NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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

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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 July 1, 2006 to June 30, 2007, in compliance with paragraph 7.13.5 of the Technical Specifications for Facility Operating License R-37.

Sincerely,

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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, 2006 – June 30, 2007

by

REACTOR STAFF

Table of Contents

MIT RESEARCH REACTOR

ANNUAL REPORT TO

U. S. NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 2006 – JUNE 30, 2007

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-second annual report required by the Technical Specifications, and it covers the period July 1, 2006 through June 30, 2007. 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 thirtieth 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 a nominal 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 period covered by this report is the thirtieth full year of normal operation for MITR-II.

The reactor averaged 142 hours per week at power compared to 118 hours per week for the previous year and 135 hours per week two years ago. The higher average this year compared to last year is the result of an effort at downtime reduction specifically for this year, improved outage planning and implementation, and preventive maintenance such as strategic replacement of key reactor components. The experiment operating in core during this fiscal year required less maintenance than any of its predecessors.

The reactor was operated throughout the year with 24 elements in the core. The remaining three positions were occupied by solid aluminum dummies or in-core experiments. During FY2007, 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, elements were inverted and rotated so as to achieve more uniform burnup gradients in those elements. Six new elements were introduced into the reactor core during FY2007.

The MITR-II fuel management program remains quite successful. All of the original MITR-II elements (445 grams U-235) have been permanently discharged. The overall burnup for the discharged elements was 42%. (Note: One element was removed prematurely because of excess out-gassing.) The maximum overall burnup achieved was 48%. A total of one hundred eighty-one of the newer, MITR-II elements (506 grams U-235) have been introduced to the core. Of these, one hundred thirteen have attained the maximum allowed fission density and were discharged. Six 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-nine 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 FY2007, no spent 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 FY2007 include:

a) Use of the thermal neutron beam (TNB) to irradiate samples for track-etch analyses to determine micro-distribution of boron in various biological samples, and to irradiate tumor-bearing animals for imaging study of tumor progression, characterization of mechanisms of vascular damage to the gastro-intestinal system as a result of radiation exposure, and evaluation of methods to characterize new boron delivery compounds in cells.

b) Use of the fission converter beam (FCB) to study the role of the vascular endothelium in mediating the onset of radiation-induced gastrointestinal syndrome and to determine the dose response for vascular endothelial cell apoptosis using boronated liposomes and BPA as a control.

c) Use of the prompt gamma neutron activation analysis (PGNAA) facility to study the pharmacokinetics of three different classes of boron compounds in various tumor models: boronated unnatural amino acids; boron-loaded and encapsulated liposomes; boronated porphyrins.

d) Activation of yttrium foils for an on-going clinical trial at the Massachusetts General Hospital as well as Sloan Memorial Kettering Cancer Center for spinal cord cancer removal therapy.

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

f) Activation of uranium foils for detector calibration at the Los Alamos National Laboratories and other national Department of Energy (DOE) facilities.

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

h) Experiments at the 4DH1 radial beam port facility by MIT undergraduates, 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 and 22.921, and the Reactor Technology Course for nuclear power executives).

j) Neutron activation analysis (NAA) to evaluate the connection of vanadium to the occurrence of ALS through biopsy-derived mouse brain tissues as well as human scalp and genital hair samples.

k) Use of the reactor facility by local high school students sponsored by DOE's Harnessed Atom program.

l) NAA of welding fume samples for the Harvard School of Public Health.

m) NAA of plastics, resins, acrylics, and epoxies for the University of Alabama.

n) NAA for a multi-laboratory certification of a new standard reference material (SRM) for NIST.

o) Testing of carbon composites as neutron shielding for portable electronic devices.

p) Activation of gold electrodes and carbon nano-tubes on quartz slides to evaluate their sensitivity to neutron radiation conditions.

In addition to the above list of current activities, the 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 has been in-core undergoing irradiation since December 2006 and is ongoing. 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. This experiment is expected to continue through September 2007.

During this fiscal year, the NRL continued to construct a smaller-scale diffractometer as reported in FY2006. The NRL is also continuing to test the Neutron Phase Contrast Imaging (NPCI) facility. Most of the current activities have been devoted to choosing the correct materials for the pinhole aperture and taking test images using Fuji thermal neutron imaging plates.

