-moderated for the purpose of maximizing the peak of thermal neutrons in the heavy water at the ends of the beam port re-entrant thimbles and for enhancement of the neutron flux, particularly the fast component, at in-core irradiation facilities. The core is hexagonal in shape, 15 inches across, and utilizes fuel elements which are rhomboidal in cross section and which contain UAl_x intermetallic fuel in the form of plates clad in aluminum and enriched to 93% in uranium-235. The improved design was designated MITR-II. Much of the original facility, e.g., graphite reflector, biological and thermal shields, secondary cooling systems, containment, etc., has been retained.

After Construction Permit No. CPRR-118 was issued by the former U.S. Atomic Energy Commission in April 1973, major components for the modified reactor were procured and the MITR-I completed its mission on May 24, 1974, having logged 250,445 megawatt-hours during nearly 16 years of operation.

The old core tank, associated piping, top shielding, control rods and drives, and some experimental facilities were disassembled, removed, and subsequently replaced with new equipment. After preoperational tests were conducted on all systems, the U.S. Nuclear Regulatory Commission issued Amendment No. 10 to Facility Operating License No. R-37 on July 23, 1975. After initial criticality for MITR-II on August 14, 1975, and several months of startup testing, power was raised to 2.5 MW in December 1975. Routine 5-MW operation was achieved in December 1976. Three shift operations, Monday through Friday, was continued through 1995 when a gradual transition to continuous operation (24 hours per day, 7 days per week with a shutdown for maintenance every 4-5 weeks) was initiated.

In December 2000, a fission converter medical facility was commissioned. This facility generated the highest quality epithermal beam in the world for use in the treatment of certain types of cancer, and could again be made available.

From mid-April through mid-September 2010, all major piping in the primary and secondary coolant systems was replaced and upgraded. This included a titanium heat exchanger (replacing the three previous primary heat exchangers) and the major instrumentation sensors. On November 1, 2010, NRC approved the relicensing of the reactor for 6-MW operation through November 1, 2030. Reactor power was increased in small increments from 5 MW for observations and data collection, and reached 5.8 MW on April 23, 2011. Routine 5.8 MW operation began on May 25, 2011.

The current operating mode is generally continuous operation just under 6 MW when needed, with a maintenance shutdown scheduled every calendar quarter.

This is the fortieth annual report required by the Technical Specifications, and it covers the period from January 1, 2014 through December 31, 2014. Previous reports, along with the "MITR-II Startup Report" (Report No. MITNE-198, February 14, 1977) have covered the startup testing period and the transition to routine reactor operation. This report covers the thirty-eighth full year of routine reactor operation, now at the 6-MW power level. It was another year in which the safety and reliability of reactor operation met and exceeded requirements and expectations.

A summary of operating experience and other activities and related statistical data are provided in Sections A through I of this report.

A. SUMMARY OF OPERATING EXPERIENCE

1. General

The MIT Research Reactor, MITR-II, is operated to facilitate experiments and research including in-core irradiations and experiments, neutron activation analyses, and materials science and engineering studies such as neutron imaging. It is also used for student laboratory exercises and student operator training, and education and outreach programs. Additionally, the reactor has been used for industrial production applications and other irradiation services. When operating, the reactor is normally maintained at slightly below 6 MW. For this reporting period, the nominal full power operating cycle was eleven weeks at a time, followed by a scheduled outage lasting about two weeks, for reactor and experiment maintenance, protective system surveillance tests, and other necessary outage activities. The reactor would then be re-started to full power and maintained there for another several weeks.

Throughout CY2014, the reactor averaged 102 operating hours per week, compared to 54 hours per week for CY2013, 76 hours per week for CY2012, and 90 hours per week for CY2011. The lower average for CY2013 was the result of operating the reactor only as needed for the first half of that year, when there were no in-core experiments or other irradiations that called for continuous operation.

The reactor was operated throughout the year with 24 fuel elements in the core. The remaining three positions were occupied by solid aluminum dummies or in-core experiments. During CY2014, compensation for reactivity lost due to burnup was provided by three refuelings. These followed standard MITR practice which is to introduce fresh fuel to the inner portion of the core (the A- and B-Rings) where peaking is least and to place partially spent fuel into the outer portion of the core (the C-Ring). In addition, fuel elements were inverted and rotated so as to achieve more uniform burnup gradients in them. Six new fuel elements were introduced into the reactor core during CY2014.

The MITR-II fuel management program remains quite successful. All of the original MITR-II fuel elements (445 grams U-235) have been permanently discharged. The overall burnup for the discharged ones was 42%. (Note: One was removed prematurely because of excess out-gassing.) The maximum overall burnup achieved was 48%. A total of two hundred thirty-two of the newer, MITR-II fuel elements (506 grams U-235) have been introduced to the core. Of these, one hundred seventy-eight have attained the maximum allowed fission density and were discharged. Six fuel elements have been identified as showing excess out-gassing and three were suspected of this. All nine have been removed from service and returned to an off-site DOE storage facility. The other forty-five are either currently in the reactor core, or have been partially depleted and are in the wet storage ring awaiting reuse or discharge. During the period of CY2014, eight spent fuel elements were returned to an off-site DOE facility.

