MIT RESEARCH REACTOR

ANNUAL REPORT

TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR THE PERIOD JULY 1, 1982 - JUNE 30, 1983

BY

REACTOR STAFF

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IE24
111

TABLE OF CONTENTS

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Introduction

This report has been prepared by the staff of the Massachusetts Institute of Technology Research Reactor for submission to the Administrator 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 MTR-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 eighth annual report required by the Technical Specifications, and it covers the period July 1, 1982 through June 30, 1983. 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 sixth 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 21, 1983, marks the 25th anniversary of the date when the MIT Reactor first went critical.

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 period covered by this report (July 1, 1982-June 30, 1983), 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 sixth full year of normal operation for MITR-II.

The reactor averaged 85.2 hours per week at full power compared to 84.2 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 either 24 or 25 elements in the core. The remaining positions were occupied by irradiation facilities used for materials testing and the production of medical isotopes and/or by a solid aluminum dummy. Compensation for reactivity lost due to burnup was achieved through eight refuelings of several elements each. Six of these involved a continuation of the practice begun in previous years in which fresh fuel was introduced to the A and-B Rings while partially spent elements that had been originally removed from the B-Ring were gradually introduced to the C-Ring to replace fully spent elements. The other two refuelings entailed first conversion from a 24 to a 25 element core and, six months later, transfering back to a 24 element core. These procedures were combined with many element rotations/inversions to equalize burnup. The purpose of converting to a 25 element core was to add enough reactivity to drive nearly-depleted C-Ring elements to full depletion. The objective of the rotation/inversion was to eliminate the effects of radial/axial flux gradients.

The MITR-II fuel management program remains quite successful. All but fifteen of the original MITR-II elements (445 grams U-235) have been permanently discharged. The average overall burnup for these elements was 42%. Of the remaining fifteen elements with the 445 gram loading, fourteen will reach maximum depletion within the next twelve-eighteen months. Twenty-five 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 agricultural specimens and 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) Measurement of trace uranium in computer chip substrate materials by delayed neutron detection.

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) Closed-loop direct digital control of reactor power using the regulating rod during some steady-state and transient conditions.

o) Irradiation of NaCl crystals for use in materials testing studies.

p) Measurements of the energy spectrum of leakage neutrons using a mechanical chopper in a radial beam port (4DH1).

3. Changes to Facility Design

As indicated in past reports the uranium loading of MITR-II fuel has been increased from 29.7 grams of U-235 per plate and 445 grams per element to a nominal 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, has completed the production of 41 of the more highly loaded elements, 25 of which have been used to some degree. Three have been in operation in the core since January 1980, and now have 34% burnup. Additional elements, scheduled for fabrication during FY 1984, will be produced by a different manufacturer.

The MITR staff has been following with interest the work of the Reduced Enrichment for Research and Test Reactors (RERTR) Program at Argonne National Laboratory, particularly the development of advanced fuels that will permit uranium loadings up to several times the current upper limit of 1.6 grams total uranium/cubic centimeter. Consideration of the thermal-hydraulics and reactor physics of the MITR-II core design show that conversion of MITR-II fuel to lower enrichment must await the successful demonstration of the proposed advanced fuels.

Installation of an Instron testing machine described in the last annual report (Section E-3) was completed. Water for cooling the Instron machine is diverted from the reactor shield cooling system. Preoperational measurements showed that the affect on the shield system is negligible.

Other changes in the facility are reported in Section E.

4. Changes in Performance Characteristics

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

Section E-1 describes the research program to develop and demonstrate digital computer control of the MITR-II. As noted there, the constant speed drive motor for the regulating rod can be conveniently replaced by a variable speed drive motor. At maximum speed, the latter can move the regulating rod at 6.64 inches/minute, as compared to 4.25 inches/minute for the former, so that the maximum reactivity insertion rate is 0.27×10^{-4} ΔK/K/sec, still well below the 5×10^{-4} ΔK/K/sec limit of Technical Specification 3.9-6.

As part of the above computer control program, the uniform temperature coefficient of reactivity was remeasured in order to obtain definitive data on the coefficient at temperatures below 15°C, the lowest data point in the previous measurement. It was found that the uniform coefficient was positive in the range 8-21°C. Inasmuch as the temperature coefficient of reactivity for the core (which cannot be measured accurately and independently) is believed to be negative at all achievable operating temperatures, the uniform measurement is not considered a significant change in a performance characteristic; also the effect is small (52 mβ over the entire range), and the reactor normally does not operate below about 15°C except for special tests such as the above. A report of the test was made to NRC Region #1 in MIT's letter of July 22, 1983.

