MIT RESEARCH REACTOR

ANNUAL REPORT

TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 1981 - JUNE 30, 1982

BY

REACTOR STAFF

August 30, 1982

TABLE OF CONTENTS

MIT RESEARCH REACTOR

ANNUAL REPORT TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 1981 - JUNE 30, 1982

Introduction

This report has been prepared by the staff of the Massachusetts Institute of Technology Research Reactor for submission to the Director of Region 1, 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 MITR-type fuel, fully 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 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 undermoderated 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 was shut down 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 14th, 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.

This is the seventh annual report required by the Technical Specifications, and it covers the period July 1, 1981 through June 30, 1982. 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 relatively routine reactor operation. This report covers the fifth full year of routine reactor operation at the 5 MW licensed power level. It was a year in which the safety and reliability of reactor operation fully met the requirements of reactor users. This July marks the beginning of the 25th year since the MIT Reactor first went critical on July 21, 1958.

A summary of operating experience and other activities and related statistical data are provided in the following Sections A-H of this report.

A. SUMMARY OF OPERATING EXPERIENCE

1. General

During the peroid covered by this report (July 1, 1981 - June 30, 1982), the MIT Research Reactor, MITR-II, was operated on a routine, four days per week schedule, normally at a nominal 5 MW. It was the fifth full year of normal operation for MITR-II.

The reactor averaged 84.2 hours per week at full power compared to 88.2 hours per week for the previous year. The reactor is normally at power for 90-100 hours/week, but holidays, major maintenance, long experiment changes, waste shipping, etc., reduce the average. The reactor normally operates from late Monday afternoon until late Friday afternoon, with maintenance scheduled for Mondays and, as necessary, for Saturdays.

The reactor was operated throughout the year with 24 elements in the core. Two of the remaining three positions were occupied by irradiation facilities used in conjunction with both materials testing and the production of medical isotopes. The third was occupied by a solid aluminum dummy. Compensation for reactivity lost due to burnup was achieved through ten refuelings of several elements each. Two of these involved a continuation of the practice begun in previous years in which partially spent elements that had been originally removed from the B-Ring were gradually introduced to the C-Ring to replace fully spent elements. There were six refuleings in which fresh (510 gram U-235) elements were placed in the B-Ring and two in which many C-Ring elements were either inverted or rotated in order to equalize axial and radial burnup distributions.

The MITR-II fuel management program, which involves cycling elements between the inner and outer rings as well as inversion and rotation of each element, remains quite successful. Four more of the original MITR-II elements (445 grams U-235) have been permanently discharged. The average overall burnup for these elements was 42%. Twenty-one of the new (506 grams U-235) are either currently in the reactor core or have been partially depleted and are awaiting reuse in the C-Ring.

Protective system surveillance tests are conducted on Friday evenings after shutdown (about 1800), on Mondays, and on Saturdays as necessary.

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 facilities.

2. Experiments

The MITR-II was used throughout the year for experiments and irradiations in support of research and training programs at MIT and elsewhere.

Experiments and irradiations of the following types were conducted:

a) Neutron diffraction spectrometer alignment and studies (3 ports).

b) Molecular dynamics studies with an inelastic scattering spectrometer.

c) Dosimetry measurements of the neutron beam in the medical therapy facility and animal studies based on the boron neutron capture technique for brain cancer.

d) Dosimetry measurements for pneumatic rabbits and other irradiation facilities.

e) Irradiations of biological, geological, oceanographic, and medical specimens for neutron activation analysis purposes.

f) Irradiation of cell cultures in the medical room beam.

g) Production of phosphorus-32, gold-198, dysprosium-165, fluorine-18, osmium-191, and chlorine-38.

h) Irradiation (i) of tissue specimens on particle track detectors for plutonium radiobiology, (ii) of animal tissue for boron location, and (iii) of geological samples for fissile element distribution.

i) Use of the facility in reactor operator training.

j) Irradiation damage studies of candidate fusion reactor materials.

k) Studies of fatigue failure as a function of surface bombardment and bulk irradiation damage.

l) Components of a safeguards system of interest to the Arms Control and Disarmament Agency for monitoring the security of reactors and special nuclear materials were tested in various parts of the reactor facility.

m) Fault detection analysis of the output of control and process channels from the MIT Reactor as part of a study leading to control of reactors by use of fault-tolerant, digital computers.

n) Assay of sea water for uranium content by delayed neutron detection.

