NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Subject: Annual Report, Docket No. 50-20, License R-37,
Technical Specification 7.13.5

Gentlemen:

Forwarded herewith is the Annual Report for the MIT Research Reactor for the period from July 1, 2009 to June 30, 2010, in compliance with paragraph 7.13.5 of the Technical Specifications for Facility Operating License R-37.

Sincerely,

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Enclosure: As stated

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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 July 1, 2009 – June 30, 2010

by

REACTOR STAFF

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MIT RESEARCH REACTOR

ANNUAL REPORT TO

U. S. NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 2009 – JUNE 30, 2010

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 7.13.5, which requires an annual report following the 30th of June of each year.

The MIT Research Reactor (MITR), as originally constructed, 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 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 fully enriched in uranium-235. 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 continuous operation at full power.

In July 1999, an application to relicense the reactor for twenty years and to upgrade its power level to 6 MW was submitted to the U.S. Nuclear Regulatory Commission. That request is now being processed. In December 2000, a fission converter medical facility was commissioned. This facility generates the best epithermal beam in the world for use in the treatment of certain types of cancer.

This is the thirty-fifth annual report required by the Technical Specifications, and it covers the period July 1, 2009 through June 30, 2010. 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-third full year of routine reactor operation at the 5-MW licensed 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, medical studies such as boron neutron capture studies, and neutron activation analyses. 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 5 MW. For this reporting period, the nominal full power operating cycle continued to be four weeks at a time, followed by a shutdown lasting half a day to five days, 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 four to five weeks.

The reactor averaged 110 hours per week at power compared to 124 hours per week for the previous year and 139 hours per week two years ago. The lower average for the past year is the result of several major projects and activities that required longer or frequent planned outages, such as equipment upgrades, experiment changeouts, and the replacement of reactor heat exchangers.

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 FY2010, compensation for reactivity lost due to burnup was provided by six 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. Nine new fuel elements were introduced into the reactor core during FY2010.

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 five of the newer, MITR-II fuel elements (506 grams U-235) have been introduced to the core. Of these, one hundred thirty-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 fifty-eight are either currently in the reactor core, in the fission converter tank, or have been partially depleted and are in the wet storage ring awaiting reuse. During the period of FY2010, eight 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, which were designed to achieve a maximum peaking of the thermal neutron flux in the heavy water reflector beneath the core. These had been removed in November 1976 in order to gain the reactivity necessary to support more in-core experiment facilities.

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 FY2010 include:

a) Activation of gold-198 seeds and ytterbium pellets for brachytherapy, xenated silicon chips for trace element analyses, fusion material laminates and Ge wafers for material science studies.

b) Irradiation of SiC in 2PH1 and 3GV facility for Colorado School of Mines non-destructive irradiation damage detection studies, funded by INL's Advanced Test Reactor National Scientific User Facility (ATR-NSUF).

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

d) Activation of ocean sediments for the Woods Hole Oceanographic Institute and the University of British Columbia.

e) Activation of Teflon and Si wafers for University of Alabama.

f) Activation and NAA of crystal samples for determination of trace elements for the Earth, Atmosphere, and Planetary Sciences Department.

g) Activation and NAA of ultra high purity B-11 for determination of trace element analysis for Ceradyne Boron Inc.

h) 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.

i) Use of the reactor for training MIT student reactor operators and for MIT nuclear engineering classes (courses 22.06, 22.09, 22.921, and the Reactor Technology Course for nuclear power executives).

j) Gamma irradiation of soil samples for Yale University School of Environmental Engineering.

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

l) Activation of nanoparticles for radiotracer study 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) and this project began in mid-June 2009. Prof. Mujid Kazimi is the Principal Investigator for this project.

n) The ICSA was used to irradiate molybdenum targets to investigate the feasibility of producing "n-γ" ^{99}Mo for use in producing the medical isotope ^{99m}Tc.

An ongoing initiative is the partnership with INL Advanced Test Reactor User Facility (ATR-UF) for materials testing. The MITR is the first university facility selected to partner with the ATR-UF. During FY2010, MITR staff completed work with Prof. David Olson's group at Colorado School of Mines in irradiation of SiC. MITR staff also worked with INL staff to jointly develop advanced reactor instrumentation and reviewed ATR-UF's user proposals.