As in previous years, the reactor was operated throughout the period without the fixed hafnium absorbers.

2. Experiments and Utilization

The MITR-II was used for experiments and irradiations in support of research, training and education programs at MIT and elsewhere. Irradiations and experiments conducted in CY2014 include:

a) Activation of gold-198 seeds for brachytherapy.

b) Activation of uranium foils for detector calibration at the Los Alamos National Laboratories.

c) Activation of ocean sediments for the Woods Hole Oceanographic Institute.

d) Exploratory activation and NAA of the following materials: various components of ultrasonic detectors for Idaho National Laboratory (INL) and Pennsylvania State University (ULTRA); various components and specimens for Westinghouse Accident Tolerant Fuel Experiment (WATF); and all components and sample materials of the FS-2 Salt Capsule Experiment.

e) Activation and NAA of flux foils for a detailed thermal flux study of our Thermal Neutron Beam experimental facility.

f) Activation and NAA of rock samples for long term activation study of MIT Physics Professor Conrad's IsoDAR project for installation of a cyclotron in the Kamioka Mine in Japan.

g) Activation and NAA of FLiBe salt crystals used in the University of Wisconsin out-of-core Corrosion Experiment that ran in parallel to our in-core experiment fluoride-salt-cooled high temperature reactor (FHR) project.

h) Experiments at the 4DH1 radial beam port facility by MIT undergraduate and graduate students (courses 22.09 "Principles of Nuclear Radiation Measurement and Protection" and 8.13 "Junior Physics Lab"), including: 1) measurements of leakage neutron energy spectrum to determine reactor temperature; 2) measurement of neutron wavelength and time-of-flight; and 3) measurement of attenuation coefficients for eight shielding materials.

i) Use of the reactor for training MIT student reactor operators and for MIT nuclear engineering classes (course 22.06 "Engineering of Nuclear Systems").

j) Neutron activation of Ge wafers to study radiation-induced photonic defects for the MIT Materials Processing Center.

k) Activation and NAA of cerium oxide nanoparticles for radiotracer animal studies of nanomaterial toxicity for Harvard School of Public Health.

l) Activation and NAA of Si Photodiode components for further NAA studies for University of Alabama.

m) Activation of fusion laminate samples to study radiation damage effects for Composite Technology Development.

n) Irradiation of SiC/SiC composites continued in the MITR in-core water loop facility (WATF). An ongoing project to evaluate the use of SiC/SiC composite materials for BWR channel boxes was continued in 2014. The project is funded by the US DOE and the NRL was subcontracted by EPRI, the lead awardee, to perform an irradiation test under BWR coolant conditions. Corrosion coupons and creep samples were removed for examination and found to have high corrosion losses. Investigation of the mechanism and possible mitigating strategies are under investigation. Following removal of the BWR channel box samples, WATF samples were irradiated under PWR conditions. This irradiation is scheduled for completion in May 2015.

o) In support of the MIT, UC Berkeley, and University of Wisconsin–Madison integrated research project on the fluoride-salt-cooled high temperature reactor (FHR) concept, a follow-on irradiation to the initial 1000 hour flibe salt irradiation was performed. This irradiation, with larger amounts of flibe and a different set of samples than in the initial irradiation was operated for 300 of a scheduled 1000 hours. At that point, an unscheduled reactor shutdown occurred and problems associated with radiolysis of the salt at low temperature prevented a successful restart. Recovery and analysis of the samples is ongoing.

p) An irradiation of ultrasonic detectors for in-core sensor applications was started in February. The project (designated ULTRA) is funded under the National Scientific User Facility at INL-ATR (see below) and is led by Dr. Bernhard Tittmann of Penn State University. Two types of ultrasonic sensors (piezoelectric and magnetostrictive) are being irradiated in the ICSA facility at temperatures up to about 430 °C, with temperature and self-powered gamma and neutron instrumentation. The irradiation continued through the end of 2014 and is scheduled to be completed in May of 2015.

q) Use of the reactor (including the 4DH1 beam port facility) for educating participants of the Reactor Technology Course for Utility Executives in reactor control, neutron behavior, and radiation protection. The course is sponsored by the Institute for Nuclear Power Operations and hosted by the MIT Nuclear Science and Engineering Department faculty.

