NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JOHN A. BERNARD
Director
Director of Reactor Operations
Principal Research Engineer

138 Albany Street, Cambridge, MA 02139-4296
Telefax No. (617) 253-7300
Tel. No. (617)

Activation Analysis
Coolant Chemistry
Nuclear Medicine
Reactor Engineering

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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, 2008 to June 30, 2009, in compliance with paragraph 7.13.5 of the Technical Specifications for Facility Operating License R-37.

Sincerely,

Thomas H. Newton, Jr., Ph.D., PE
Associate Director, Engineering
MIT Research Reactor

Edward S. Lau, NE
Superintendent for Operations & Maintenance
MIT Research Reactor

John A. Bernard, Ph.D., PE, CHP
Director of Reactor Operations
MIT Research Reactor

JAB/gw

Enclosure: As stated

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

USNRC – Senior Reactor Inspector
Research and Test Reactors Branch B
Division of Policy and Rulemaking
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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, 2008 – June 30, 2009

by

REACTOR STAFF

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MIT RESEARCH REACTOR

ANNUAL REPORT TO

U. S. NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 2008 – JUNE 30, 2009

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-fourth annual report required by the Technical Specifications, and it covers the period July 1, 2008 through June 30, 2009. 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-second 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 124 hours per week at power compared to 139 hours per week for the previous year and 142 hours per week two years ago. The slightly lower average for the past year is the result of several major maintenance projects that required longer planned outages.

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 FY2009, compensation for reactivity lost due to burnup was provided by seven 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 FY2009.

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 one hundred ninety-six of the newer, MITR-II fuel elements (506 grams U-235) have been introduced to the core. Of these, one hundred twenty-nine 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 FY2009, four 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 FY2009 include:

a) Use of the fission converter neutron beam for irradiation of cell cultures and boron compounds for researchers from the University of Birmingham (UK) testing new compounds for Boron Neutron Capture Therapy.

b) Activation of yttrium foils for an ongoing clinical trial at the Massachusetts General Hospital and Memorial Sloan-Kettering Cancer Center for spinal cord cancer removal therapy.

c) 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.

d) Irradiation of SiC in 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).

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

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

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

h) Two irradiations of germanium wafers NTD using the 3GV port for astronomy x-ray detectors have been completed for a research institute in Italy.

i) Activation and NAA of X-750 metal alloys for determination of trace elements Nb and Ta for Prof. Ron Ballinger of NSE Department.

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

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

l) 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.

m) 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).

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

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

p) Activation of nanoparticles for radiotracer study of nanomaterial toxicity for Harvard School of Public Health.

q) The second Advanced Cladding Irradiation campaign (ACI-2) started in February 2009 with funding from Toshiba / Westinghouse to continue the irradiation of SiC cladding. The same experiment, with different SiC composite samples, was selected for funding by 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.

In addition to the above list of current activities, the MIT Nuclear Reactor Lab (NRL) has provided testing facilities for neutron irradiations in-core in support of the light-water nuclear power industry since 1989. The current focus of NRL's in-core materials and fuel group has been a long-term experiment to evaluate the feasibility of using SiC / SiC composite materials in pressurized water reactor (PWR) conditions. A first set of samples was irradiated from May 2006 to September 2006. This initial set of samples was shipped to Oak Ridge National Laboratory for further analysis although initial post-irradiation examination was done on-site. A second set of samples, including some samples carried over from the first irradiation, was irradiated from December 2006 to October 2007. Initial PIE has been completed and mechanical property testing at MIT was conducted from February through June of 2009. These materials have been proposed as a replacement for Zircaloy™ fuel cladding for PWRs in order to improve fuel performance in loss of coolant accidents and thus allow for increased reactor power and higher fuel burnup.

A new initiative currently ongoing is the collaboration 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 FY2008, MITR staff worked with Prof. David Olson's group at Colorado School of Mines in irradiation of SiC irradiation damage sensors. MITR staff are also working with INL staff to jointly develop advanced reactor instrumentation and FY2009 call-for-proposal.