The new In-Core Sample Assembly (ICSA) was fabricated and test-fitted in February 2009. The goals of the ICSA redesign were to provide positive sweep gas flow and to allow for a wider range of feedthroughs to accommodate temperature and other in-core measurements or active control of irradiation parameters. During December 2009 – January 2010, a gamma heating susceptor concept was successfully demonstrated to provide capsule irradiation up to 850 °C.

Irradiation programs have been funded to utilize this facility for testing advanced high temperature materials (MAX phases) and advanced in-core thermocouples and fiber optic sensors. The ICSA was also used to irradiate molybdenum targets to investigate the feasibility of producing "n-γ" ^{99}Mo for use in producing the medically important isotope ^{99m}Tc. This project was undertaken in cooperation with GE with funding from NNSA.

The MITR has completed a web-enabled neutron spectrometer at the 4DH1 beam facility, which was utilized by several student groups. 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 will provide educational opportunities to students nationwide and internationally that do not have the benefit of an on-site nuclear reactor or other neutron source.

3. Changes to Facility Design

Except for minor changes reported in Section E, no changes in the facility design were made during this fiscal year. As indicated in past reports the uranium loading of MITR-II fuel was increased from 29.7 grams of U-235 per plate and 445 grams per element (as made by Gulf United Nuclear Fuels, Inc.) to a nominal 34 and 510 grams respectively (made originally by the Atomics International (AI) Division of Rockwell International, now by B&W). With the exception of seven elements (one Gulf, six AI) that were found to be out-gassing excessively, performance of these fuel elements has been good. The heavier 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 sixty-five elements fabricated by B&W have been received, fifty-eight of which remain in use. One has been removed because of suspected excess out-gassing and one hundred 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, currently under development by the RERTR Program. Although studies show that the use of these fuels is feasible, conversion of the MITR-II to lower enrichment must await the 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.

5. <u>Changes in Operating Procedures</u>

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 6.1.3.11, "Emergency Power Transfer Test", is a quarterly test procedure that was rewritten to reflect current practices and equipment. Notifications were added for medical beam experimenters and the MIT Police. Equipment to restart or check following the test was listed more specifically, and new steps were provided to allow the procedure to be done without reconfiguring the process systems to shutdown alignment. This makes it possible for the test to be performed during shorter shutdowns that do not involve closing the containment building. (SR#-0-10-1)

b) PM 7.4.3.1, "Cooling Tower Drain"; and "Special Procedure to Drain the Secondary System Piping" – The maintenance procedure for draining the cooling towers was updated for use with the current towers. A corresponding Special Procedure was established for draining the rest of the secondary piping in preparation for replacement of the reactor's main heat exchangers and other necessary reactor maintenance. (SR#-0-10-3)

c) "Special Procedure to Lower the Core Tank Level and to Drain the Primary System" was established for draining the core tank to the level of the anti-siphon valves and inlet plenum, for replacement of the reactor's main heat exchangers and any future similar needs. (SR#-0-10-4)

d) "External Core Tank Sampling/Recirculation System" – The design was described and a Special Procedure was established for use of a small sampling / recirculation system (external to the core tank) that can be installed while the core tank level is below that of the anti-siphon valves / inlet penetration, during replacement of the reactor's main heat exchangers and for any future similar needs. (SR#-M-10-3 & SR#-M-10-4)

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 16 hours, before startup if a channel has been repaired or de-energized, and at least monthly; a few are on different schedules. Procedures for such surveillance are incorporated into daily or monthly 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 FY2010, there was one shipment made, reducing the inventory of spent fuel at MIT to close to zero. The U.S. Department of Energy has indicated that further shipments may be feasible in FY2011 for future fuel discharges.

A replacement for the BMI-1 cask, the BEA Research Reactor (BRR) package has been manufactured and licensed for the shipment of MITR-II fuel. Upon approval of use of the BRR cask at the Savannah River Site, MITR will begin shipping using the BRR cask.