An ongoing initiative is the partnership with INL Advanced Test Reactor National Scientific User Facility (ATR-NSUF) for materials testing. The MITR was selected in 2008 as the first university research reactor to be a partner facility with the ATR-NSUF. MITR staff also worked with INL staff to jointly develop advanced reactor instrumentation, and reviewed ATR-NSUF's user proposals. Following up on final design work for an in-core crack growth monitor for use in the MITR and the Advanced Test Reactor (ATR), MITR staff supervised the manufacture of several critical components of the system, and continued to work with INL to demonstrate the system out-of-pile in preparation for an irradiation in MITR in CY 2015.

3. Changes to Facility Design

Except as reported in Section E, no changes in the facility design were made during this calendar year. The nominal uranium loading of MITR-II fuel is 34 grams of U-235 per plate and 510 grams per element (made by B&W). Performance of these fuel elements has been good. The loading results in 41.2 w/o U in the fuel meat, based on 7% voids, and corresponds to the maximum loading in Advanced Test Reactor (ATR) fuel. One hundred ninety-two elements fabricated by B&W have been received, forty-five of which remain in use. One has been removed because of suspected excess out-gassing and one hundred forty-six have been discharged because they have attained the fission density limit.

The MITR is actively involved in studies for the use of low enrichment uranium (LEU) in the MITR, partially supported by the Reduced Enrichment for Research and Test Reactors (RERTR) Program at DOE. These studies principally focus on the use of monolithic U-Mo fuels with uranium densities in excess of 15 g/cm^3 (compared with 1.5 g/cm^3 for UAl_x fuel), currently under development by the RERTR Program. Although initial studies show that the use of these fuels is feasible, conversion of the MITR-II to lower enrichment must await the final successful qualification of these fuels.

4. Changes in Performance Characteristics

Performance characteristics of the MITR-II were reported in the "MITR-II Startup Report." Minor changes have been described in previous reports. Performance characteristics of the Fission Converter Facility were reported in the "Fission Converter Facility Startup Report", and in the FY2006 report which described a 20% improvement in the intensity of the unfiltered epithermal neutron beam. In CY2012, fuel was removed from the fission converter. It will remain unfueled pending resumption of epithermal beam research. In CY2013, the D_2O coolant was removed from the fission converter and replaced with demineralized light water. The D_2O was put into storage for future use.

5. Changes in Operating Procedures

With respect to operating procedures subject only to MITR internal review and approval, a summary is given below of changes implemented during CY2014.

a) PM 6.1.3.1B, "Ion Chamber Neutron Detector Plateau Test", was updated for better compatibility with the current high voltage power supplies. Reactor power for the procedure was revised from 1 MW to full power, in line with the ion chamber manufacturer's recommendation, and the acceptance criteria were modernized, without changing the intent. (SR #O-13-9)

b) AOP 5.7.11, "Reception Desk", AOP 5.8.19, "Civil Disturbance Involving the Reactor Facility", AOP 5.8.20, "Bomb Threat", AOP 5.8.21, "Sabotage or Theft of Special Nuclear Material or Threat of Sabotage or Theft", and AOP 5.8.22, "Loss or Degradation of a Security System", were updated to reflect current equipment and practices. (SR #O-13-28)

c) PM 3.6, "Waste Tank Discharge Procedure", received a new section to address changing of the inline discharge filters during the discharge if the filters become clogged. Additionally, the waste tank high level alarm's final set-point was changed from 900 gallons to 50 gallons above the current level, to allow early detection of a sink faucet being left open. (SR #2014-2)

d) PM 6.1.6, "Monthly Technical Specification Tests", received administrative changes to reflect current practices and equipment. There were no safety concerns involved. (SR #2014-5)

e) PM 3.1.1.1 & 3.1.1.2, "Full Power Startup Checklists", were updated to incorporate temporary changes and to reflect current equipment configurations and best practices. The changes were evaluated as free of negative effects on safety, equipment, and ALARA. (SR #2014-15)

f) PM 6.1.3.10, "Emergency Battery Discharge Test", and PM 6.1.3.11, "Emergency Power Transfer Test" received updates to its specifications for current ranges, pilot cell voltage and specific gravity, to reflect manufacturer recommendations as well as be consistent with the PM 3.5 "Daily Surveillance" procedure. Additions were made regarding advance notification to the MIT Facilities Operations Center and adjustment of the variable frequency drive for pump MM-2. (SR #2014-16)

g) PM 6.6.2.2, "Self-Contained Breathing Devices", was revised to reflect updated equipment and current NRC and OSHA guidelines. All SCBAs are now 30-minute units and are stored in a central location near the NW12-116 Operations Office. Access to this locker is controlled to prevent usage by untrained personnel. The procedure calls for four units to be available so two people can make a re-entry while two people are in standby mode for rescue. (SR #2-14-20)

6. Surveillance Tests and Inspections

There are many written procedures in use for surveillance tests and inspections required by the Technical Specifications. These procedures provide a detailed method for conducting each test or inspection and specify an acceptance criterion which must be met in order for the equipment or system to comply with the requirements of the Technical Specifications. The tests and inspections are scheduled throughout the year with a frequency at least equal to that required by the Technical Specifications. Thirty such tests and calibrations are conducted on an annual, semi-annual, or quarterly basis.