The NRL is designing and constructing a web-enabled neutron spectrometer at the 4DH1 beam facility. In collaboration with MIT's iCampus program, the NRL plans to debut the first online, interactive, real-time neutron-based experiment this winter. Using a combination of LabVIEW software and a prototype iCampus-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., Connecticut) to a nominal 34 and 510 grams respectively (made originally by the Atomics International Division of Rockwell International, California, now by BWX Technologies, Inc., Virginia). 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. Of the forty elements that were used, thirty-two with about 40% burnup were discharged because they attained the fission density limit. Of the other eight, six were, as previously reported to the U.S. Nuclear Regulatory Commission, removed from service because of excess out-gassing and two were removed because of suspected excess out-gassing. One hundred forty-one elements fabricated by BWXT have been received, fifty-nine of which remain in use. One has been removed because of suspected excess out-gassing and eighty-one 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". As reported in FY2006, ten spent fuel elements used in the fission converter were replaced with eleven fuel elements of lesser use, increasing the unfiltered beam intensity by about 20%.

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) AOP 5.1.8, "Remote Scram System", and PM 6.2.5, "Remote Scram Operability Test", established a testing procedure and an individual Abnormal Operating Procedure (AOP) for the Remote Scram system. The AOP provides greater clarity than the previous arrangement of using AOP 5.1.2 Withdraw Permit Circuit for response to the Remote Scram alarm. (SR#-0-05-16)

b) "Containment Building Pressure Test Measurements, Calculation, and New Wall Penetrations" modified the instruments and the corresponding computer calculation methods used for the annual pressure test of the containment building. The equipment was updated from dry bulb / wet bulb psychrometers to stations using a solid state measurement of temperature and relative humidity. The method of analysis for leakage calculation was changed from a FORTRAN program to an Excel worksheet, and was updated to reflect the use of relative humidity in calculating the partial pressure of air in the building. The July 2006 test also covered the pressure test requirement for a set of new penetrations through the containment wall. (SR#-0-06-3)

c) PM 3.5, "Daily Surveillance Check", was updated to reflect current instrument readings and locations of equipment, and to add a step for regular recording of the spent fuel storage pool level in response to a suggestion from American Nuclear Insurers. (SR#-0-07-1)

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 FY2007, there were no shipments made, since the inventory of spent fuel at MIT was at or close to zero. The U.S. Department of Energy has indicated that further shipments may be feasible in FY2008 for future fuel discharges.

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 FY2007) (normally at 4.9 MW)	287.6	280.7	293.7	354.2	1216.2
b) MITR-II (MIT FY1976-2006)					26,841.5
c) MITR-I (MIT FY1959-1974)					10,435.2
d) Cumulative, MITR-I & MITR-II					38,492.9
2. MITR-II Operation (hours): (MIT FY2007)					
a) At Power (>0.5-MW) for Research	2034.1	1701.7	1640.8	2002.9	7379.5
b) Low Power (<0.5-MW) for Training(1) and Test	88.3	89.5	47.7	86.5	312.0
c) Total Critical	2122.4	1791.2	1688.5	2089.4	7691.5

(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 five inadvertent scrams and nine 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.

1. Nuclear Safety System Scrams	Total
a) Trip on Channel #1 as result of spurious electronic noise while in ion chamber range.	1
Subtotal	1

2. Process System Scrams	
a) High temperature trip on MT-5A as result of electronic noise from loose wire at its detector.	1
b) Low flow shield coolant trip as result of student operator error with a temporary digital flow display.	1
c) Low flow primary coolant trip as result of faulty thermal overload on the variable frequency drive for primary pump MM-1.	1
d) Low flow D_2O reflector coolant trip as result of failure of reflector pump DM-1 and its circuit breaker at motor control center MCC-2.	1
Subtotal	4

3. Unscheduled Shutdowns

a)	Shutdown due to loss of offsite electricity.	6
b)	Shutdown due to magnet drop of shim blade #1.	1
c)	Shutdown due to loss of offsite steam supply to reactor building ventilation system.	2
	Subtotal	9
	Total	14

4. Experience during recent years has been as follows:

Fiscal Year	Nuclear Safety and Process System Scrams
2007	5
2006	6
2005	6
2004	9
2003	17

D. MAJOR MAINTENANCE

Major maintenance projects performed during FY2007 are described in this Section. These were scheduled and performed to improve safety, reliability and efficiency of operation of the MIT Research Reactor, and hence, a more predictable reactor operating schedule. With increasing use of the reactor, reactor staff are fulfilling an expanded role in the support of these activities:

(a) Advanced Clad Irradiation (ACI) Experiment – Reactor staff supported the continual operation of the experiment in core. In this fiscal year, the experiment had to be removed from its in-core location on four occasions for in-core work such as refueling operations, and then reinstalled afterward. Additionally, the experiment was removed twice; once upon completion of its first phase of operation, and the other for replacement of its signal connectors.