3. Changes to Facility Design

As indicated in last year's report the uranium loading of MITR-II fuel has been increased from 29.7 grams to U-235 per plate and 445 grams per element to 34 and 510 grams respectively. The new loading results in 41.2 w/o U in the core, based on 7% voids, and corresponds to the maximum loading in Advanced Test Reactor (ATR) fuel. The fuel fabricator, Atomics International Division of Rockwell International, completed the production of 25 of the more highly loaded elements in December 1979 and 16 more during the past year. Three have been in operation in the core since January 1980 and an additional five since February 1981; 13 more were inserted in the core during the period of this report. The remaining 20 are in storage, mostly at AI, and will be installed in the core as needed over the next two years. Additional elements, scheduled for fabrication during FY 1984, will be produced by a different manufacturer.

One of the containment building hot cells described in last year's report has been utilized during the year, principally for examining and handling the capsules used in the above-mentioned fatigue failure studies. An Instron mechanical testing machine was installed in the second cell and should be in use during the coming year.

The first transfers of spent fuel elements (a total of 14 on three different occasions) to the racks in the spent fuel storage pool were made in July and August 1981. The MITR fuel transfer flask had been modified for this purpose, as reported in last year's Annual Report.

Other changes in the facility are reported in Section E.

4. Changes in Performance Characteristics

Performance characteristics for the MITR-II were reported in the "MITR-II Startup Report", and no significant changes have occured since that time.

As mentioned in last year's report, however, plans had been made during the previous year to change the six boron-stainless steel shim blades, and a transfer cask was fabricated for that purpose. In July and August 1981, three of the blades (#2, 4 and 6) were replaced. The remaining three blades were replaced in January 1982. The exposures and loss of worth have been calculated to be as follows:

Blade No.	Exposure (MWH)	Loss of Initial Integral Worth (%)
1	111,795	16.4
2	104,395	15.7
3	112,196	16.5
4	105,280	15.8
5	113,246	16.6
6	103,506	15.6

The regulating rod, a cadmium cylinder clad in aluminum with a 7/8" O.D., was also changed in January after being in the core since 1975 for an exposure of 114,503 MWH. Its worth had decreased to 0.10% $\Delta K/K$, compared to the worth of the replacement absorber, which was measured at 0.20% $\Delta K/K$.

Other than loss of worth, there were no obvious effects of exposure in the core for five years for either the shim blades or the regulating rod.

5. Changes in Operating Procedures Related to Safety

On May 21, 1981, USNRC granted a waiver from Technical Specification 3.8-1(a), which limited to one Curie the release of tritium from the reactor's waste tanks and cooling towers to the sanitary sewer. Amendment No. 18 to the Facility Operating License, dated Sept. 28, 1981, changed the effluent limitation to comply with 10 CFR 20.303(d).

Amendment No. 19 to the Facility Operating License identified a revised physical security plan for the reactor and incorporated it into the license. The revised plan had been submitted as Safety Analysis Report (SAR) Revision No. 24 (August 24, 1981).

Amendment No. 20 revised Technical Specification 5.2-1 by substituting 0.008" as the minimum cladding thickness for the 0.015 $^{+.015}_{-.005}$ tolerance previously shown. This change permits a thinner fuel cladding which maintaining cladding integrity, as made possible by present day fabrication techniques.

Amendment No. 21 revised Technical Specification 3.10 to authorize improved storage arrangements for unirradiated fuel elements. A corresponding change in the MITR Safety Analysis Report was submitted to NRC as SAR Revision No. 21 (May 14, 1981).

SAR Revision No. 25 (December 14, 1981) was a designation established for several earlier submittals (6/30/78, 8/5/80 and 2/26/81) related to the MIT Reactor QA Program for Shipping Packages.

SAR Revision No. 26 (December 16, 1981) was a submission for the purpose of updating the SAR in several areas (containment penetrations, instrumentation, and control blade transfers) where approved changes had been made but SAR revisions had not previously been submitted.

With respect to operating procedures subject only to internal review and approval, a summary of those related to safety is given below:

a) A new procedure, Procedure Manual No. PM 1.15.1, was established for authorizing the removal of spent fuel from the storage ring in the reactor core tank. Additional procedures, PM 3.3.2 and PM 3.3.2.1, were prepared for the actual transfer from the storage ring to the spent fuel pool. Review and approval of all three procedures is documented under Safety Review No. SR 0-81-13. A preop test of the procedures is documented in QA file #M-80-9.

b) The methods for numbering samples of radioactive material and for recording radiation survey information specified in Procedure PM 1.10.9, Radioactive Material Governed by License No. R-37, was revised (SR #0-81-14).

c) As a result of the preop testing (QA #M-80-9) of fuel removal procedures PM 3.3.2 and PM 3.3.2.1, revisions to improve the procedures were incorporated (SR #0-81-15).