Other surveillance tests are done each time before startup of the reactor if shut down for more than 24 hours, before startup if a channel has been repaired or de-energized, and at least quarterly; a few are on different schedules. Procedures for such surveillance are incorporated into daily or quarterly startup, shutdown, or other checklists.

During this reporting period, the surveillance frequency has been at least equal to that required by the Technical Specification, and the results of tests and inspections were satisfactory throughout the year for Facility Operating License No. R-37.

7. Status of Spent Fuel Shipment

In CY2014, there was one shipment made, reducing the inventory of spent fuel at MIT. These shipments were made using the BEA Research Reactor (BRR) package. The U.S. Department of Energy has indicated that further shipments may be feasible in CY2015 for future fuel discharges.

B. REACTOR OPERATION

Information on energy generated and on reactor operating hours is tabulated below:

	Calendar Quarter 1	2	3	4	Total
1. Energy Generated (MWD):					
a) MITR-II (MIT CY2014) (normally at 5.8 MW)	211.2	346.9	282.3	257.3	1097.7
b) MITR-II (MIT FY1976-CY2013)					33,883.8
c) MITR-I (MIT FY1959-FY1974)					10,435.2
d) Cumulative, MITR-I & MITR-II					45,416.7
2. MITR-II Operation (hours): (MIT CY2014)					
a) At Power (> 0.5-MW) for Research	1002	1536	1319	1085	4942
b) Low Power (< 0.5-MW) for Training[1] and Test	140	102	71	38	351
c) Total Critical	1142	1638	1390	1123	5293

[1] These hours do not include reactor operator and other training conducted while the reactor is at full power for research purposes (spectrometer, etc.) or for isotope production. Such hours are included in the previous line.

C. SHUTDOWNS AND SCRAMS

During this reporting period, there were thirteen inadvertent scrams and three unscheduled shutdowns.

The term "scram" refers to shutting down of the reactor through protective system automatic action when the reactor is at power or at least critical, while the term "shutdown" refers to an unscheduled power reduction to subcritical by the reactor operator in response to an abnormal condition indication. Rod drops and electric power loss without protective system action are included in unscheduled shutdowns.

The following summary of scrams and shutdowns is provided in approximately the same format as for previous years in order to facilitate a comparison.

			Total
1.	Nuclear Safety System Scrams		
	a)	Trip on Channel #5 as result of spurious electronic noise.	5
	b)	Trip on Channel #2 as a result of spurious electronic noise during startup while the reactor was critical.	1
	c)	Scram on low voltage chamber power supply for Channel #3 caused by human error during ion chamber plateau testing.	1
		Subtotal	7
2.	Process System Scrams		
	a)	Low flow core purge scram because of ventilation trip on failure of exhaust damper hydraulic pump motor or system.	2
	b)	Low flow core purge scram because of ventilation trip on failure of plenum blower.	1
	c)	High temperature core tank MTS-1/MTS-1A scram caused by human error re-programming fan controller or de-energizing a nearby instrument.	2
	d)	Low flow shield coolant scram caused by failure of the shield coolant pump, PM-1.	1
		Subtotal	6

3. Unscheduled Shutdowns

a)	Shutdown as result of a shim blade drive shaft seal leak.	1
b)	Shutdown in response to erratic behavior of Channel #9.	1
c)	Shutdown to correct inaccurate cable connection to the nuclear safety channels causing unexpected readings.	1
	Subtotal	3
	Total	**16**

4. Experience during recent years has been as follows:

Calendar Year	Nuclear Safety and Process System Scrams
2014	13
2013	4
2012	6
2011	9
2010	20
Fiscal Year	
2010	6
2009	2
2008	4
2007	5
2006	6

D. MAJOR MAINTENANCE

Major reactor maintenance projects performed during CY2014 are described in this Section. These were planned and performed to improve safety, reliability and efficiency of operation of the MIT Research Reactor, and hence improve the predictability of the reactor operating schedule and the availability of the reactor for experiments, research and training purposes. Additionally, Reactor Operations staff performed safety reviews for all reactor experiments and their operating procedures. The staff also provided support for installations and removals of reactor experiments, and monitored key performance data from the experiments during reactor operations.

For continuous support of neutron transmutation doping of silicon, reactor staff performed routine irradiation and shipping activities. There is an annual external audit to review the program for maintaining the ISO 9001 Certification. Preventive maintenance on conveyor machinery, such as alignment of conveyor carriages, was performed during major outages. In December 2014, the 6" facility's rotation tube was entirely replaced.

