NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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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, 2012 to December 31, 2012, in compliance with paragraph 7.7.1 of the Technical Specifications issued November 1, 2010, for Facility Operating License R-37.

Sincerely,

for J. Foster

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Enclosure: As stated

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Research and Test Reactors Branch A
Division of Policy and Rulemaking
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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, 2012 – December 31, 2012

by

REACTOR STAFF

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MIT RESEARCH REACTOR

ANNUAL REPORT TO

U. S. NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JANUARY 1, 2012 - DECEMBER 31, 2012

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 and cooled and moderated by heavy water in a four-foot diameter core tank, 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. 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. The current operating mode is generally continuous operation at full power when needed.

In December 2000, a fission converter medical facility was commissioned. This facility generates the highest quality epithermal beam in the world for use in the treatment of certain types of cancer.

On November 1, 2010, NRC relicensed 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.

This is the thirty-eighth annual report required by the Technical Specifications, and it covers the period January 1, 2012 through December 31, 2012. 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-sixth 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 and other necessary outage activities. The reactor would then be re-started to full power and maintained there for another several weeks.

Throughout CY2012, the reactor averaged 76 operating hours per week, compared to 90 hours per week for CY2011, and 70 hours per week for CY2010. The lower average for CY2010 was the result of the major planned outage from May to September 2010 for replacement of reactor heat exchangers and for major piping upgrades of the primary and secondary coolant systems. In CY2011, there were also extended planned outages for replacement of the main heat exchanger in the D_2O reflector system and its associated piping, and for repair and maintenance on reactor instrumentation.

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 CY2012, compensation for reactivity lost due to burnup was provided by five 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 CY2012. In addition, eleven fuel elements were reintroduced into the core from the fission converter.

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 twenty-three of the newer, MITR-II fuel elements (506 grams U-235) have been introduced to the core. Of these, one hundred sixty-six 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-eight are either currently in the reactor core, or have been partially depleted and are in the wet storage ring awaiting reuse or discharge. In

July of 2012, all eleven of these fuel elements that had been in the fission converter tank were removed. During the period of CY2012, sixteen spent fuel elements were returned to an off-site DOE facility.

Protective system surveillance tests are conducted whenever the reactor is scheduled to be shut down.

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

2. Experiments

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 CY2012 include:

a) Activation of gold-198 seeds for brachytherapy.

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

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

d) Activation and NAA of ultra high purity B-11 for determination of trace element analysis for Ceradyne Boron Products, LLC.

e) Exploratory activation and NAA of the following materials: various components of optical fiber sensors for Luna Technologies; and finger nail samples for nutritional research by Dr. Joseph J. Kehayias, Director, Body Composition Laboratory, USDA Human Nutrition Research Center on Aging, Tufts University.

f) Activation and NAA of various flux wires for a detailed fast and thermal flux study of our different pneumatic, graphite, and in-core experimental facilities.

g) Activation and NAA of FLiNaK and FLiBe salt crystals for Fluoride salt cooled high temperature reactor Project.

h) Use of the 4DH1 radial beam port facility by INL researchers for testing energy dependent detection efficiency of diamond-based neutron detectors.

i) Experiments at the 4DH1 radial beam port facility by MIT undergraduate and graduate students, 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. In addition, the 4DH1 spectrometer was used for experiments to measure the capture cross-sections of copper isotopes.

j) Use of the reactor for training MIT student reactor operators and for MIT nuclear engineering classes (courses 22.06 "Engineering of Nuclear Systems", 22.09 "Principles of Nuclear Radiation Measurement and Protection").

k) Neutron transmutation doping of Ge wafers for Lawrence Berkley National Labs. These wafers were then used for further neutrino detector research.

l) Activation and NAA of Zinc Oxide, Barium Sulfate, and Cerium Oxide nanoparticles for radiotracer animal studies of nanomaterial toxicity for Harvard School of Public Health.

m) The Advanced Cladding Irradiation (ACI) campaign continued with funding from INL's Advanced Test Reactor National Scientific User Facility (ATR-NSUF). Prof. Mujid Kazimi is the Principal Investigator for this project, which began in mid-June 2009. A variety of samples to test bonding methods for SiC were irradiated in addition to composite cladding tube samples.

n) Successful completion of two irradiation campaigns of optical fiber sensors for Luna Technologies, and preparatory work for an additional custom-built in-core high temperature facility for irradiation to 1200 °C with real time read-out of the fiber sensors.

o) 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.