As for other in-core facility upgrades, a new In-Core Sample Assembly (ICSA) was fabricated and test-fitted in February. 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. Design is currently underway of a gamma heating susceptor that would allow irradiation at up to 800 °C.

During this fiscal year, the NRL staff finished constructing a neutron triple-axis diffractometer and neutron-optics test station at NRL at the 4DH4 beam facility. The new neutron instrument at NRL has already been used for testing novel neutron detectors by several groups. A new program to develop specialized neutron optics was recently funded by DOE.

The MITR has completed a web-enabled neutron spectrometer at the 4DH1 beam facility. In collaboration with MIT's iLabs program, the MITR plans to debut the first 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 Babcock & Wilcox). 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 fifty-six elements fabricated by Babcock & Wilcox have been received, fifty-eight of which remain in use. One has been removed because of suspected excess out-gassing and ninety-seven have been discharged because they have attained the fission density limit.

The MITR is actively involved in feasibility 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 Argonne National Laboratory. 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 preliminary studies show that the use of these fuels may be 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. 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 6.5.5, "Backup Steam Supply Availability", is an annual test procedure that was rewritten for use with a new boiler and associated piping system. Installation of this equipment was completed by MIT Facilities in winter 2007-2008, and provided for the first time a dedicated steam supply for the containment building. However, a separate steam supply from the central utility plant remains capable of automatically supplying sufficient pressure to continue operating the reactor ventilation system in the event of failure of the on-site boiler. (SR#-0-08-4)

b) PM 7.3.2, "D_2O Ion Column Dedeuterization / Deutrization", was updated to reflect current practices and equipment. Steps were simplified and clarified for safety, efficiency, and dose reduction. (SR#-0-08-6)

c) "NTD Silicon Procedures for Unload, Load, and Entering Silicon Cells" continued to refine the main handling procedures for the Silicon Program with ALARA-oriented updates, and established a cell entry procedure to codify existing practices. (SR#-0-08-2)

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 FY2009, 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 FY2010 for future fuel discharges.

The certificate of compliance for the BMI-1 cask (the cask used for shipping MITR-II fuel) was scheduled to expire on October 1, 2008. In FY2009, MIT applied for and received a one-year extension for the use of the BMI-1 while a replacement cask is built and licensed by AREVA Federal Services (AFS). Delays in completion of manufacturing the replacement cask and approval for its use at the Savannah River Site will necessitate an application for an additional one-year extension for use of the BMI-1 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 FY2009) (normally at 4.9 MW)	247.6	249.8	326.9	229.7	1054.0
b) MITR-II (MIT FY1976-2008)					29,235.0
c) MITR-I (MIT FY1959-1974)					10,435.2
d) Cumulative, MITR-I & MITR-II					40,724.2
2. MITR-II Operation (hours): (MIT FY2009)					
a) At Power ($\geq$ 0.5-MW) for Research	1708.77	1410.25	1738.70	1602.25	6459.97
b) Low Power (< 0.5-MW) for Training(1) and Test	84.23	50.10	73.70	50.03	258.06
c) Total Critical	1793.00	1460.35	1812.40	1652.28	6718.03

(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 two inadvertent scrams and five 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) None.		0
		Subtotal	0
2.	Process System Scrams		
	a) Multiple simultaneous low flow trips as result of failure of the Chessell flow recorder.		2
		Subtotal	2

3. Unscheduled Shutdowns

a)	Shutdown due to loss of offsite electricity.	2
b)	Shutdown due to loss of ventilation when exhaust fan motor failed.	1
c)	Shutdown due to failure of the D_2O recombiner blower.	1
d)	Shutdown due to ventilation exhaust damper closing as result of trip of its hydraulic pump.	1
	Subtotal	5
	Total	7

4. Experience during recent years has been as follows:

Fiscal Year	Nuclear Safety and Process System Scrams
2009	2
2008	4
2007	5
2006	6
2005	6

D. MAJOR MAINTENANCE

Major maintenance projects performed during FY2009 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 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 will be the longest-running in-core experiment for the reactor, surpassing the record of the original ACI. Irradiation began in March 2009 and is expected to continue until the end of the calendar year. Reactor Operations staff supported several ACI-2 maintenance activities, including replacement of its charging pump and pump controller, and later its main recirculation pump. A new chiller was plumbed in, replacing the original ACI's charging tank.