d) The Radiation Emergency Procedure, PM #4.4.1, was revised to include a step to notify the nuclear insurance company if notification of an emergency is made to civil authorities (SR #0-81-16).

e) As a result of changing to a new water treatment company, a new procedure, PM 6.5.19, was established for use of that company's water testing kits for determining the concentration of corrosion control chemicals in the secondary coolant water (SR #0-81-18). Appropriate parts of the Surveillance Check for Continuous Operation, PM 3.5, were updated to reflect the chnage.

f) A new procedure, PM 1.10.10, established an "Operator Qualification Sheet for the Medical Facility" to be used for checking out non-licensed experimenters who wish to operate the facility's beam shutters unescorted (SR #0-81-19).

g) A new procedure, PM 1.10.11, was established to provide instructions for use of the perchloric acid fume hood set up under SR #M-80-3 and QA #M-80-11 in Room NW12-139, which is within the reactor restricted area, but outside the containment (SR #0-81-20).

h) PM 3.4.2, Replacement of Control Blade, was established under SR #0-81-12 and used in July and August 1981 for replacement of three of the six control blades (see FY1981 Annual Report). Based on this experience, PM 3.4.2 was revised to improve the procedure (SR #0-81-21) and was used in January 1982 for replacement of the other three blades.

i) PM 3.4.3, Replacement of Regulating Rod Drive, was revised based on experience with changing control blade drives so that it parallels the procedure for the latter. A new PM 3.4.4, Replacement of Regulating Rod Absorber, was established, as was a new PM 3.4.4A, Removal of Regulating Road Absorber with Drive Installed (SR #0-81-22). The first two procedures were successfully used in January 1982.

j) The waste tank overflow piping has been changed as described in Section E of this report (SR #M-80-1 and SAR Revision #22). Pre-operational procedures were prepared for testing the modified piping and the new interlocks (SR #0-81-24). The piping preop has been successfully completed and the documentation filed in QA #M-80-18. PM 3.6, Waste Storage Tank Dump Procedure, was rewritten to incorporate changes required by the piping (SR #0-81-27).

k) PM 6.1.3.4, for calibration of the reactor H_2O outlet temperature sensors, was revised to reduce radiation exposures to operating personnel and to reduce the test time. Whereas the former method required removal of core tank shielding to permit installation of a calibrated thermocouple, the revised method calibrates the outlet recorder, MT-5A, against a calibrated therocouple and potentiometer, using water baths, and then calibrates temperature indicators MTS-1 and MTS-1A in place in the core tank against corrected MT-5A values as the core tank temperature is varied over the operating range (including the scram points) by use of decay heat followed by slow cooling (SR #0-81-26).

l) PM 6.5.20.1, Calibration of Combustible Gas Meter, and PM 6.5.20.2, Combustible Gas Meter Use, were established for the calibration of a Johnson-Williams Model SS-P meter used to detect hydrogen in the helium cover gas of the heavy water reflector (SR #0-82-2).

m) PM 6.3.4, Fan Interlocks and Alarms, was revised to include testing of the new Hot Cell Blower—Auxiliary Fans Interlock and the new Hot Cell Blower—Fire Detector Interlock (SR # 0-82-3), both of which were added as part of the ventilation installation for the hot cells in the reactor.

n) New procedure PM 1.2.8, Protection of Safeguards Information, was established to assure compliance with the requirements of 10 CFR 73.21. PM 1.2.9, Limited Distribution of Physical Security Information, was established to limit the distribution of information that is related to the physical security of the MIT Reactor but that is not classified as Safeguards Information (SR #0-82-4).

o) New procedures PM 7.4.4.6 and PM 7.4.4.7, Replacement of MM-1 and MM-1A Shaft Seals, were established for use in replacing the shaft seals on these two primary coolant pumps (SR #0-82-7). The procedures incorporate previous experience and manufacturer's directions.

p) New procedures PM 7.4.3.5 and PM 7.4.3.6, Replacement of HM-2A and HM-2 Shaft Seals, were established for use in replacing the shaft seals on these two secondary coolant booster pumps (SR #0-82-8). The procedures incorporate experience obtained during the 1974-75 reactor modification.

q) Three of the emergency procedures that had previously been revised under SR #0-81-10 were further revised under SR #0-82-11 in response to comments from the Reactor Safeguards Committee. PM 4.4.4.3, Reactor Fire, was substantially revised to assure compliance with OSHA Standard 1910.156 concerning the organization, training, equipping, etc., of reactor personnel who would serve as a fire brigade for an incipient stage fire or as escorts for the Cambridge Fire Department. The corresponding Abnormal Operating Procedure, AOP 5.7.8, was modified in the same manner (SR #0-82-14).