(b) Fission Converter (FC) – The FC tank level probe was replaced when it became erratic. Replacement required temporarily removing three reactor control drives and all FC shielding covers to open the FC tank. Reactor staff also supported troubleshooting the stickiness observed in the Converter Control Shutter (CCS). Testing showed the stickiness was related to higher operating temperatures of the FC. It was determined that smooth CCS operation was obtained whenever the reactor was at or below 4.5 MW.

(c) 4DH4 Diffractometer – A new 4DH4 diffractometer port plug was designed and fabricated to replace the solid port plug in 4DH4. Beam centerline measurement afterward demonstrated that the beam path in the new port plug was well aligned. The diffractometer's drum shutter and peripheral shielding were subsequently installed. Some of the shielding pieces were torch-cut to match the beam height above the reactor floor. These installations were followed by several beam characterizations using gold foils at low power.

(d) Neutron Phase Contrast Imaging Project (NPCI) – In this fiscal year, reactor staff continued assisting in the improvement of its neutron beam alignment, and replaced a pin-hole plate for improved imaging.

For continuous support of neutron transmutation doping of silicon (NTD Si), reactor staff created and upgraded many NTD Si operational procedures and recordkeeping practices. Preventive maintenance on conveyor machinery was performed during each scheduled outage. During this fiscal year, both of the servers for computer control and monitoring were replaced. Additionally, the silicon storage corral on the reactor floor was separated into two areas to make room for the components of the newly-installed 4DH4 diffractometer. Furthermore, the silicon workbench on the reactor floor was fitted with a Plexiglas shield to minimize spread of contamination during handling of activated containers and silicon ingots.

Major reactor maintenance items performed in FY2007 are summarized as follows:

1) The remaining thirty-two lead-acid battery cells were replaced in the reactor's emergency battery bank (28 replaced last year) in the utility room. The system's integral performance was tested afterward under load for an extended duration (more than two hours vs. the nominal one hour), and it met all reactor and manufacturer's standards. At this point, the reactor's emergency battery system, totaling 60 cells, is successfully renewed and is expected to provide its intended function for another ten-plus years.

2) The control room remote indication for the shield coolant system storage tank level, formerly an analog unit and a pneumatic device, was replaced with a new digital pneumatic unit as a prototype to test reliability of such a system. We have planned to also replace similar pneumatic devices for the D_2O dump tank and primary storage tank level indications in the future when the digital unit is tested satisfactory. The analog devices have shown signs of aging and have no replacement parts available.

3) Reactor control shim blade drive #1 was rebuilt and replaced. A new magnet and new absorber section for the shim blade were installed. Shim blade #2 drive and shaft seal were replaced. Shim blade #4 drive and magnet were also replaced.

4) Doors at tactical points in the restricted area and in the containment building were replaced with steel security doors equipped with card-readers and other necessary features for improved protection against intrusion. The reactor's card-reader hardware and software were upgraded to permit this expansion. Funding for the upgrades was provided by the DOE University Reactor Instrumentation grant.

5) The reactor site boundary security fence surrounding the backyard area and some areas in the reactor parking lot was replaced with high security type commonly used nowadays for the nation's airports. The project was coordinated through the MIT Police Department and funded by a grant that originated from the Department of Homeland Security. The new fence expanded beyond the restricted area boundary and includes an area immediately outside the NW12 lunch room to better protect other MIT installations in that area.

6) The ground between the truck lock and the cooling tower was graded and paved with gravel and asphalt. This area had been graveled in the past but not paved. Over the previous year, it sank about 6". Improvement of this area was necessary for trucking and forklift rigging operations. Additionally, a newly graded and asphalted walk path four feet wide was installed in the backyard to improve personnel safety, especially during winter snows.

7) The 1PH1 ⇔ NW13 pneumatic tube system was adjusted and upgraded; specifically the rabbit transfer hose mechanism inside the secondary chem. area

hot cell was replaced. Rabbit transit time was optimized by measurement to determine a suitable vacuum setting for the tube. The NW13 hot lab rooftop blower for this system was also replaced, after it failed. The electrical wiring to the blower was completely overhauled to bring it up to code.