Major maintenance items performed in CY2014 are summarized as follows:

1. On 1/13 the electromagnet, blade drive and proximity switch for shim blade #5 were replaced.

2. On 1/24 reactor staff completed installation of a refurbished drive, a new shim blade magnet, and a new set of proximity switches for the shim blade #6 system.

3. During the week of 2/16 the shield system was drained in order to rebuild valve PV-61.

4. On 3/7 the first HYFI capsule was successfully transferred from the spent fuel storage pool, using the blade transfer cask, to reactor floor Hot Cell #1.

5. The week of 3/31 the biennial containment building pressure test was completed.

6. On 4/3 the primary ion column and inlet filter were replaced.

7. On 4/3 MIT Facilities electricians performed an inspection of the new wiring installed for the control room A/C units.

8. On 4/4 the D_2O ion column was replaced.

9. During the week of 4/6 the ICSA ULTRA experiment was reinstalled after the refueling, and the new ACI experiment was installed.

10. On 4/7 the leak alarm system panel was repaired by installing a new circuit board module.

11. On 4/10 the 480-volt 3-phase wiring for the exhaust damper's hydraulic pump was replaced.

12. On 4/11 the shaft seal of the makeup water system's main pump, WM-1 was replaced.

13. The week of 5/19 the reactor shield pump motor was rebuilt.

14. Starting on 5/28 Siemens technicians began repairs on the communication links at the reactor floor.

15. On 6/2 MIT Facilities electricians repaired the 120-volt wire for the main airlock outer door.

16. The week of 6/30 the cooling tower bypass valve (QV-1) was replaced.

17. In-core experiment HTIF FS-2 was installed on 7/9.

18. A new high voltage power supply for channel 7 was installed during the week of 7/7.

19. The primary ion column was replaced on 7/10.

20. During the week of 7/14 core purge blower #2 was replaced.

21. On 7/23 core purge blower #1 was replaced.

22. On 8/12 the FS-2 experiment was removed.

23. On 8/26 the cooling tower cleanup filter # 2 back-flush control valve was replaced.

24. On 9/12 the G-M tube for the effluent monitor Plenum Part 2 was replaced.

25. During the week of 9/29 the circulation pump for the spent fuel pool was replaced.

26. On 10/8 the proximity switch for blade #1 was replaced.

27. On 10/10 the D_2O ion column was replaced.

28. On 10/14 MIT Facilities installed belt and shaft guards for the reactor ventilation intake fan.

29. On 10/17 the intake filters and fan belts were replaced by MIT Facilities and contractors.

30. On 10/14 the shield ion column was repacked.

31. During the week of 10/20 the control room floor tiles were replaced.

32. The shaft seal for the shield pump was replaced on 10/24.

33. On 10/25 the horizontal shaft seal for blade drive #3 was replaced.

34. On 11/5 and 11/6 the spent fuel pool ion column was repacked and the filters changed.

35. On 11/17 the pump contactor for the sewer pump (RM-3) was replaced.

36. On 11/20 the cooling tower level controller module was replaced.

37. On 11/20 the primary ion column inlet filter was replaced.

38. On 12/3 the containment polar crane 3-ton hook wire rope was replaced.

Many other routine maintenance and preventive maintenance items were also scheduled and completed throughout the fiscal year.

E. SECTION 50.59 CHANGES, TESTS, AND EXPERIMENTS

This section contains a description of each change to the reactor facility and associated procedures, and of the conduct of tests and experiments carried out under the conditions of Section 50.59 of 10 CFR 50, together with a summary of the safety evaluation in each case.

Changes that affect only the operating procedures and that are subject only to MITR internal review and approval, including those that were carried out under the provisions of 10 CFR 50.59, are similarly discussed in Section A.5 of this report.

The review and approval of changes in the facility and in the procedures as described in the SAR are documented in the MITR records by means of "Safety Review Forms". These have been paraphrased for this report and are identified on the following pages for ready reference if further information should be required with regard to any item. Pertinent pages in the SAR have been or are being revised to reflect these changes, and they either have or will be forwarded to the Document Control Desk, USNRC.

The conduct of tests and experiments on the reactor are normally documented in the experiments and irradiation files. For experiments carried out under the provisions of 10 CFR 50.59, the review and approval is documented by means of the Safety Review Form. All other experiments have been done in accordance with the descriptions provided in Section 10 of the SAR, "Experimental Facilities".

Advance Cladding Irradiation Facility (ACI)
SR #0-06-4 (04/03/2006), #0-06-6 (05/18/2006)

An in-core experiment loop was installed on May 22, 2006, to investigate the effects at various stages of irradiation on specimens of silicon carbide intended for use in advanced fuel cladding designs. Its envelope of operating conditions is very similar to that of previous in-core experiments such as the Zircaloy Corrosion Loop and the Electro-Chemical Potential Loop. No new safety issues were raised. Operation continued until October 2007. A second advanced cladding loop, designated ACI-2, operated in core from March 2009 through mid-December 2009, March to April 2010, December 2010 through June 2011, from October 2011 to July 2012, and from August through October 2013. The current version of this loop, designated the Westinghouse Accident-Tolerant Fuel experiment, was installed in 2014 and continues in operation in 2015.