r) Installation of an Instron Materials Testing Machine in the left cell of the reactor floor hot cell required the establishment or revision of several procedures (SR #0-82-12):

PM 1.10.12, Regulations Governing the Reactor Floor Hot Cell Instron Machine
AOP (Abnormal Operating Procedure) 5.4.2, Low Level Shield Coolant Storage Tank
AOP 5.7.10, Instron Cooling System
AOP 5.8.15, Instron Materials Testing Machine
EOP (Emergency Operating Procedure) 4.4.4.3, Reactor Fire

See also Section E, Item 3, of this report.

s) A new procedure, PM 5.7.11, was established to provide guidance in response to certain security alarms (SR #0-82-13).

t) A new procedure, PM 7.4.7.1, Replacement of Main Personnel Air-Lock Inner Door Gasket, was established to provide written guidance for performing this replacement (SR #0-82-15). The replacement and leak test are filed in QA #0-82-2.

u) Instructions in the Shim Blade Drop Time Log were modified to provide more flexibility in scheduling drop time tests, subject to meeting the surviellance requirements of the Technical Specifications (SR #0-82-16).

v) In a step to reduce superfluous work without reducing safety (actually increasing safety by making Reactor Operations staff time available for more important activities), several changes were approved in surveillance procedures for the make-up water system that maintains a reserve supply of de-ionized water for use in reactor cooling systems (SM #M-82-1). Calibration of pressure relief and vacuum valves on the 2000-gallon de-ionized water storage tank, which is vented through a filter in any event, will be eliminated by replacing the valves with a burst disc. Calibration of two temperature probes, used for local indication with no control functions, was eliminated, since the system operates only in the range between incoming city water temperature and room ambient, and the probes serve no safety function. The frequency for performing PM 6.3.16, Surveillance Procedure for Makeup Water System Alarms and Interlocks was changed from semi-annual to annual.

w) Miscellaneous minor changes to operating procedures and equipment were approved and implemented throughout the year.

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. Twenty-three 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 weekly startup, shutdown or other checklists.

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

B. REACTOR OPERATION

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

	Quarter				Total
	1	2	3	4	
1. Energy Generated (MWD):					
a) MITR-II (MIT FY82) (normally at 4.9 MW)	196.1	213.8	216.9	228.8	855.6
b) MITR-II (MIT FY76-81)					4,315.2
c) MITR-I (MIT FY59-74)					10,435.2
d) Cumulative, MITR-I & MITR-II					15,606.0
2. Hours of Operation MIT FY1982, MITR-II					
a) At Power (>0.5 MW) for research	1017.8	1112.4	1103.0	1143.4	4,376.6
b) Low Power (<0.5 MW) for training(1) and test	41.6	27.6	35.6	10.4	115.2
c) Total critical	1059.4	1140.0	1138.6	1153.8	4,491.8

Note (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 previous line.

C. SHUTDOWN AND SCRAMS

During the period of this report there were 14 inadvertent scrams and 14 unscheduled power reductions or shutdown.

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 "reduction" or "shutdown" refers to an unscheduled power reduction or shutdown 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 shutdown.

The following summary of scrams and shutdown is provided in approximately the same format as last year in order to facilitate a comparison.

I. Nuclear Safety System	Total
a) Period channel (#3) off scale, resulting from electrical noise.	3
b) Level channel (#4) tripped on high level (no apparent cause, other channels normal; replaced chamber).	7
Subtotal	10
II. Process Systems	
a) Low pressure signal at reactor inlet caused by pressure pulse transmitted through heat exchangers when revalving cooling towers.	2
b) High temperature primary system due to mechanical noise on outlet temperature detector.	1
c) Malfunction of primary coolant flow indicator.	1
Subtotal	4
III. Other Scrams or Unscheduled Shutdowns	
a) Shutdowns without operator action:	
i) Electric company power loss	3
ii) Blade drops due to blade magnet failure or due to decoupling caused by misalignment	3
iii) Coincident operation of inner and outer doors defeated interlock and permitted simultaneous deflation of both basement personnel lock gaskets	2
b) Operator shutdown by "All Rods In" to investigate:	
i) Primary coolant flow instability	1
ii) Failure of sample to eject	1
iii) Low pressure in the helium supply to an irradiation thimble and subsequently to repair the supply line	1

	Total
b) (Continued)	
iv) An increase in stack particulate activity (caused by a leaking sample in 2PH1)	1
c) Automatic blade rundown lowered power to 3 MW or less when automatic control reached end of effective range (as a result of tardy operator response)	2
Subtotal	14
Total	28

The 28 scrams and shutdowns during FY 82 is quite comparable to the 24 experienced in FY 81. Detector, cabling and component failures in the nuclear safety system continue to represent more than one-third of the causes. Installation of new detectors and cabling and procurement of replacement components should reduce the frequency.