8) The main blower for the pneumatic tube system was retrofitted via its variable frequency drive with a remote speed selector in the control room for setting of vacuum in the tube. This allows vacuum adjustment from the control room, to reduce physical impact on polyethylene rabbits by reducing the air flow, or to increase rabbit payload capacity by increasing the air flow.

9) The reactor staff coordinated with MIT Information System and Technology (IS&T) to install and upgrade phone and signal communication lines through the containment building with optical fibers for high capacity digital data and imaging transfer. Using core drilling, reactor staff installed a total of eighteen steel-lined wall penetrations of various sizes through the west side of the containment building to facilitate feed-through of the fiber-optic cables. The new cables are sealed in the penetrations. Local and bulk building pressure tests were performed immediately afterward to verify and document their air-tightness.

10) Reactor staff arranged for MIT IS&T to replace all telephone and data lines in NW12 and the restricted area with high-speed lines, with a new telephone switching center for the west side of campus relocated to the second floor of NW12. Antenna units for wireless connections were also installed throughout the building. Planning for this started about three years ago.

11) All sixteen large size air filters in the reactor intake ventilation manifold were replaced as an annual maintenance effort to maintain containment building air quality.

12) The two containment building A/C units were rebuilt and retrofitted with new cooling fan motors to improve their reliability. Their refrigerant coils were replaced and refrigerant refilled.

13) The stack base pressure relief damper stanchion, winch, and 16-foot steel cable were upgraded and replaced for ease of use and improved indication of damper opening and closing.

14) One of the two manipulators for reactor floor Hot Cell #1 was replaced with a new unit purchased from Central Research for post-irradiation examination. The hot cell internals were refurbished, and a new area radiation monitor was installed to provide local indication, with remote indication in the control room. A new penetration was torch-cut through the foot-thick hot cell wall for the radiation monitor wiring. The new manipulator and monitor were purchased with funds from the DOE's INIE grant.

15) Further wiring work was completed on the new annunciator alarm panel in the control room, to allow remote reset of alarms from the Operations Office. This is an important add-on feature, particularly during a radiological emergency or whenever remote access to the control room is required.

16) All three reactor core tank level indications were upgraded with new transmitters, signal conditioners, and digital displays in both the control room and a remote location outside the containment building (utility room). The utility room indication provides remote monitoring of core tank level during emergencies. The old meters had shown signs of aging, with no analog replacement parts available.

17) The ion chamber for Channel #1, one of the three reactor startup period channels, was replaced in the 3GV1 vertical port. The old ion chamber had become inoperable, as confirmed by tests of its voltage plateau.

18) Protective slats at the reactor ventilation intake outside the utility room were replaced, as the ones from the 1950s were deteriorating due to weather.

19) The utility room rooftop exhaust fan was replaced with one of higher horsepower, and the doors to the utility room were retro-fitted with new ventilation louvers. These upgrades improve fresh air flow through the room for the reactor emergency battery bank and for the 13.8 kV offsite electrical power feeds and the 1000 kVA transformer that supply the site's electricity.

20) The existing reactor intercom system was expanded into six new areas which had been identified as communication "blind spots". New conduit, wiring, and additional intercom boxes and submaster stations were installed.

21) The washdown system for the perchloric acid hood in the engineering lab was rebuilt for effective use of the hood.

22) The ion column for the reactor primary coolant system was repacked and replaced three times during the fiscal year in normal frequency. The D_2O reflector system's ion column was repacked, deuterized, and replaced. The spent fuel storage pool's ion column was also repacked and replaced.

23) MM-1, one of the two main primary pumps, was rebuilt after it developed unusual vibration.

24) In the restricted area, fifteen new illuminated EXIT signs and six new self-contained emergency lights were installed. This upgrade met current state fire codes, and was coordinated through MIT EHS Safety Office and MIT Facilities.

25) The floor tiles were replaced in the primary entryway to the containment building – maintenance set up area, emergency decon shower room, health physics protective clothing supply room, and isotope prep room. The old floor tiles

contained asbestos, and had been breaking up due to wear over time. Their removal required asbestos abatement measures before the new tiles could be installed.

26) The reactor heat exchangers were chemically flushed with a phosphoric acid cleaning solution for 48 continuous hours.

27) Reactor staff coordinated with a contractor to inspect the polar crane in the containment building.

28) Four fume hoods in the reactor restricted area had their HEPA filters and pre-filters replaced. MIT EHS Industrial Hygiene measured airflow afterward and certified normal operation for these hoods, which are frequently used for preparation of activated samples for shipment.