(b) 4DH4 Diffractometer – During this fiscal year, reactor staff supported the development and hardware installation for control of the beam shutter with automatic safety interlocks. 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.

(c) 3GV Irradiations – Reactor staff supported five irradiations at the 3GV6 facility over the course of the year. New special procedures were developed for loading and removal of irradiated targets to minimize personnel dose exposure.

For continuous support of neutron transmutation doping of silicon, reactor staff has 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. During this fiscal year, additional radiation area monitors were installed near the unload-side windows. The new units read out locally, and also transmit their readings to the control room and to the Operations Office. Reactor staff also completed a real-time display station for remote monitoring of silicon status from the Operations Office.

Major maintenance items performed in FY2009 are summarized as follows:

1) The control room console shim blade and regulating rod position indicator system was completely replaced. A new backup display was also installed at the reactor top to provide redundancy. The previous system, in place since 1958, consisted

of gun turret indicators from WWII-era battleships. It had provided excellent service but was starting to show its age. This replacement had been planned starting two years earlier. The new system was designed and fabricated by reactor staff, using current-day electronic components.

2) The two cooling tower units of the secondary system were replaced with an upgraded model after a total of nine years of use. The new towers incorporated a significant number of modifications from the original version. The major redesign was for leak prevention. The new water cascades are made of a material that is stronger and more resistant to erosion. The cascades are also designed for improved aerodynamics, thus reducing air resistance and noise. The upgraded design also improved maintainability of the fan blades and motors, and positioned them farther off the ground to reduce intake of environmental debris. The piping associated with the cooling towers was also replaced to fit the new towers.

3) A new housing was constructed for the support equipment and piping adjacent to the towers. The housing is crucial for protecting the new VFDs for the cooling tower fans. It also protects the secondary coolant cleanup system.

4) The entire containment building exterior was painted. First all spots with signs of corrosion were sanded. The building was then coated with a two-step anticorrosion treatment followed by a topcoat.

5) The new reactor graphite region CO_2 supply system was completed and evaluated; it provides a reliable purge of CO_2 to minimize argon-41 production in the containment. The flow adjustment point (SV-16C) is now located in a low-dose area outside the equipment room proper, allowing adjustment while the reactor is operating. The key element of the new system is a low-pressure regulator which was not available at the time of the original design. The original CO_2 gasholder is no longer needed and was retired. The gasholder will eventually be dismantled in order to provide space for replacement of the reactor heat exchangers.

6) The reactor's regulating rod was replaced after four years of service. Its drive was also rebuilt.

7) The electromagnet for shim blade #5 was replaced and the blade drive was rebuilt.

8) The compensated ion chamber for linear flux Channel 7 was replaced with a new one after nearly 25 years of service.

9) Reactor staff assisted in the disassembly and removal of the Neutron Phase Contrast Irradiation (NPCI) facility from the 6SH2 beam port, as the project came to a conclusion. The shutter drum and the NPCI port plug were put into storage for potential future use. The shutter drum was only slightly activated, but the port plug was over 300 R/hour at the tip. The beam port was then shielded with a solid port plug.

10) Water-cooled air conditioning units were installed in two rooms in the basement of the containment building – the primary chemistry room and the data closet. These two rooms have in recent years been used to accommodate increasing amounts of equipment that generates substantial heat, such as central computer modules and variable frequency drive controllers (VFDs) for the main pumps. Dedicated cooling had become a requirement.