D. MAJOR MAINTENANCE

Major maintenance projects during FY82, including the effect, if any, on safe operation of the reactor, are described below in this section.

1) FY82 saw a continuation of the program for upgrading reactor instrumentation that was begun several years ago. A new multi-point temperature recorder having alarm and scram capabilities was procured and should be in operation shortly. Additional temperature probes have been mounted in and on the primary piping as redundant ΔT sensors. The differential pressure transmitters for the secondary flow meters were rebuilt and re-installed. Several replacement fission chambers and compensated and uncompensated ion chambers were installed in safety channels, and much of the high voltage and signal cabling was replaced. The plug for instrument port 4IH2 was rebuilt and now incorporates features to facilitate the positioning of the chambers in that port as a means for optimizing the channel sensitivity. In addition, a slave read-out unit in the Reactor Operations Office outside the containment now provides an indication of what abnormal condition within the containment may have been responsible for a "weekend alarm" (reactor facility unoccupied) at Campus Police headquarters; the purpose is to provide reactor personnel responding to the alarm an indication of what to expect upon entering the building.

2) As mentioned in Section A-4, all six shim blades and the regulating rod were replaced during the year. In the process of making the changes, the shim blade drives were all rebuilt, as was the drive for the regulating rod. The magnets for all six blades were likewise replaced, since some were beginning to show signs of shorting out. Also, test boxes were installed in each magnet circuit to facilitate checking of the in-core magnet conditions. Fuses for circuit protection were added at the same time. The proximity switches for all six blades were replaced during the year, as was the tube for the blade #4 proximity switch.

3) All shim blades and the regulating rod were calibrated after installation.

4) The inflatable rubber gasket on the inner door of the main personnel lock developed an inflation leak and was replaced, along with all the air supply hoses. Before being placed in use it was leak tested for containment integrity and proven to meet the building leak requirements. The drive gears for the outer door were replaced after several teeth failed.

5) The shaft seals on both primary coolant pumps developed leaks (leaked most when the pumps were OFF), and both were replaced. The shaft seal on one of the secondary coolant pumps was also replaced.

6) The shield coolant heat exchanger was replaced with an identical unit when a substantial fraction of the tubes developed leaks.

7) The reactor floor hot cell blower was replaced with a larger one in anticipation of greater capacity being needed for the second cell of the double unit.

8) The cadmium-lined racks for storage of fuel in the spent fuel pool were inspected, cleaned and reassembled in the pool. The shielding cone which was used for the MITR-I fuel transfer operation was modified to allow discharging of MITR-II fuel elements into the fuel storage pool. Fourteen elements were transferred to the racks from the storage ring in the reactor core tank.

9) In preparation for storage once again of spent fuel in the pool, a new PVC system with an ion column was installed to maintain the purity of the water. A cartridge-type disposable filter was used in the design in order to reduce the radiation exposures incurred during cleaning of the previous type of filter.

10) The lexan (plastic) bumpers on a pneumatic rabbit melted and substantially blocked the air flow in the 2PH1 facility. The blockage was relieved by chemically cleaning the tubes with a mixture of glycol and ammonia after thorough review of the proposed method.

11) The cable for the 3-ton crane was damaged and had to be replaced.

12) The wood roll-up garage door that opens onto Albany Street from the Building NW12 restricted area was replaced with a steel door to increase security for the restricted area.

13) The primary chemistry area in the basement of the containment building was refurbished for use in the nuclear medicine research program. The chemical filters in the hood were checked and found satisfactory, the floor was retiled and the walls repainted.

14) Several reusable shipping containers meeting DOT specifications were procured. They are equipped with lead pigs that can be replaced with sealed depleted uranium pigs, also procured during the year.

15) A long shielded trough formerly used in Room NW12-113 for work on low-enriched uranium rods was moved to NW12-139 for storage of steel specimens used in radiation damage studies.

16) A rack was constructed on the reactor top for better storage of the many tools used for fuel transfers, maintenance, etc., in the reactor core tank.

17) Many other routine maintenance and preventive maintenance jobs were done throughout the year.

E. SECTION 50.59 CHANGES, TEST 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 will be forwarded to the Chief, Standardization and Special Projects Branch, Division of Licensing, USNRC.

The conduct of tests and experiments on the reactor are normally documented in the experiments and irradiations 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".