The MITR staff continues to improve a web-enabled neutron spectrometer at the 4DH1 beam facility, which was utilized by student groups and research. In collaboration with MIT's iLabs program, the MITR provides the online, interactive, real-time neutron-based experiment with a few partner universities. Using a combination of LabVIEW software and a prototype iLabs-developed architecture, this facility provides educational opportunities to students nationwide and internationally that do not have the benefit of an on-site nuclear reactor or other neutron source. In CY2012, students from the West Point Military Academy nuclear engineering laboratory course used the facility for remote neutron time-of-flight spectroscopy experiments.

An ongoing initiative is the partnership with INL Advanced Test Reactor User Facility (ATR-UF) for materials testing. The MITR is the first university research reactor selected as a partner facility with the ATR-UF. MITR staff also worked with INL staff to jointly develop advanced reactor instrumentation, and reviewed ATR-UF's user proposals.

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 eighty-three elements fabricated by B&W have been received, forty-eight of which remain in use. One has been removed because of suspected excess out-gassing and one hundred thirty-four 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.

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 the past year. Those changes related to safety and subject to additional review and approval are discussed in Section E of this report.

a) PM 6.0, "Test and Calibrations", and PM 7.0, "Maintenance Procedures", received general updates to reflect current practices, Technical Specification references, and equipment. PM 6.1.6, "Monthly Technical Specifications Tests", was compiled. The periodicity of all other tests and calibrations was shifted to a quarterly operating cycle. PM 6.1.4.6, "Electromagnet Coil Resistance Measurements", was created. (SR #0-11-14, #0-12-2, & #0-12-24)

b) PM 3.1.1.1 & 3.1.1.2, "Full Power Startup Checklists", were updated for best practices such as placing or checking the primary ion column online early in the Mechanical procedure, and new steps reflecting the previous modification (SR #M-11-5) of the pressure relief system. Details of many instrument readings and tolerance ranges were updated and clarified. (SR #0-12-8)

c) PM 3.3.3, "General Conduct of Fuel Transfer to/from Fission Converter", was updated to add the option of transferring partially spent fuel from the fission converter tank to the wet storage ring in the core tank. New procedure PM 3.3.3.4, "Fuel Element Transfers: Fission Converter to Wet Storage Ring", was created for transferring fuel in this manner. (SR #0-12-18)

d) PM 7.3.7, "D_2O Physical Inventory Procedure", was established to formalize the inventory process including proper containers and transport. (SR #0-12-1)

e) PM 7.4.4.8, "General Preparation for Work in the Core Tank" – Inspection of one's personal effects was broadened for the purpose of excluding foreign material that could inadvertently enter the core tank. (SR #0-12-13)

f) "BRR Spent Fuel Shipping Procedures" were updated to reflect the use of the Battelle Energy Alliance Research Reactor (BRR) cask. (SR #0-12-14)

g) "Hydride Fuel Irradiation Experiment Test and Handling Procedures" sub-item HYFI-9, "Hydride Fuel Irradiation Experiment Transfer of Irradiated Capsules 1 and 3 from Wet Storage Ring to Spent Fuel Pool", was updated to transfer previously irradiated HYFI fuel capsules to a designated location in the Spent Fuel Pool, cutting away non-activated sections of fuel capsule gas tubes so they would fit inside the transfer cask. (SR #0-11-4 & #0-11-4B)

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 CY2012, there were two shipments made, reducing the inventory of spent fuel at MIT to fourteen elements. 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 CY2013 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 CY2012) (normally at 5.8 MW)	207.3	319.8	218.7	100.0	845.8
b) MITR-II (MIT FY1976-CY2011)					32,411.8
c) MITR-I (MIT FY1959-FY1974)					10,435.2
d) Cumulative, MITR-I & MITR-II					43,692.8
2. MITR-II Operation (hours): (MIT CY2012)					
a) At Power (≥ 0.5-MW) for Research	401.5	1948.0	961.9	439.0	3750.4
b) Low Power (< 0.5-MW) for Training[1] and Test	13.5	64.5	133.3	4.5	215.8
c) Total Critical	415.0	2012.5	1095.2	443.5	3966.2

[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 six 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.