Heated In-Core Sample Assembly Experiment (ICSA)
SR #0-04-19 (12/01/2004), #M-04-2 (12/30/2004), #0-05-11 (07/22/2005),
SR #M-09-1 (07/30/2009), #M-09-2 (12/11/2009), #0-10-2 (03/28/2010),
SR #0-12-17 (06/04/2012), #0-12-19 (07/09/2012)

High-temperature sample capsules were used with the redesigned titanium 2" ICSA tube to provide a heated irradiation environment for the specimens within. These capsules include gamma-heating susceptors similar in principal to the High Temperature Irradiation Facility. No new safety issues were raised. An alternate 16" plug was designed and installed in the reactor top shield lid to allow simultaneous use of the ICSA and the ACI-2 in-core experiments. The ICSA operated in core from December 2009 through April 2010, from August 2010 to January 2012, from April to July 2012, and from mid-September through October 2013 for various sample irradiations using heated and unheated capsules. The MIT Reactor Safeguards Committee (MITRSC) approved two ICSA Safety Evaluation Report amendments in early 2013 to allow the 2013 irradiation of molten fluoride salt in-core using a nickel capsule inside the ICSA.

High Temperature Irradiation Facility (HTIF) FS-2
SR #2014-12 (06/11/2014)

The MITRSC In-Core Experiments Subcommittee approved the latest HTIF test rig (FS-2) by mail ballot between 6/07/2014 and 6/11/2014.

Update of Medical Emergency Procedure
SR #O-13-23 (05/27/2014)

The MITR Emergency Operating Procedure 4.4.4.10, "Medical Emergency", were upgraded to reflect current practices and improve coordination with emergency responders. The changes were reviewed and approved by the MITRSC on 12/02/2014.

DWK 250 Wide Range Monitors and Mirion Fission Chamber Detectors
SR #O-12-21 (10/19/2012), #O-13-22 (07/11/2013), #O-13-27 (11/08/2013)

Three analog display meters were added to the control console from a new nuclear instrument channel (a DWK 250 Wide Range Monitor) that is under test. These meters are completely independent of the reactor protection and reactor control systems and do not interfere with normal use of required control room instrumentation. All the display meters are labelled "unofficial instrument", as use of the DWK 250 system is pending NRC review and approval. Two sets of DWK 250 flux monitors, and their associated pre-amplifiers and fission chambers, were installed for on-line testing in 2013. The DWK 250 monitors were installed in the control room console. The fission chamber for one was installed in 3GV2, and for the other in 4IH3. The TKV23 pre-amplifier modules for both these fission chambers were installed in protective electrical boxes on the reactor utility shelf.

Ventilation Damper System Upgrades
SR #M-13-2 (01/06/2014), SR #2014-22 (11/20/2014)

The mechanism for holding the auxiliary exhaust damper open was re-designed such that the damper could be reset by electrical means rather than by pulling on it manually via a cable. The main exhaust damper motor control contactor protection hardware was replaced with thermal overload protection of a rating more appropriate to its environment.

Ch. 1 Fission Chamber Signal Using TKV23 Pre-Amplifier
SR #E-13-6 (01/14/2014)

The non-discriminated pulse signal from the new fission chamber in 4IH3, passing without distortion in analog form through a DWK 250 flux monitor, was used as input to the existing nuclear safety Channel #1 for source-range startup application. The non-discriminated signal does not go through the signal processing path within the DWK 250.

Procedures Governing Shipment of Spent Fuel
SR #O-12-22 (03/21/2013), SR #O-13-2 (03/28/2013), SR #O-13-12 (06/28/2014), SR #O-13-12A (07/03/2014)

Section 2.7.5 in the reactor's Standard Operating Plan was modified to allow omission of the inverse multiplication measurements when loading spent fuel elements into the shipping cask with U-235 masses similar to or less than that of a previous loading. This change had been reviewed and approved by the MITRSC on 11/06/2012. The PM 3.3.4 Spent Fuel Shipping Procedures were updated accordingly. Furthermore, PM 3.3.4.1 Fuel Shipping Supervisory Checklist and the other implementing procedures were updated to expand and improve oversight and coordination of the spent fuel shipment process, and for verbatim compliance with the shipping cask's Safety Analysis Report Chapters 7 and 8. These updates were inspected by NRC during an actual shipment and were deemed satisfactory.