1. SR #M-81-3 (11/17/81), M-81-4 (12/10/81). E-82-2 (01/08/82), E-82-3 (02/24/82), E-82-4 (03/03/82, E-82-5 (04/14/82).

Digital Computer Control of Reactors Under Steady-State Conditions

A joint project involving computer analysis and signal validation of data from reactor instruments was continued with the Charles Stark Draper Laboratory in Cambridge. Tests were conducted on reactor power, temperature, and flow instruments during transient conditions. These experiments showed that the computer-aided signal validation technique did improve reactor plant reliability. Signals used in the experiments have been decoupled from the reactor by isolation amplifiers.

Once the signal validation technique was demonstrated, digital controllers were designed to control the reactor's regulating rod. That rod, whose worth is limited to 0.7% $\Delta K/K$ and is actually worth 0.2% $\Delta K/K$, is normally positioned by an analog controller. The digital controller has been shown to be equal to the analog one during near steady-state conditions while transients such as those due to xenon or temperature are in progress.

Studies are now under way to develop a digital controller for power changes. The eventual goal of this program is to use fault-tolerant computers coupled with closed-loop digital control and signal validation methods to demonstrate the improvements that can be achieved in reactor control.

Reactor Staff approval 10/06/80

MIT Reactor Safeguards Committee Approval 12/03/81

MIT Reactor Safeguards Subcommittee Approval 05/27/82

2. SR #M-80-1 (1/24/80)

Waste Tank Overflow Piping and High Level Alarm System

The waste tank piping was modified to provide a common overflow pipe between the two 1000-gallon tanks so that the capacity of the reserve tank would be added to that of the on-line tank, thereby doubling the on-line capacity.

Plans also call for a further change so that liquid waste being pumped from the containment sump to either waste tank can be monitored by the detector now used only when the contents of either tank are being discharged to the sanitary sewer. Interlocks will shut off the sump pump if abnormal levels of radioactivity are detected in the water or if both tanks become full.

Reactor Staff approval 11/04/80

MIT Reactor Safeguards Committee approval 11/26/80

SAR Revision #22, 5/19/81

3. SR #M-81-2 (11/02/81)

Instron Machine Installation in Reactor Floor Hot Cell

The Instron Materials Testing Machine mentioned in the FY 1981 Annual Report (Section E, Item 2) was installed during FY 1982 and will be ready for operation during the coming year. Instead of receiving its cooling from sources external to the reactor containment, most of the cooling (hydraulic pump, diffusion pump and induction heating unit) will be supplied by the reactor shield cooling system, while heat from the vacuum chamber will be transferred by means of a chiller to the containment atmosphere.

Review of the Instron installation included evaluation of its impact on the shield cooling system and on the containment atmosphere and the potential for fire. The shield system is judged to have sufficient capacity, but measurements will be made to confirm this, and limitations have been specified for the additional heat load. Means for manual and automatic isolation of the system are provided. Impact on the containment atmosphere will be minimal. Precautions against hydraulic oil fires have been included in the installation.

No unresolved safety questions have been identified. Documentation related to the installation is provided in QA file # M-81-2.

Reactor Staff approval 12/29/81

MIT Reactor Safeguards Committee approval 12/03/81

MIT Reactor Safeguards Subcommittee approval 12/23/81

4. SR #M-81-5

Installation of Gas-Water Separator in the Medical Shutter System

The water tank in the Medical Room beam beneath the reactor serves as one of the shutters to cut off neutrons from the facility. When water is drained back into the tank to "close" that shutter, some of the helium cover gas is forced into the suction line of the pump that "opens" the shutter. The pump would become gas-bound and fail to function if the helium were not first vented from the line by manually opening a vent valve, BV-6 in SAR Fig. 4.2.1-1, that allows the helium to flow back to the gas holder.

A change to the reactor facility as shown in SAR Fig. 4.2.1-1 consisted of replacing manual valve BV-6 by a water separator and a solenoid-operated valve that opens during the shutter fill cycle to vent the helium automatically. No unreviewed safety question is involved. Documentation of the change is contained in QA file #M-81-4.

Reactor Staff approval 12/30/81

F. ENVIRONMENTAL SURVEYS

Environmental surveys, outside the facility, were performed using area monitors. The systems (located approximately in a ¼ mile radius from the reactor site) consist of calibrated G.M. detectors with associated electronics and recorders.