1. Nuclear Safety System Scrams	Total
a) Trip on Channel #2 as result of unexpected electronic noise during manipulation of the signal input cable.	1
b) Trip on Channel #3 as result of short period caused by operator error leaving Channels #1 & 2 on source range.	1
c) Trip on Channel #3 as result of spurious electronic noise during operation at power.	1
d) Trip on Channel #5 as result of conservative setting combined with power variation during a reshim.	1
e) Trip on Channel #5 as result of spurious electronic noise during operation at power.	1
Subtotal	5

2. Process System Scrams	
a) Low flow primary coolant scram when a local electric power transient from work on a failed roof A/C unit affected the main pumps' variable frequency drives.	1
Subtotal	1

3. <u>Unscheduled Shutdowns</u>

a)	Shutdown upon concern about Channel #1 accuracy during startup.	1
b)	Shutdown as result of extended loss of off-site electricity.	1
c)	Shutdown from apparent fluctuation of off-site electricity.	1
	Subtotal	3
	Total	**9**

4. Experience during recent years has been as follows:

Calendar Year	Nuclear Safety and Process System Scrams
2012	6
2011	9
2010	20

Fiscal Year	Nuclear Safety and Process System Scrams
2010	6
2009	2
2008	4
2007	5
2006	6

D. MAJOR MAINTENANCE

Major maintenance projects performed during CY2012 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 experiments, and monitored key performance data from the experiments during reactor operations. In CY2012 these experiments included the Advanced Clad Irradiation (ACI-2), the In-Core Sample Assembly (ICSA) Luna–1 & –2, and the Diffractometer at the 4DH4 beam facility.

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 continuation of ISO 9001 Certification. Preventive maintenance on conveyor machinery, such as alignment of conveyor carriages, was performed during major outages. Components for instrumentation and controls were replaced and tested. These included power supply connectors, conveyor watch-dog switches, and airlock control gears.

Major reactor maintenance items performed in CY2012 are summarized as follows:

1) The electromagnets for shim blades 1 & 6 were replaced on 01/17/12.

2) The blade drive for shim blade 1 was rebuilt and replaced on 01/17/12.

3) The blade drive for shim blade 6 was rebuilt and replaced on 04/19/12.

4) The primary ion column was repacked and replaced on 02/08/12, 04/09/12, 07/05/12, and 10/04/12.

5) The primary ion column inlet and outlet filters were replaced on 04/09/12.

6) The primary and D_2O conductivity meters were replaced on 04/09/12.

7) The D_2O ion column was repacked and replaced on 04/09/12.

8) The shield coolant pump shaft seal was replaced on 02/09/12.

9) The fire alarm system for NW12 was replaced over the first two weeks of March 2012.

10) All circuit breakers on motor control center one (MCC-1) were cleaned and inspected on 04/07/12. Four breaker trips were observed to be faulty. Two were replaced that day.

11) During the week of 9 April 2012 there were several changes to nuclear instrumentation. The Gamma-Metrics fission chambers from 4IH1 and 3GV4 were removed. The ion chambers for nuclear safety Channels 1 and 5 were transferred from 3GV1 to 3GV4. The broken Channel 7 compensated ion chamber was removed from 4IH4 and replaced with a working spare fission chamber from the old Gamma-Metrics project.

12) During the week of 9 April 2012 the motors for primary coolant pump MM-1 and secondary coolant pump HM-B were replaced as preventative measures.

13) The shield coolant pump's circuit breaker contactor coil was replaced on 04/25/13.

14) The cleanup system recirculation pump for the fission converter's water shutter was replaced on 06/12/12.

15) Repair of several pinhole leaks in the secondary coolant system piping in the equipment room, and installation of two spare flanges in the cooling tower cleanup system, were completed on 07/06/12.