5. Changes in Operating Procedures Related to Safety

There were two amendments to the Facility Operating License during the year:

a) Amendment No. 22 was administrative only, extending for 30 days (from September 9, 1982 to October 9, 1982) the effective dates of license Amendments No. 19 and No. 21 for implementation of revised plans for physical security and for storage of fresh fuel.

b) Amendment No. 23 changed the Technical Specifications to reduce the required frequencies of surveillance testing from semi-annual to annual for the emergency core cooling system (ECCS) and for the charcoal filters in the building pressure relief system.

Three SAR revisions were submitted during the year:

a) SAR Revision No. 27 submitted a revision to the "Physical Security Plan" (classified as Safeguards Information). The revision was approved by NRC's letter of December 8, 1982. It was reviewed internally under Safety Review (SR) #0-82-23.

b) SAR Revision No. 28 (SR #0-82-27) incorporated changes to the SAR reflecting the reduced frequency of surveillance testing for the ECCS; see License Amendment No. 23 above. (No SAR revision was necessary for the reduced frequency of testing the charcoal filters, since the SAR already specified annually (subsection 5.3.5.3).) This revision also corrected SAR page 6.6 (SR #0-82-28) which contained a statement regarding observation of in-core tank safety mechanisms by means of viewing window which was originally included in the design of the reactor top shield.

c) SAR Chapter 13A, Emergency Plans for the MIT Reactor (which also appears in MITR Procedure Manual Chapter 4 along with the implementing procedures) was completely re-written, evaluated under SR #0-82-19, and submitted to NRC on September 3, 1982 in compliance with 10 CFR 50.54 (q) and (r). The plan was approved by NRC on June 24, 1983, with implementation to be accomplished within 120 days. SAR Revision No. 29 has been assigned to this SAR change.

Another submission to NRC was an application for renewal of License No. SNM-986 on July 28, 1982 (SR #0-82-18). This license covers kilogram quantities of slightly enriched U-235, gram quantities of Pu, normal and depleted U. Other licenses covering smaller quantities of similar material would be combined with License SNM-986. The MIT Reactor is involved, because most of the SNM is stored on the reactor site, and much of it is used on the reactor in accordance with authorized experiment review and approval procedures.

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

a) Safety Review #0-82-17 provided a criticality evaluation and procedure for the disassembly of Blanket Test Facility Blanket #6, which contained about 25 Kg U-235 in 26 subassemblies in the form of 1.016 w/o - 1.143 w/o enriched U metal and UO_2 rods clad mostly in steel. The blanket had previously been used in the Fast Blanket Test Facility on the thermal column extension for studies of blanket neutronics.

b) A special test procedure was developed (SR #0-82-20), using Ar-41 as a tracer, to determine if air was being drawn into the primary coolant at the primary pump seals and, if so, to see if this could be correlated with minor power instabilities that were intermittently experienced. Test results were negative.

c) Minor revisions were made to the Reactor Exclusion Area Entry Permit (Blue Badge) in order to incorporate changes in the security and emergency plans (SR #0-82-21).

d) Procedure 2.7.4 of the MITR Procedure Manual was revised (SR #0-82-24) to specify that an uncertainty of 12.25% should be allowed in calculating the fission density in the 10"-14" section of fuel plates and 15% in other sections. This permits operating fuel in the reactor up to 87.75% of the Technical Specification limit (1.8×10^{21} f/cc) in that section, 85% elsewhere. The relaxation is based on the fact that the uncertainties used in determining the operating and safety limits for the core (i.e. 5% on power, 10% on fuel loading and 10% on flux level) are not entirely decoupled, since a high fuel loading leads to a depressed flux. Also flux level in the center of the core (10"-14" section) is known to at least 5%, giving a statistical, combined value of 12.25% for the three uncertainties.

e) Procedure 3.3.1, General Conduct of Refueling Operations was revised (SR #0-82-26) to eliminate the need for duplicate recording of information relative to refueling and to delete the requirement, if the reflector is dumped, that each in-core irradiation thimble that is removed be replaced with a solid dummy (which would otherwise be necessary to limit the amount of water in the core).

f) Procedure 7.4.7.1, Replacement of Main Personnel Air-Lock Inner Door Gasket, was revised to add a precaution regarding a potentially dangerous pressure build-up in the lock during the test that could force the inner door to open violently.