29) Following abatement of its asbestos insulation, the condemned NW12 boiler was cut into pieces for removal in preparation for replacement.

30) DM-1, the main D_2O reflector pump, was replaced. A new shaft seal for the pump was also installed. The circuit breaker for this pump was rebuilt. The variable frequency drive for DM-2, the D_2O auxiliary pump, was relocated outside of the high radiation dose part of the equipment room.

31) Four of the eight cooling tower fan controller variable frequency drives were replaced. The old ones were showing signs of deterioration. The replacement recovered the cooling tower's operating efficiency.

32) 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.

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 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
SR #0-06-4 (04/03/06), #0-06-6 (05/18/06)

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 continues in the summer of 2007.

Student Spectrometer at 4DH1
SR #M-06-1 (09/22/06)

The spectrometer at the 4DH1 beam port was modified to allow the entire associated teaching experiment to be performed remotely from a computer using linear and rotational displacement machinery. The beam guard/support was replaced by a new aluminum support assembly and polycarbonate beam guard, with the overall length of the experiment apparatus reduced to six feet.

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 detectable radiation levels 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 (07/01/06 – 06/30/07)
North	0.06 mrem
East	0.13 mrem
South	0.46 mrem
West	0.18 mrem
Green (east)	0.13 mrem

Fiscal Year Averages

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 EXPOSURE AND SURVEYS WITHIN THE FACILITY

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

July 1, 2006 - June 30, 2007

Whole Body Exposure Range (rems)	Number of Personnel
No measurable	38
Measurable – < 0.1	71
0.1 – 0.25	19
0.25 – 0.5	3
0.5 – 0.75	3
0.75 – 1.00	0
1.00 – 1.25	0

Total Person Rem = 7.36 Total Number of Personnel = 134

From July 1, 2006 through June 30, 2007, 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 12,675,834 liters discharged during FY2007 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 6.39 E-6 Ci for FY2007. The total tritium was 233.0 mCi. The total effluent water volume was 12,676,000 liters, giving an average tritium concentration of 18.4 E-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 2033.95 Ci of Ar-41 was released at an average concentration of 5.43 E-9 μCi/ml. This represents 54.3% of EC (Effluent Concentration (1×10^{-8} μCi/ml)).

3. Solid Waste

No shipments of solid waste were made during the year. The information pertaining to these shipments is provided in Table H-2.

TABLE H-1

ARGON-41 STACK RELEASES

FISCAL YEAR 2007

	Ar-41 Discharged (Curies)	Average Concentration[1] (μCi/ml)
July 2006	78.45	2.74 E-9
August	106.51	3.72 E-9
September	166.91	4.66 E-9
October	111.35	3.85 E-9
November	108.75	3.01 E-9
December	208.20	7.20 E-9
January 2007	189.08	6.54 E-9
February	162.47	5.62 E-9
March	254.37	7.04 E-9
April	195.80	6.83 E-9
May	203.47	7.10 E-9
June	248.59	6.94 E-9
Totals (12 Months)	2033.95	5.43 E-9 **
EC (Table II, Column I)		1×10^{-8}
% EC		54.3% **

(Note 1: 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 2007

Description	
Volume	0
Weight	0
Activity	0
Date of shipment	No Shipment FY2007
Disposition to licensee for burial	
Waste broker	N/A

TABLE H-3

LIQUID EFFLUENT DISCHARGES
FISCAL YEAR 2007

	Total Activity Less Tritium (x10^{-6} Ci)	Total Tritium Activity (mCi)	Volume of Effluent Water[(1)] (x10^{4} liters)	Average Tritium Concentration (x10^{-6} μCi/ml)
July 2006	NDA	6.24	116.8	5.35
Aug.	NDA	11.10	131.8	8.40
Sept.	1.64	8.10	140.9	5.75
Oct.	NDA	28.90	119.1	24.2
Nov.	NDA	46.80	120.7	38.8
Dec.	NDA	8.18	79.4	8.19
Jan. 2007	4.75	7.44	117.3	6.34
Feb.	NDA	2.71	55.9	4.84
Mar.	NDA	9.35	79.4	11.8
Apr.	NDA	6.31	98.5	6.41
May	NDA	93.9	95.7	98.1
June	NDA	4.03	94.4	4.27
12 months	6.39	233.0	1267.6	18.4

(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 is now available from the Fission Converter Facility. New Phase I / Phase II trials (melanoma and glioblastoma) began with that beam in October 2002.