11) A major effort was launched to reduce argon-41 activity in the containment. Numerous small air gaps around the reactor were sealed including wall penetrations, the shim blade drive penetrations, the top of the fission converter, and all seven electrical junction boxes at the reactor's utility shelf. Most important was application of 100% silicone sealant to the gasket space between the upper shield ring and the upper shield access ring at the top of the core tank. Additionally, ventilation pressures and suctions throughout the building were rebalanced by adjusting the vanes at the openings of all the air supply registers and of the major exhaust register in the equipment room. Finally, reactor CO_2 cover gas feed rates for the graphite region, port boxes, and other experiment facilities were fine-tuned to optimal values. The result was a 50% reduction of containment argon-41.

12) The flow path for the core purge system was thoroughly inspected. Its flow meter, associated piping, flow switch, inlet filter (0.45 micron), automatic inlet valve MV-83 diaphragm, automatic outlet valve MV-64 actuator, and filter jars were all replaced.

13) The leak detector probe for the back stairwell floor was moved into the stairwell's dry-sump.

14) Further rainwater leakage at the back stairwell's outer wall was repaired by sealing wall seams below grade with cement sealant.

15) The containment exhaust fan motor in the ventilation stack base was replaced upon failing due to an electrical short inside the motor after ~15 years of service.

16) The cover gas recombiner blower (GM-1) for the D_2O reflector was replaced. Its main pulley was also replaced on a later date in order to boost the flow rate.

17) The ion column for the reactor primary coolant system was repacked and replaced five times during the fiscal year. The D_2O reflector system's ion column was repacked, deuterized, and replaced. The spent fuel storage pool's ion column was repacked and replaced. The shield system's ion column was also repacked and replaced after one year in service.

18) The flow meter and flow switch for the spent fuel pool's cleanup system were upgraded. The system's inlet filter housing and isolation valve were replaced. An ultrasonic level detector was installed with a display outside the room for better tracking of changes in the pool water level.

19) A Magnetoflow gage was installed in the waste tank recirculation system to allow remote monitoring of the recirculation flow and discharge flow downstream of the system's absolute filters. In the past, recirculation flow was only interpreted from pressure drops, and the pressure gages were prone to clogging. The Magnetoflow meter has no moving parts; it measures flow by change in electromagnetic flux.

20) The control variac for the D_2O cover gas recombiner was replaced after ~20 years of service, along with all related wiring. The variac was also relocated to a low-dose area outside the equipment room proper, allowing adjustment while the reactor is operating.

21) The Chessell flow recorder for indication of reflector, shield, and secondary system main flows was modified to branch its input to a set of four digital meters which now provide dedicated alarm and scram functions.

22) The blower for the reactor floor hot cells was replaced.

23) The main circulating pump (WM-1) for the makeup water system was replaced.

24) The roughing filters and HEPA filters for containment ventilation exhaust in the stack base were replaced. Stack flow was verified after replacement of the filters.

25) Optical fiber communication cables were installed for cooling tower data acquisition equipment. The cables linked the new cooling tower equipment housing to the control room through a new containment penetration that was installed just prior to the annual building pressure test.

26) A significant maintenance focus over the course of FY2009 was on shipping low-level waste to reduce the inventory on site. The two shipments included five 55-gallon drums of spent ion column resin, five B-25 containers (12,000# capacity, certified for use in Type A packaging) and five B-12 containers (approximately half the size). Preparation during this fiscal year included re-sealing the B-25 and B-12 containers, weighing them, and loading them onto shipping trucks using a high-capacity rental forklift.

27) This year also saw a major effort to reduce liquid waste inventory on site. Liquid waste was first diluted by mixing with fresh city water in the waste tanks, sampled, and then discharged. A total of 27 such discharges took place this year, all completed without problems.

28) Two more riser pipe sections of the shield coolant manifold in the equipment room were replaced in an effort to prevent chronic development of leaks.

29) The main intake and exhaust ventilation dampers were cleaned, lubricated and vacuum-tested satisfactory. This is a scheduled preventive maintenance item to ensure reliable operation for containment isolation when needed.

30) All reactor pump motors, shafts, and bearings were inspected and lubricated twice during the year as preventive maintenance for over a dozen pumps and blowers.