g) Procedures 3.4.3 and 3.4.4, Replacement of the Regulating Rod Drive and Absorber, respectively, where revised to incorporate actual experience obtained through use of the procedures in 1982 (SR #0-83-2).

h) Procedure 5.5.15 for response to abnormal conditions in the building heat and air conditioning systems was extensively re-written to reflect recent changes in the utility room air conditioning controls and provide much more information to the operator regarding the various conditions that could lead to abnormal situations and the specific responses required in each case (SR #0-83-3).

i) Procedures 3.7.1 and 3.7.2, Weekly and Daily Security Checklists respectively, were revised to reflect the change in the reactor fuel storage location and to eliminate duplication in the inspection of exterior barriers (SR #0-83-4). The second list was subsequently further revised (SR #0-83-10) to mention specifically the Building NW12 front door (it was listed only generally under "doors" in the original checklist).

j) Procedure 6.1.3.5, Building ΔP Indicator and Recorder Calibration, was established (SR #0-83-6) for the purpose of calibrating these instruments annually against a water manometer. Although the trip point for the reactor startup - containment ΔP interlock had been tested semi-annually, no calibration of the indicator or recorder had been performed. The new procedure rectifies this discrepancy. Refer to NRC Inspection Report No. 50-20/83-01, Item 4.

k) Procedure 7.3.1 provides the "Schedule for Surveillance Tests and Calibrations". The schedule was revised to add two new test procedures and to delete or reduce the frequency of seven others for reasons explained in the individual safety reviews (SR #0-83-7).

l) Procedures 6.5.10.1 and 6.5.10.2 for the calibration of pressure relief valves and vacuum breaker valves respectively, were revised (SR # 0-83-8) to delete the requirement to calibrate such valves on the makeup water storage tank. The valves were replaced by rupture disks (SR #M-82-1).

m) Procedures 3.12 - 3.12.4, Reactor Floor Hot Cell Procedures, were revised to incorporate recommendations of the MIT Industrial Hygiene Office that the air flow be increased to 200 CFM, to provide a format having specific sections on preconditions, to provide greater generality, and to establish separate entry procedures for the right and left cells (SR #0-83-9).

n) Procedure 1.3, Authority and Responsibility for Safe Operations, was revised (SR #0-83-11) to include the provisions of the new 10 CFR 50.54(x)and (y), effective June 1, 1983, permitting licensees to take reasonable action that departs from a license condition or technical specification in an emergency when this action is immediately needed to protect the public health and safety.

o) Procedure 6.1.2.2, Main Ventilation Damper Inspection, was revised (SR #0-83-13) to clarify the method of calculating the damper leak rate from measurements of the changing air pressure in the space between the dampers.

p) Procedure 7.1.5, Damper Accumulators Charging and Actuator Inspection Procedure, was revised (SR #0-83-14) to include steps to inspect the clearance between the rod eye and the valve lever arm. This completed the corrective action specified in Reportable Occurrence Report #83-1.

q) Procedures 7.3.1, Schedule of Surveillance Tests and Calibrations, was revised (SR #0-83-15) to shift the annual stack flow rate calibration from January to June and Procedure 7.3.1.1, Index of Surveillance Tests and Calibrations was revised to show the months during which each test is normally performed.

r) Radiation Emergency Procedure, 4.4.1.3.1, Plan Y Area Designations, was updated (SR #0-83-16) to reflect changes in the business occupancy of buildings in the vicinity of the reactor.

s) The MITR-RPO "Special Instructions" memorandum, page 5 of Procedure 1.12, was revised (SR #0-83-17) to add a requirement that all film badge and dosimeter holders record on RPO data sheets the reading of the latter within the last two days of each month. (Formerly only the recording of accumulated occupational exposures of 50 mR was required.)

t) 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-five 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 shcedules. 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 1	Quarter 2	Quarter 3	Quarter 4	Total
1. Energy Generated (MWD):					
a) MITR-II (MIT FY83) (normally at 4.9 MW)	219.5	208.1	224.8	221.4	873.8
b) MITR-II (MIT FY76-82)					5,170.8
c) MITR-I (MIT FY59-74)					10,435.2
d) Cumulative, MITR-I & MITR-II					16,479.8
2. Hours of Operation MIT FY1983, MITR-II					
a) At Power (>0.5 MW) for research	1108.7	1051.4	1121.9	1147.3	4,429.3
b) Low Power (<0.5 MW) for training(1) and test	15.7	31.9	31.1	25.2	103.9
c) Total critical	1124.4	1083.3	1153.0	1172.5	4,533.2

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 11 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 shutdowns.