The detectable radiation levels due to Argon-41 are listed below:

Site	July 1, 1981 - June 30, 1982
North	2.6 mR/year
South	2.2 mR/year
East	4.3 mR/year
West	2.4 mR/year
Green (East)	0.8 mR/year

Fiscal Yearly Averages:

1978	1.9 mR/year
1979	1.5 mR/year
1980	1.9 mR/year
1981	1.9 mR/year
1982	2.5 mR/year

G. RADIATION EXPOSURES AND SURVEYS WITHIN THE FACILITY

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

Whole Body Exposure Range (Rems)	Period 7/01/81 - 6/30/82 No. of Personnel
No Measurable	55
Measureable - Exposure Less than 0.1	27
0.1 - 0.25	9
0.25 - 0.5	9
0.5 - 0.75	8
0.75 - 1.0	2
1.0 - 2.0	2

Summary of the results of radiation and contamination surveys from July 1981 to June 1982:

> During the 1981-1982 period, the Reactor Radiation Protection Office continued to provide radiation protection services necessary for full-power (5 megawatts) operation of the reactor. Such services (performed on a daily, weekly, or monthly schedule) include the following:
>
> 1. Collection and analysis of air samples taken within the reactor containment shell, and in the exhaust-ventilation system.
> 2. Collection and analysis of water samples taken from the reactor cooling towers, D_2O system, waste storage tanks, shield coolant, heat exchangers, fuel storage facility, and the primary system.
> 3. Performance of radiation and contamination surveys, radioactive waste collection, calibration of reactor radiation monitoring systems, and servicing of radiation survey meters.
> 4. The providing of radiation protection services for control rod removal, spent-fuel element transfers, ion column removal, etc.

The results of all surveys described above have been within the guide lines established for the facility.

H. RADIOACTIVE EFFLUENTS

The nature and amounts of radioactive effluents from the MITR during FY81 are summarized in Table H-1a, b and c.

For the activity in liquids released to the sanitary sewerage system, the amounts are given on lines 1(a), 1(b), 2(a), and 2(b). Line 1(a) gives the totals of activities, except tritium, in liquids released to the sanitary sewerage system from the reactor waste tanks, from the cooling towers, and from on-site laboratory drains.

Line 1(b) gives the total radioactivity released (except tritium) for specific nuclides, if the gross beta activity (except tritium) exceeded 3×10^{-6} μCi/cm^3. Except for ^{32}P in September, the amounts were less than 0.0005 Ci and, hence, reported as 0.000 Ci. For all line 1(b) nuclides the total concentrations did not exceed 3×10^{-6} μCi/ml, when credit is taken for dilution of the waste tank or other drain water by the measured cooling tower water, both of which discharge into the sewer at the same point. No credit is taken for dilution by non-radioactive waste water from the Nuclear Engineering Building on the reactor facility site or from the remainder of the MIT Cambridge campus, since these are not routinely measured. The volumes of water discharged from the waste tanks, or other drains, and the cooling tower blowdown are measured, however, and are given in lines 2(a) and 2(b).

The principal gaseous nuclide is Ar-41 from the stack. The annual average concentration as a percent of MPC (56%) is slightly above last year. The curies per unit of energy generated was also up at 10.0 Ci/MWD in FY82, compared to 9.2 Ci/MWD in FY81. This will be closely watched to see if a trend is developing and, if so, to determine and evaluate the cause.

Other gaseous effluents are reported in the balance of Table H-1a and in Table H-1b. The sum of the fractions of MPC add up to approximately 1.1%. Values are calculated from analyses made of the core purge gas (air flowing across the top of the core tank and through the primary coolant storage tank at 5-6 CFM). Concentrations here are 1400 times greater than after dilution in the building exhaust (8500 CFM). The fission gas activity is more than double last year. While not serious at the present level, efforts to determine the source or sources through fuel sipping techniques and through interchanging fuel with other elements in storage have been made. Because of the low levels of activity, these have been inconclusive to date.

The activity in solid waste shipments is reported in Table H-1c.