B. REACTOR OPERATION

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

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
1. Energy Generated (MWD):					
a) MITR-II (MIT FY2010) (normally at 4.9 MW)	247.8	208.8	299.2	80.6	836.4
b) MITR-II (MIT FY1976-2009)					30,289.0
c) MITR-I (MIT FY1959-1974)					10,435.2
d) Cumulative, MITR-I & MITR-II					41,560.6
2. MITR-II Operation (hours): (MIT FY2010)					
a) At Power ($\geq$ 0.5-MW) for Research	1845.867	1870.526	1535.904	455.261	5707.558
b) Low Power (< 0.5-MW) for Training[(1)] and Test	24.109	0.767	0.404	0.244	25.523
c) Total Critical	1869.976	1871.293	1536.307	455.505	5733.081

(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 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.	6
	Subtotal	6
2.	Process System Scrams	
a)	None.	0
	Subtotal	0

3. Unscheduled Shutdowns

a)	Shutdown due to magnet drop of shim blade #2.	1
b)	Shutdown due to magnet drop of shim blade #6.	1
c)	Shutdown due to failure of core purge blower pulley.	1
	Subtotal	3
	Total	9

4. Experience during recent years has been as follows:

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 FY2010 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 and research. Additionally, Reactor Operations staff provided safety reviews and essential support for all installations and removals of reactor experiments, and monitored key performance data from the experiments.

(a) Advanced Clad Irradiation (ACI-2) – This is the longest-running in-core experiment for the reactor, surpassing the record of the original ACI. First irradiation began in March 2009 and continued until mid-December 2009. Second irradiation, with a different batch of specimens, was loaded into the reactor in early March 2010 and concluded at end of April 2010. Reactor Operations staff supported all ACI-2 activities, including final removal from the core in two stages, and setup for post-irradiation inspections by experimenters.

(b) In-Core Sample Irradiation Assembly (ICSA) – Reactor staff performed reactivity worth measurement for the new design, and supported several removals and installations of the assembly for experiment change-outs, including one batch of medical target molybdenum. Reactor staff also supported shipment of the irradiated molybdenum-99 sample to an independent off-site lab for analysis.

(c) 4DH4 Diffractometer – During this fiscal year, reactor staff continued to develop software and hardware control of the beam shutter to improve operational safety such as remote emergency shut-off of the neutron beam. Reactor staff also reconfigured peripheral shielding to reduce side-scattering when the beam is on. In November 2008, the diffractometer beam first passed through its bismuth filter, showing a 8.7E+06 neutrons/cm^2/second flux at full power. By January 2009, the diffractometer successfully produced monochromatic neutrons at a 41.5 degree angle from its main axis. The monochromatic neutron flux was measured at 3.27E+06. The facility had been utilized both by MIT researchers and outside experimenters such as NASA in FY2010.

(d) 3GV Irradiations – Reactor staff supported five irradiations at the 3GV6 facility over the course of the fiscal year. 3GV load and unload procedures are done with the reactor at low power or shut down, to minimize personnel dose exposure from sample handling. The procedures are therefore usually scheduled to coincide with shutdowns and startups.

For continuous support of neutron transmutation doping of silicon, reactor staff have created and upgraded many operational procedures and recordkeeping practices. There is an annual external audit to review the program for continuation of ISO 9001 Certification. Preventive maintenance on conveyor machinery was performed during major outages.

Major maintenance items performed in FY2010 are summarized as follows:

1) The core purge blower and pulley system were replaced. The core purge system continuously draws air across the small enclosed space at the top of the core tank to reduce accumulation of Ar-41 there. Deterioration of the pulley could result in reduced air flow from the enclosed area. The pulley was original equipment, and a new pulley setup was not readily compatible with the blower. Therefore the blower and pulley were both replaced with updated equipment. Additionally, the core purge system's inlet and outlet filter jars were replaced to improve their air seals. The flow gauge at the blower's discharge was also replaced.

2) The stack base access was modified from just a hatch to room-size housing for improved personnel fall protection. Access to the base of the reactor stack requires climbing down a 20-foot long staircase. To improve fall protection, the handrail of the staircase was extended upward to ensure an ample grip area for personnel using the stairs. This meets new OSHA requirements. The new access area is now covered within the protective housing, and is therefore weather-proofed. It is equipped with new lighting, intercom, a small freight-lift, and an automatic roll-up door. General lighting in the stack base area was also improved. Planning and procurement started about a year ago with consultation from MIT EHS. Reactor staff performed the installation.