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

		Total
I.	Nuclear Safety System	
	Withdraw Permit Circuit Open, due to:	
	a) electrical noise	2
	b) faulty relays	2
	c) cause unknown	1
	Subtotal	5
II.	Process Systems	
	a) Primary coolant pump tripped off due to thermal overload (dirty circuit breaker contacts replaced)	5
	b) Shield coolant pump failed	1
	Subtotal	6
III.	Other Scrams or Unscheduled Shutdowns	
	a) Shutdowns without operator action:	
	i) Electric company power loss	4
	ii) Simultaneous deflation of both gaskets on main personnel lock	1
	b) Operator lowered power to investigate:	
	i) Leak alarm	1
	ii) Failure of sample to eject	1
	iii) Low pressure in the helium supply to an irradiation thimble and subsequent in-leakage of water	4
	iv) High primary conductivity	1
	v) Activation of cooling tower vibration switch	1

c) Operator shut down by "All Rods In" to minimize Ar-41 buildup when ventilation failed shut		1
	Subtotal	14
	Total	25

The 25 scrams and shutdowns during FY 83 is quite comparable to the 28 and 24 experienced in FY 82 and FY 81 respectively.

D. MAJOR MAINTENANCE

Major maintenance projects during FY 83, including the effect, if any, on safe operation of the reactor, are described below in this section.

FY 83 saw a continuation of the program for upgrading reactor instrumentation that was begun several years ago. Installation of the new multi-point temperature recorder having alarm and scram capabilities was completed; it has performed well and, as expected, is much more reliable than the older units that it replaced. A new shield plug having several neutron detector positioning tubes was installed in instrument port 41H2 and incorporates two uncompensated ion chambers and two spare fission chambers. Flow meter HF-3 for the secondary side of the cleanup loop heat exchanger was rebuilt and calibrated. Parts for the effluent monitors are becoming obsolete and difficult to find, and so a new design is being investigated. Thermocouples clad in stainless steel were fabricated and installed to facilitate calibration of temperature indicating switches that monitor the core tank outlet.

Several of the coarse and fine selsyns that indicate shim blade height were either rebuilt or replaced in order to correct binding problems that had developed. The magnet for blade no. 6 failed and had to be replaced. Three new boron-stainless steel shim blades were fabricated to serve as spares and ultimately to replace three of those now in service. A large fume hood was installed in the "hot" machine shop for over-haul of contaminated items such as control blade drives, magnets, etc.

Both the camera and monitor for the containment building closed circuit TV system were badly deteriorated and were replaced.

Several circuit breakers for pumps and compressors were repaired or replaced due to overheating of the contacts or for other reasons. The shield coolant pump burned out and was replaced. Shaft bearings on the intake fan had to be replaced. The intake isolation valve accumulator was replaced due to a failed diaphragm.

When the cadmium-lined sleeves of the racks for storage of spent fuel elements were inspected, it was noted that some showed signs of corrosion. These are to be replaced by new sleeves now being fabricated. Neutron transmission measurements will be made to assure the presence of cadmium.

The containment building exterior and much of the interior was repainted during the year. The suspended ceiling of the medical therapy area was refurbished.

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), E-82-6 (07/13/82), 0-83-5 (02/03/83), E-83-1 (02/08/83), 0-83-12 (04/23/83).

Digital Computer Control of Reactors Under Steady-State and Transient 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. Replacement of the constant speed regulating rod drive motor by a variable speed drive motor further improves control.

Studies are now under way to perfect a digital controller for power changes. A non-linear supervisory algorithm has been developed and demonstrated. It, combined with the signal validation procedures, insures that there will not be any challenge to the reactor safety system while testing closed-loop control methods. Several such methods, including decision analysis and modern control theory, are now being experimentally evaluated. 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.

Each new step in the program is evaluated for safety in accordance with standard review procedures (Safety Review numbers listed above) and approved as necessary by the MIT Reactor Safeguards Committee. To date no unreviewed safety questions requiring advance NRC approval have been identified.

Reactor Staff approval 10/06/80

MIT Reactor Safeguards Committee Approval 12/03/81

MIT Reactor Safeguards Subcommittee Approval 05/27/82

MIT Reactor Safeguards Committee Approval 12/06/82

MIT Reactor Safeguards Subcommittee Approval 03/04/83, 05/27/83

2. SR #M-83-1 (2/24/83)

Reactor Off-Gas Sampling for Cd-Te Detector

Plans have been prepared and approved to provide a gas volume of reactor core tank off-gas for the testing of Cadmium-Telluride detectors. Gas sampling lines will be run from two points in the core purge system to a detector station outside the Primary Chemistry Room in the containment building basement, with appropriate valves, filters, water trap, gas pump, and interlocks. Circulated core purge gas is returned to the building exhaust system. Prior to utilization of the system, procedures will be prepared covering startup of the system, operation and actions required in the event of high radiation levels in the core purge system. No unresolved safety questions are involved.