Physical Security Plan Revision
SR #O-13-16 (05/12/2014), SR #O-13-30 (12/24/2013), SR #2014-19 (11/07/2014)

MITRSC approval for revised Plan was granted per the Security Subcommittee meeting of 6/6/2013. It was then submitted to NRC as a License Amendment Request, for which approval was received on 5/12/2014. The PM 3.2.4.*, "Response to Weekend Alarms" procedures were then revised accordingly, along with those under PM 3.7.3, "Normal Containment Entry/Exit".

Replacement of Differential Galvanometer
SR #2014-3 (2/20/2014)

This was installed in 2014 but remains in test as an unofficial instrument.

Automatic Cooling Tower Fan Control
SR #2014-4 (2/24/2014)

A proportional-integral-derivative (PID) controller that was provided by the manufacturer of the cooling tower fan control system in 2009 was programmed and activated, controlling the cooling tower fan speed based on the water temperature at the tower's outlet (cold leg). This safety review also suggested methods of test and calibration.

Core Purge System
SR #2014-10 (6/26/2014), SR #2014-18 (10/10/2014)

The system was fitted with an automatic system to return collected condensate to the primary storage tank.

Digital Logbook Computer
SR #2014-14 (6/25/2014)

After a full safety review, several sets of control console instruments were relocated to other parts of the console in 2014 to accommodate a new display for the digital logbook computer.

Radial Hoist Electrical Guard
SR #2014-24 (12/22/2014)

Guard rails comprised of angle iron were welded to the hoist superstructure of the containment building's polar crane. This modification increased safety by physically preventing the hoist's wire rope from contacting the powered rails.

F. ENVIRONMENTAL SURVEYS

Environmental monitoring is performed using continuous radiation monitors and passive dosimetry devices (TLD). The radiation monitoring system consists of detectors and associated electronics at each remote site with data transmitted continuously to the Reactor Radiation Protection office and recorded electronically in a database. The remote sites are located within a quarter mile radius of the facility. The calendar year totals per sector, due primarily to Ar-41, are presented below. The passive TLDs were in place at all times throughout the year and are exchanged quarterly.

Site	Exposure (01/01/14 – 12/31/14)
North	0.62 mrem
East	1.3 mrem
South	0.61 mrem
West	1.3 mrem
Green (east)	0.03 mrem

Calendar Year Average

2014	0.8 mrem
2013	0.2 mrem
2012	0.3 mrem
2011	0.3 mrem
2010	0.1 mrem

Fiscal Year Average

2010	0.2 mrem
2009	0.3 mrem
2008	0.3 mrem
2007	0.2 mrem
2006	0.2 mrem

G. RADIATION EXPOSURES AND SURVEYS WITHIN THE FACILITY

A summary of radiation exposures received by facility personnel and experimenters is given below:

January 1, 2014 - December 31, 2014

Whole Body Exposure Range (rems)	Number of Personnel
No measurable	45
Measurable – < 0.1	24
0.1 – 0.25	6
0.25 – 0.50	0
0.50 – 0.75	0
0.75 – 1.00	0
1.00 – 1.25	0
1.25 – 1.50	0
1.50 – 1.75	0
1.75 – 2.00	0

Total Person Rem = 1.7 Total Number of Personnel = 75

From January 1, 2014, through December 31, 2014, the Reactor Radiation Protection program provided radiation protection services for the facility which included power and non-power operational surveillance (performed on daily, weekly, monthly, quarterly, and other frequencies as required), maintenance activities, and experimental project support. Specific examples of these activities included, but are not limited to, the following:

1. Collection and analysis of air samples taken within the containment building and in the exhaust/ventilation systems.
2. Collection and analysis of water samples taken from the secondary, D_2O, primary, shield coolant, liquid waste, and experimental systems, and fuel storage pool.
3. Performance of radiation and contamination surveys, radioactive waste collection and shipping, calibration of area radiation monitors, calibration of effluent and process radiation monitors, calibration of radiation protection/survey instrumentation, and establishing/posting radiological control areas.
4. Provision of radiation protection services during fuel movements, in-core experiments, sample irradiations, beam port use, ion column removal, diffractometer beam testing, etc.

The results of all surveys and surveillances conducted have been within the guidelines established for the facility.

H. RADIOACTIVE EFFLUENTS

This section summarizes the nature and amount of liquid, gaseous, and solid radioactive wastes released or discharged from the facility.

1. Liquid Waste

Liquid radioactive wastes generated at the facility are discharged only to the sanitary sewer serving the facility. The possible sources of such wastes during the year include cooling tower blowdown, the liquid waste storage tanks, and one controlled sink in the Restricted Area (Engineering Lab). All of the liquid volumes are measured, by far the largest being the 6,319,381 liters discharged during CY2014 from the cooling towers. (Other large quantities of non-radioactive waste water are discharged to the sanitary sewer system by other parts of MIT, but no credit for such dilution is taken because the volume is not routinely measured.)