3) The reactor security system went through major upgrade. Reactor staff installed some specialty security equipment, and supervised various contractors such as Siemens Building Technologies and Wise Construction on facility-wide installation of CCTV systems, sensors, switches, transmitters, gates, doors, and data closets. Logistical support for the installation was provided by MIT Facilities, MIT Security and Emergency Management Office (SEMO), the MIT Police, and the MIT Information Services and Technology (IS&T). The Reactor Radiation Protection Office provided radiological training and issued dosimetry for all contractor workers for dose monitoring. Planning and design work started in December 2008. Request for funding of the upgrade for $1.4M was approved in July 2009, and provided by the National Nuclear Security Administration of the Department of Energy (DOE-NNSA). Construction started in late August 2009, and was completed in January 2010. Final acceptance and assurance tests by both reactor staff and DOE were completed in March 2010.

4) More than 30 leak tapes at the reactor reflector system were replaced with new style leak detection units. This is the first stage in an effort to transition all reactor leak tapes to the new style. Reactor staff accepted the performance of the new tapes after more than a year of field-testing to assure reliability. Replacement and installation is labor-intensive and will be performed only during extended outages following sufficient reactor cool-down time so as to minimize personnel dose exposure. The new tapes are made of materials that are more durable, and

can be better secured to piping and flanges. They are also color-coded for ease of identification.

5) All four picoammeters in the Control Room main console for neutron power indications were replaced with upgraded units. The new picoammeters contain added functions such as auto-ranging and communication ports for remote signal transmission. These units replaced those for nuclear Channels #7, #9 and Linear N-16. The Channel #8 picoammeter will be put to use when the ion chamber for the channel is replaced in the next fiscal year.

6) The drive for reactor control shim blade #4 was rebuilt and its electromagnet and neutron absorber section were all replaced on 01/28/2010.

7) The drive for reactor control shim blade #6 was rebuilt and its electromagnet was replaced on 02/02/2010.

8) The drive for reactor control shim blade #2 was rebuilt and its electromagnet was replaced on 03/15/2010. The proximity switch and tube for shim blade #2 were replaced the following day.

9) The neutron absorber section for reactor control shim blade #5 was replaced on 04/27/2010.

10) A new mezzanine was constructed at the southeast quadrant inside the containment building. This mezzanine would become the new location for the D_2O helium gasholder upon its relocation from the Equipment Room during the heat exchanger replacement outage in order to make room for new Equipment Room piping. (Note: The actual D_2O helium gasholder in the Equipment Room would be removed and then retired or refurbished. The graphite CO_2 gasholder, in better condition, would also be removed from the Equipment Room and placed on the mezzanine for use as the new D_2O helium gasholder.)

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

On Friday 04/23/2010 the reactor was shut down as planned for an extended outage to replace its main heat exchangers and all associated primary and secondary piping. Activities the week of 04/26/2010 were for final preparation. Reactor staff began removing the existing heat exchangers and piping the week of 05/03/2010. By early June, removal was completed and the construction phase began. This would continue into the early part of the next 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."

<u>Advance Cladding Irradiation Facility (ACI)</u>
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, and from March 2010 to April 2010.

<u>Heated In-Core Sample Assembly Experiment (ICSA)</u>
SR #0-04-19 (12/01/2004), #M-04-2 (12/30/2004), #0-05-11 (07-22/2005),
SR #M-09-1 (7/30/2009), #M-09-2 (12/11/2009), #0-10-2 (03/28/2010)

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. The ICSA operated in core from December 2009 through April 2010 for various sample irradiations using heated and unheated capsules. 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.

<u>Expansion of Back Mezzanine at Reactor Top</u>
SR #M-10-1 (04/22/2010), #M-10-2 (04/29/2010)

A previously-existing structural platform was reconstructed beyond dhte far side of the reactor top. The new section is made of steel support beam and steel grating, with a top deck of aluminum tread plates (diamond plate). It is rated for a live load of 150 lbs. per square foot. The area will be used for relocation of the D_2O helium gasholder from the equipment room in an effort to create space for installation of a new heat exchanger and associated piping later in 2010.