31) A shaft seal leak at shim blade drive #1 was repaired. The drive is normally embedded within the shielding above the fission converter. When the shaft seal leaked, the water went through the bottom of the shielding and into the reactor pipe tunnel, formed a pool at the bottom of the pipe tunnel, and eventually leaked into the equipment room. Samples of this water were analyzed and various tests were performed. The detective work led to identification of the source of the leak. The shielding was then disassembled to reveal the path of the leakage. (Reactor document UOR #2009-1 contains the detailed report.)

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, was installed in March 2009, and is currently in operation in core.

New Blade Height Indicators
SR #E-08-1 (07/01/2008)

A new shim blade and regulating rod position indicator system was designed, constructed, and installed as described in Item 1 of Section D of this report. No new safety issues were involved.

Graphite Gasholder Bypass
SR #M-08-1 (07/23/2008)

A new reactor graphite region CO_2 supply system, eliminating need for a gasholder, was developed and installed as described in Item 5 of Section D of this report. No new safety issues were raised.

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 (07/01/08 – 06/30/09)
North	0.41 mrem
East	0.21 mrem
South	0.52 mrem
West	0.22 mrem
Green (east)	0.24 mrem

Fiscal Year Averages

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, 2008 - June 30, 2009

Whole Body Exposure Range (rems)	Number of Personnel
No measurable	70
Measurable – < 0.1	47
0.1 – 0.25	12
0.25 – 0.5	0
0.5 – 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 = 3.2 Total Number of Personnel = 129

From July 1, 2008 through June 30, 2009, 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 9,903,816 liters discharged during FY2009 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 2.11E-4 Ci for FY2009. The total tritium was 577.53 mCi. The total effluent water volume was 9,992,637 liters, giving an average tritium concentration of 0.578×10^{-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 1,767.00 Ci of Ar-41 was released at an average concentration of 4.75E-9 μCi/ml. This represents 47.5% 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 2009

		Ar-41 Discharged (Curies)	Average Concentration(1) (μCi/ml)
July 2008		101.44	2.83 E-9
August		122.72	4.28 E-9
September		102.37	3.57 E-9
October		160.34	4.44 E-9
November		319.05	1.10 E-8
December		43.32	1.50 E-9
January 2009		174.75	4.84 E-9
February		115.62	4.00 E-9
March		171.12	5.92 E-9
April		195.67	5.46 E-9
May		161.12	5.62 E-9
June		99.49	3.47 E-9
	Totals (12 Months)	**1767.00**	**4.75 E-9**
	EC (Table II, Column I)		1×10^{-8}
	% EC		**47.5%**

(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 2009

Description	
Volume	734 ft^3
Weight	53,123 lbs.
Activity	1105 mCi
Date of shipment	June 23, 2009
Disposition to licensee for burial	Studvik Processing Facility, Erwin, TN and Impact Services, Oak Ridge, TN Disposal will be at Energy Solution, Clive, UT, after processing.
Waste broker	Philotechnics Ltd., Oak Ridge, TN

TABLE H-3

LIQUID EFFLUENT DISCHARGES
FISCAL YEAR 2009

	Total Activity Less Tritium	Total Tritium Activity	Volume of Effluent Water(1)	Average Tritium Concentration
	($x10^{-6}$ Ci)	(mCi)	($x10^{4}$ liters)	($x10^{-6}$ μCi/ml)
July 2008	11.30	15.90	83.5	19.1
Aug.	7.02	29.40	120.5	24.4
Sept.	2.25	31.90	96.5	33.1
Oct.	3.90	8.01	112.4	7.13
Nov.	5.45	42.00	139.4	30.1
Dec.	NDA	0.016	20.2	.077
Jan. 2009	9.58	145.00	66.2	219.0
Feb.	2.53	39.40	47.3	83.4
Mar.	60.00	79.40	64.5	123.0
Apr.	55.40	26.30	107.0	24.6
May	40.30	130.00	117.1	111.0
June	13.00	30.2	24.7	122.0
12 months	210.73	577.53	999.3	0.578

(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.