16) The multipoint temperature recorder in the control room was replaced with a digital paperless recorder on 07/06/12.

17) All circuit breakers on motor control center two (MCC-2) were cleaned and inspected on 07/02/12.

18) The medical water shutter overflow probe (BL-4) was replaced on 07/06/12.

19) The fission converter tank was defueled the week on 16 July 2012.

20) The two remaining faulty circuit breakers in MCC-1 were replaced on 07/27/12.

21) New xenon worth buildup curves were developed the week of 6 August 2012.

22) New xenon worth decay curves were developed the week of 13 August 2012.

23) Plenum blower #2 was replaced on 09/14/12.

24) A pinhole leak in a 3GV cooling line was repaired on 10/04/12.

25) Fan belts were replaced for all blowers and fans on 10/5/12.

26) During the week of 8 October 2012 the motors for primary coolant pump MM-1A and secondary coolant pump HM-A were replaced as preventative measures.

27) The reactor's automatic controller for the regulating rod was replaced 11/07/12.

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 or 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.

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, and from October 2011 to July 2012.

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, and from April to July 2012 for various sample irradiations using heated and unheated capsules.

Ion Column Resin Recovery
SR #M-12-1 (01/13/2012), #M-12-2 (01/17/2012), #M-12-3 (02/10/2012)

A special procedure was prepared and performed to operate the primary coolant cleanup system in various flow paths, in order to collect resin beads that had escaped from the primary ion column during a maintenance outage and had been observed circulating throughout the system upon restart of the main primary pumps. In addition, existing core tank recirculation equipment was modified to allow primary coolant to be suctioned from the core tank, filtered for foreign material, and returned to the primary storage tank. Finally, a filter screen with minimal flow resistance was installed at the primary coolant inlet to the main heat exchanger HE-1 to prevent foreign material from entering its coolant channels. All procedures, materials, and equipment for this project were evaluated to be compatible for use inside the core tank and primary system.

LUNA-HTIF
SR #0-12-20 (07/23/2012)

A test fit procedure was established and performed for a future high-temperature fiber-optic sensor test that will be done in a custom-built in-core High Temperature Irradiation Facility with real time read-out of the fiber sensors. Set-up requirements and radiological controls were maintained to match existing in-core handling procedures.

MCODE for Fuel Management
SR #0-11-12 (08/21/2012)

The existing CITATION-based fuel management code was replaced with MCODE-FM, a coupling of the Monte-Carlo-based MCNP with the ORIGEN point depletion code. The MCNP and MCODE models of the MITR were benchmarked extensively. Comparisons of measured and generated values for fast flux, thermal flux, and reactivity for a number of cores all showed excellent agreement.

New Digital Recorders for the Control Room
SR #E-12-1 (10/11/2012), #E-12-2 (07/23/2012)

A program is underway to replace aged analog recorders in the control room with new digital paperless equivalents. The multipoint temperature recorder and the radiation monitor recorder were replaced in CY2012. A third recorder will be installed in CY2013 to replace three separate recorders – the building delta-P recorder, the D_2O gasholder recorder, and eventually the Gould effluent recorder. These recorders do not provide any reactor control functions, nor do they initiate any scram signals. The alarm functions of the temperature recorder were verified to remain unchanged. The greater reliability of the digital equipment was judged to be an improvement in safety.

DWK250 Wide Range Monitors
SR #0-12-21 (10/19/2012)

Three analog display meters were added to the control console from a new nuclear instrument channel (a DWK250 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.

Replacement Auto-Control Unit
SR #E-12-3 (11/02/2012)

The existing analog proportional-integral-derivative (PID) servo-controller for automatic control of steady-state reactor power was replaced with an equivalent modern digital PID servo-controller. Rather than an ion chamber (valid for reactor power levels of 10 kW to 6000 kW), this upgrade includes use of a miniature ("peanut-type") fission chamber, which has sufficient response for at least a similar range and more. The fission chamber and the servo-controller were both tested extensively. Together, this new automatic control system continues to meet the bounding limitations of all relevant Technical Specifications, in particular TS 3.2.2, "Reactivity Insertion Rates and Automatic Control", and SAR Section 7.3.1, "Automatic Control".