F. ENVIRONMENTAL SURVEYS

Environmental monitoring is performed using continuous radiation monitors and dosimetry devices. 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. The remote sites are located within a quarter mile radius of the facility. The fiscal year total detectable radiation exposures per sector, due primarily to Ar-41, are presented below. Units located at east and south sector were inoperable periodically during the reporting period due to site renovations. These values are adjusted for the period(s) the sites were not operational.

Site	Exposure (07/01/09 – 06/30/10)
North	0.22 mrem
East	0.12 mrem
South	0.32 mrem
West	0.36 mrem
Green (east)	0.13 mrem

Fiscal Year Averages

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:

July 1, 2009 - June 30, 2010

Whole Body Exposure Range (rems)	Number of Personnel
No measurable	107
Measurable – < 0.1	67
0.1 – 0.25	12
0.25 – 0.50	2
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 = 3.9 Total Number of Personnel = 188

From July 1, 2009 through June 30, 2010, 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 fission converter 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 various sinks. All of the liquid volumes are measured, by far the largest being the 5,200,430 liters discharged during FY2010 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 3.25E-4 Ci for FY2010. The total tritium was 154.3 mCi. The total effluent water volume was 5,302,829 liters, giving an average tritium concentration of 29.1×10^{-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 after the authorized dilution factor of 3000 with the exception of Ar-41, which is reported in the following Table H-1. The 1,355.82 Ci of Ar-41 was released at an average concentration of 3.53E-9 µCi/ml. This represents 35.3% of EC (Effluent Concentration (1×10^{-8} µCi/ml)).

3. Solid Waste

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

TABLE H-1

ARGON-41 STACK RELEASES

FISCAL YEAR 2010

	Ar-41 Discharged (Curies)	Average Concentration[1] (µCi/ml)
July 2009	121.57	3.39 E-9
August	85.36	2.98 E-9
September	121.04	4.22 E-9
October	191.75	5.31 E-9
November	186.13	6.44 E-9
December	99.23	2.75 E-9
January 2010	132.45	3.67 E-9
February	136.33	4.72 E-9
March	150.43	5.20 E-9
April	131.54	3.67 E-9
May	0	0
June	0	0
Totals (12 Months)	**1355.82**	**3.53 E-9**
EC (Table II, Column I)		1×10^{-8}
% EC		**35.3%**

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

TABLE H-2

SUMMARY OF MITR-II RADIOACTIVE SOLID WASTE SHIPMENTS

FISCAL YEAR 2010

Description	
Volume	75 ft^3
Weight	2,358 lbs.
Activity	11.9 mCi
Date of shipment	February 3, 2010
Disposition to licensee for burial	Impact Services, Oak Ridge, TN
Waste broker	Philotechnics Ltd., Oak Ridge, TN

TABLE H-3

LIQUID EFFLUENT DISCHARGES
FISCAL YEAR 2010

	Total Activity Less Tritium	Total Tritium Activity	Volume of Effluent Water(1)	Average Tritium Concentration
	($x10^{-6}$ Ci)	(mCi)	(liters)	($x10^{-6}$ μCi/ml)
July 2009	2.16	13.4	688,000	19.5
Aug.	11.5	18.8	476,000	39.4
Sept.	3.12	.0333	580,000	.0574
Oct.	NDA	.145	411,000	.354
Nov.	28.9	1.67	471,000	3.54
Dec.	4.64	3.59	205,000	17.5
Jan. 2010	5.34	3.16	627,000	5.04
Feb.	NDA	.300	653,000	.458
Mar.	NDA	5.07	505,000	10.0
Apr.	23.2	3.76	614,000	6.13
May	38.0	10.0	17,000	582.0
June	208.0	94.4	54,000	1,730.0
12 months	325.0	154.3	5,303,000	29.1

(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. 7.13.5(i).

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 because they used the original epithermal beam in the basement medical therapy room. A new beam that is superior in both flux and quality continues to be 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.