Reactor Staff approval 3/15/83

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, 1982 - June 30, 1983
North	3.7 mR/year
South	3.3 mR/year
East	0.9 mR/year *
West	2.5 mR/year
Green (East)	0.4 mR/year

*The measurement period was from July 1, 1982 to March 1, 1983.

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
1983	2.3 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 7/01/82 - 6/30/83 No. of Personnel
No Measurable	68
Measurable - Exposure Less than 0.1	33
0.1 - 0.25	6
0.25 - 0.5	10
0.5 - 0.75	8
0.75 - 1.0	1
1.0 - 2.0	1

Summary of the results of radiation and contamination surveys from July 1982 to June 1983:

During the 1982-1983 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

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. There were three sources of such wastes during the year: the cooling tower blowdowns, the liquid waste storage tanks and laboratory drains. All of the liquid volumes are measured, by far the largest being the 4,850,000 liters discharged during FY 1983 from the cooling towers. (Larger 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 since the volume is not routinely measured.)

All releases were in accordance with Technical Specification 3.8-1, including Part 20, Title 10, Code of Federal Regulations. There are no reportable radionuclides inasmuch as all activities, including tritium, were substantially below the limits specified in 10 CFR 20.303 and 10 CFR 20, Appendix B, Note 5.

2. Gaseous Waste

Gaseous radioactivity is discharged to the atmosphere from the containment building exhaust stack and by evaporation from the cooling towers. All gaseous releases likewise were in accordance with the Technical Specifications and Part 20, and all nuclides were below the limits of 10 CFR 20.106 after the authorized dilution factor of 3000. Also, all were substantially below the limits of 10 CFR 20, Appendix B, Note 5, with the exception of argon-41, which is reported in the following Table H-1. The 9444 Ci of Ar-41 was released at an average concentration of 2.44×10^{-8} μCi/ml for the year. This represents 61% of MPC (4×10^{-8} μCi/ml).

3. Solid Waste

Only one shipment of solid waste was made during the year, information on which is provided in the following Table H-2.

Table H-1

ARGON-41 STACK RELEASES

FISCAL YEAR 1983

	Ar-41 Discharged (Curies)	Average Concentration (1) (μ Ci/ml)
July 1982	717	2.41×10^{-8}
August	744	2.50
September	873	2.35
October	648	2.18
November	698	2.34
December	807	2.17
January 1983	741	2.49
February	770	2.58
March	1089	2.93
April	721	2.42
May	836	2.81
June	800	2.15
12 months	9444	2.44×10^{-8}
MPC (Table II, Column I)		4×10^{-8}
% MPC		61%

Note: (1) After authorized dilution factor (3000).

TABLE H-2

SUMMARY OF MITR RADIOACTIVE SOLID WASTE SHIPMENTS - FISCAL YEAR 1983

	UNITS			TOTAL
1. Solid waste packaged	Cubic Feet	67.5		67.5
2. Total activity (irradiated components, ion exchange resins, etc.) ^{60}Co, ^{51}Cr, $^{55-59}Fe$ ^{65}Zn, etc.	(Ci)	0.061		0.061
3. (a) Dates of shipment (b) Disposition to licensee for burial		3/09/83 Radiation Service Organization		

NUCLEAR REACTOR LABORATORY
AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

O.K. HARLING
Director

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L. CLARK, JR.
Director of Reactor Operations

August 30, 1983

Dr. Thomas E. Murley, Administrator
U.S. Nuclear Regulatory Commission
Region #1
631 Park Avenue
King of Prussia, PA 19406

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

Dear Dr. Murley:

Forwarded herewith are two (2) copies of the Annual Report for the MIT Research Reactor for the period July 1, 1982-June 30, 1983, in compliance with paragraph 7.13.5 of the Technical Specifications for Facility Operating License R-37.

Sincerely,

Lincoln Clark, Jr.

Lincoln Clark, Jr.
Director of Reactor Operations

LC/sbs
Enclosure: As stated

cc: MITRSC
USNRC-OI&E
USNRC-DMB
USNRC-OMIPC

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