Total activity less tritium in the liquid effluents (cooling tower blowdown, waste storage tank discharges, and engineering lab sink discharges) amounted to 69.4 μCi for CY2014. The total tritium was 48.9 mCi. The total effluent water volume was 6,364,656 liters, giving an average tritium concentration of 7.68E-6 μCi/ml.

The above liquid waste discharges are provided on a monthly basis in the following Table H-3.

All releases were in accordance with Technical Specification 3.8-1, including Part 20, Title 20, Code of Federal Regulations. All activities were substantially below the limits specified in 10 CFR 20.2003. Nevertheless, the monthly tritium releases are reported in Table H-3.

2. Gaseous Waste

Gaseous radioactivity is discharged to the atmosphere from the containment building exhaust stack. All gaseous releases likewise were in accordance with the Technical Specifications and 10 CFR 20.1302, and all nuclides were substantially below the limits, using the authorized dilution factor of 50,000 (changed from 3,000 starting with CY2011 per the renewed license's Technical Specifications). The only principal nuclide was Ar-41, which is reported in the following Table H-1. The 1568.66 Ci of Ar-41 was released at an average concentration of 2.48E-10 μCi/ml. This represents 2.48% of EC (Effluent Concentration (1E-08 μCi/ml)).

3. Solid Waste

Two shipments of solid waste were made during the calendar year. The information pertaining to these shipments is provided in Table H-2.

TABLE H-1

ARGON-41 STACK RELEASES

CALENDAR YEAR 2014

		Ar-41 Discharged (Curies)	Average Concentration[1] (μCi/ml)
January 2014		50.18	1.05 E-10
February		96.20	2.01 E-10
March		197.31	3.30 E-10
April		63.75	1.33 E-10
May		267.43	4.48 E-10
June		140.34	2.94 E-10
July		47.35	9.91 E-11
August		156.50	2.62 E-10
September		190.00	3.97 E-10
October		104.05	1.74 E-10
November		130.28	2.73 E-10
December		125.27	2.62 E-10
	Totals (12 Months)[2]	**1568.66**	**2.48 E-10**
	EC (Table II, Column I)		1×10^{-8}
	% EC		**2.48%**

(1) Average concentrations do not vary linearly with curies discharged because of differing monthly dilution volumes.

(2) Last decimal place may vary because of rounding.

TABLE H-2

SUMMARY OF MITR-II RADIOACTIVE SOLID WASTE SHIPMENTS

CALENDAR YEAR 2014

Description	
Volume	130.5 ft^3
Weight	461 lbs.
Activity	17 mCi
Date of shipment	May 7, 2014
Disposition to licensee for burial	Energy Solutions, Clive, UT
Waste broker	Ecology Services Inc., Columbia, MD

Description	
Volume	111 ft^3
Weight	779 lbs.
Activity	3.4 mCi
Date of shipment	July 30, 2014
Disposition to licensee for burial	Energy Solutions, Clive, UT
Waste broker	Ecology Services Inc., Columbia, MD

TABLE H-3

LIQUID EFFLUENT DISCHARGES
CALENDAR YEAR 2014

	Total Activity Less Tritium	Total Tritium Activity	Volume of Effluent Water[1]	Average Tritium Concentration
	(x10^{-6} Ci)	(mCi)	(liters)	(x10^{-6} μCi/ml)
Jan. 2014	NDA[2]	2.42	513,379	4.72
Feb.	NDA[2]	2.16	87,689	24.6
Mar.	NDA[2]	1.26	95,011	13.2
Apr.	1.70	2.43	52,178	46.6
May	1.39	6.09	124,445	48.9
June	NDA[2]	17.6	757,017	23.3
July	NDA[2]	2.74	739,096	3.71
Aug.	NDA[2]	2.31	764,021	3.02
Sept.	61.8	9.65	1,140,690	8.46
Oct.	NDA[2]	.959	365,306	2.63
Nov.	1.47	.943	1,141,539	.826
Dec.	NDA[2]	.319	584,286	.547
12 months	66.36	48.88	6,364,656	7.68

(1) Volume of effluent from cooling towers, waste tanks, and NW12-139 Engineering Lab sink. Does not include other diluent from MIT estimated at 2.7 million gallons/day.

(2) No Detectable Activity (NDA): less than 1.26x10^{-6} μCi/ml beta for each sample.

I. SUMMARY OF USE OF MEDICAL FACILITY FOR HUMAN THERAPY

The use of the medical therapy facility for human therapy is summarized here pursuant to Technical Specification No. 7.7.1.9.

1. Investigative Studies

Investigative studies remain as summarized in the annual report for FY2005.

2. Human Therapy

None.

3. Status of Clinical Trials

The Phase I glioblastoma and melanoma trials with BIDMC have been closed. A beam that is superior to the original epithermal beam in the basement Medical Therapy Room in both flux and quality could again be made available from the Fission Converter Facility. No use of that beam is anticipated in the near term because of a nationwide funding hiatus for work of this type.