Table H-1a

SUMMARY OF MITR RADIOACTIVE EFFLUENTS
FISCAL YEAR 1982

	MPC(1) (µCi/ml)	Units	1981:						1982:						
Activity in liquids released to sanitary sewerage systems:			July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	Total
1(a) Total gross β, excluding ^3H		(Ci)	0.000(3)	0.000	0.001	0.000	0.000	0.000	NDA(2)	0.000	0.000	0.000	NDA	NDA	0.001
(b) Specific nuclides other than ^3H where line 1(a) >3×10^{-6} µCi/ml															
^{60}Co from waste tanks & other drains		(Ci)	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000			0.000
^{65}Zn, ^{32}P, and other identified nuclides from waste tanks & other drains		(Ci)			0.001	0.000	0.000	0.000			0.000				0.001
2(a) ^3H from waste tanks & other drains		(Ci)	0.000	0.001	0.018	NDA	0.000	NDA	NO	0.011	NDA	0.003	NO	NO	0.033
Average concentration	1×10^{-1}	($\times 10^{-4}$ µCi/ml)	<200	3.42	58	-	0.9	-	disch.	31	-	8.3	disch.	disch.	20(4)
Volume of effluent water(5)		($\times 10^{4}$ liters)	0.000	0.38	0.32	0.03	0.19	0.000		0.36	0.001	0.35			1.64
(b) ^3H from cooling towers		(Ci)	0.003	0.002	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.018
Average concentration	1×10^{-1}(8)	($\times 10^{-4}$ µCi/ml)	0.035	0.031	0.025	0.018	0.027	0.032	0.021	0.024	0.014	0.026	0.024	0.024	0.027
Volume of effluent water(5)		($\times 10^{4}$ liters)	71.7	70.5	55.6	84.7	54.6	56.8	42.0	28.8	43.0	42.7	58.3	57.8	667
Activity in gaseous wastes:															
1. ^{41}Ar from stack		(Ci)	581	620	573	685	639	796	676	728	1013	704	776	769	8560
Average concentration(6)	4×10^{-8}	($\times 10^{-8}$ µCi/ml)	1.95	2.08	1.54	2.30	2.14	2.14	2.27	2.45	2.72	2.37	2.61	2.07	2.22(7) 56% MPC
2(a) ^3H from stack		(Ci)	2.59	1.45	1.59	1.36	1.43	1.96	1.60	1.54	2.58	1.81	2.01	2.47	22.39
Average concentration(6)	2×10^{-7}	($\times 10^{-11}$ µCi/ml)	8.40	4.92	4.26	4.59	5.18	5.14	5.17	5.17	6.93	6.08	6.75	6.60	5.77 0.03% MPC
(b) ^3H from cooling tower		(Ci)	0.010	0.008	0.004	0.004	0.006	0.006	0.003	0.005	0.004	0.007	0.006	0.006	0.069
Average concentration	2×10^{-7}	($\times 10^{-11}$ µCi/ml)	7.61	5.71	3.20	2.79	4.15	3.93	2.64	3.58	1.97	5.08	3.64	3.57	3.99 0.02% MPC

Notes: (1) 10CFR20. (2) NDA - No detectable Activity, less than 1.26×10^{-6} µCi/ml Beta for every sample. (3) 0.000 indicates less than 0.0005 Ci (4) Weighted Average of individual discharges for liquid releases. (5) Does not include other diluent from MIT estimated at 2.7 million gal/day. (6) Average concentrations of gaseous stack wastes include authorized dilution factor of 3000. (7) Fiscal year totals are averaged over 12 months for gaseous releases. (8) Technical Specifications 3.8-1.b limits cooling tower concentration to 1×10^{-3} µCi/ml.

TABLE H-1b

SUMMARY OF MITR RADIOACTIVE EFFLUENTS - FISCAL YEAR 1982

Activity in Gaseous Waste

Estimates of annual releases from stack for other nuclides based on representative samples:

Nuclide	MPC (uCi/ml)	Average Conc. (uCi/ml)	% MPC	Curies
^{80}Br	3×10^{-8}	0.05×10^{-11}	0.0017	0.192
^{80m}Br	0.01×10^{-8}	0.002×10^{-11}	0.02	0.008
^{82}Br	4×10^{-8}	0.002×10^{-11}	0.00005	0.008
^{85m}Kr	1×10^{-7}	2.0×10^{-11}	0.020	7.68
^{88}Kr	2×10^{-8}	5.1×10^{-11}	0.255	19.58
^{135}Xe	1×10^{-7}	3.4×10^{-11}	0.034	13.06
^{138}Xe	3×10^{-8}	8.9×10^{-11}	0.297	34.18
^{87}Kr	2×10^{-8}	8.0×10^{-11}	0.40	30.72
^{135m}Xe	3×10^{-8}	1.4×10^{-11}	0.047	5.38
^{133m}Xe	3×10^{-7}	0.7×10^{-11}	0.002	2.69
^{133}Xe	3×10^{-7}	0.7×10^{-11}	0.002	2.69
^{131}I	1×10^{-10}	3.66×10^{-14}	0.0366	0.00002
		TOTALS	1.12	116.2

TABLE H-1c

SUMMARY OF MITR RADIOACTIVE SOLID WASTE SHIPMENTS - FISCAL YEAR 1982

	Units	March 1982	June 1982	Total
1. Solid waste packaged	Cubic Feet	172.5	213.2	404.7
2. Total activity (irradiated components, ion exchange resins, etc.) ^{60}Co, ^{51}Cr, $^{55-59}Fe$ ^{65}Zn, etc.	(Ci)	0.176	0.067	0.243
3. (a) Dates of Shipment (b) Disposition to Licensee for Burial		3/18/82 Radiation Service Organization	6/23/82 Radiation Service Organization	