F. ENVIRONMENTAL SURVEYS

Environmental monitoring is performed using continuous radiation monitors and passive dosimetry devices (TLD). The radiation monitoring system consists of G-M detectors and associated electronics at each remote site with data transmitted continuously to the Reactor Radiation Protection Office and recorded on strip chart recorders and electronically in a database. The remote sites are located within a quarter mile radius of the facility. The calendar year total in a databases detectable radiation exposures per sector, due primarily to Ar-41, are presented below. Some units were inoperable periodically during the reporting period due to site renovations. These values are adjusted for the period(s) when the site units were not operational. The passive TLDs were in place at all times during the year and are exchanged quarterly.

Site	Exposure (01/01/12 – 12/31/12)
North	0.05 mrem
East	0.63 mrem
South	0.02 mrem
West	0.71 mrem
Green (east)	0.00 mrem

Calendar Year Average

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
2005	0.2 mrem
2004	0.2 mrem
2003	0.2 mrem
2002	0.3 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, 2012 - December 31, 2012

Whole Body Exposure Range (rems)	Number of Personnel
No measurable	44
Measurable – < 0.1	29
0.1 – 0.25	9
0.25 – 0.50	1
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
2.00 – 2.25	0

Total Person Rem = 2.8 Total Number of Personnel = 83

From January 1, 2012, through December 31, 2012, the Reactor Radiation Protection Office 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, and diffractometer beam installation and 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 8,019,006 liters discharged during CY2012 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 168.6 μCi for CY2012. The total tritium was 130.9 mCi. The total effluent water volume was 11,338,549 liters, giving an average tritium concentration of 11.5E-06 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 1062.45 Ci of Ar-41 was released at an average concentration of 1.54E-10 μCi/ml. This represents 1.54% of EC (Effluent Concentration (1E-08 μCi/ml)).

3. Solid Waste

One shipment of solid waste was made during the calendar year. The information pertaining to this shipment is provided in Table H-2.

TABLE H-1

ARGON-41 STACK RELEASES

CALENDAR YEAR 2012

		Ar-41 Discharged (Curies)	Average Concentration[1] (µCi/ml)
January 2012	(shutdown)	0	0
February		128.92	2.25 E-10
March		184.47	3.22 E-10
April		NDA[2]	NDA[2]
May		200.31	3.49 E-10
June		113.86	1.98 E-10
July		19.34	3.37 E-11
August		76.77	1.34 E-10
September		261.91	4.57 E-10
October		NDA[2]	NDA[2]
November		29.90	5.21 E-11
December		46.97	8.19 E-11
	Totals (12 Months)	**1062.45**	**1.54 E-10**
	EC (Table II, Column I)		1×10^{-8}
	% EC		**1.54%**

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

(2) No Detectable Activity.

TABLE H-2

SUMMARY OF MITR-II RADIOACTIVE SOLID WASTE SHIPMENTS

CALENDAR YEAR 2012

Description	
Volume	60 ft^3
Weight	2,344 lbs.
Activity	1.1 mCi
Date of shipment	February 12, 2012
Disposition to licensee for burial	Energy Solutions, Clive, UT
Waste broker	Philotechnics

TABLE H-3

LIQUID EFFLUENT DISCHARGES
CALENDAR YEAR 2012

	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. 2011	2.12	4.11	121,473	33.9
Feb.	40.9	33.9	949,995	35.7
Mar.	12.7	6.92	1,113,671	6.22
Apr.	24.2	9.98	81,988	122
May	2.07	1.47	1,549,501	.950
June	1.67	5.29	1,420,568	3.72
July	NDA(2)	15.4	143,980	107
Aug.	NDA(2)	10.2	3,926,663	2.60
Sept.	NDA(2)	16.0	1,393,128	11.5
Oct.	74.1	1.99	52,179	38.1
Nov.	5.81	10.2	296,009	34.3
Dec.	5.01	15.5	289,394	53.5
12 months	168.6	130.9	11,338,549	11.5

(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.