NUCLEAR REACTOR LABORATORY

AN INTERDEPARTMENTAL CENTER OF
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

O. K. HARLING
Director

138 Albany Street, Cambridge, Mass. 02139-4296
Telefax No. (617) 253-7300
Telex No. 92-1473-MIT-CAM
Tel. No. (617)253-4202

J. A. BERNARD, JR.
Director of Reactor Operations

29 September 1994

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Subject: Response to Request Dated 08/31/94 for Additional Information Regarding Request for Adjustment of Facility Operating License No. R-37 for the Massachusetts Institute of Technology Research Reactor (MITR); Docket No. 50-20.

Gentlemen:

On 03/31/94, the Massachusetts Institute of Technology submitted a request that Facility Operating License No. R-37 be extended to April 24, 2001. On 08/31/94, the U.S. Nuclear Regulatory Commission requested additional information concerning that proposed license extension. Enclosed is our response.

Sincerely,

Jim A Berny

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

JAB/CRM

Enclosure

cc: USNRC - Project Manager,
NRR/ONDD

USNRC - Region I - Project Scientist,
Effluents Radiation Protection Section (ERPS)
FRSSB/DRSS

Question #1 – Containment Building Surveillance and Testing

The MIT Research Reactor is equipped with a full containment. The major penetrations are the main and basement personnel air locks, the intake and exhaust ventilation ducts, and a number of small lines for CO_2, helium, and compressed air. In addition, there is an air lock of sufficient size to accommodate large vehicles. This air lock, which is referred to as the 'truck lock,' has in recent years been downgraded so that it is used only when the reactor is in a secured condition. The containment building is protected against both under and overpressure. The former is achieved through doubly redundant sets (i.e., two sets each with two breakers in series) of vacuum breakers. These open to admit air into the building in the event of an underpressure. Overpressure protection is provided by a pressure relief system that must be manually operated.

The material condition of the containment building is maintained below ground level through the use of sacrificial zinc anodes (cathodic protection system). Protection above ground is provided by periodic painting of the building.

There are a number of test procedures that are specific to the containment building and/or its penetrations. These are listed in Table 1-1.

MITR Technical Specifications TS #3.5, "Reactor Containment Integrity and Pressure Relief System," TS #4.2 "Containment and Pressure Relief System Surveillance," and certain parts of TS #4.3, "Reactor Control, Safety, and Radiation Monitoring System Surveillance" pertain to the containment building. The first of these specifies the allowed building leak rate (1% of the contained volume per day per pound of overpressure), the efficiency for iodine removal (10%) of the pressure relief system filters, the setpoint (0.1 inches of H_2O) of the interlock that precludes reactor startup unless the building is slightly below atmospheric pressure, the setpoint (atmospheric pressure 0.1 psig above building) for the vacuum breakers, and the setpoint (3 psig) for the building overpressure scram. Specifications #4.2 and #4.3 specify surveillance frequencies. Table 1-2 shows the MITR procedures that are used to fulfill the requirements of the Technical Specifications that relate to containment building surveillance and testing. A comparison with Table 1-1 shows that many of the procedures that are performed relative to the containment building and/or its penetrations are NOT technical specification requirements.

Results of the containment building surveillance and testing for the last five years have been as follows:

(1) All surveillance and test requirements as specified by both the Technical Specifications and internal MITR Procedures (Tables 1-1 and 1-2) have been performed at the specified frequency. Moreover, all setpoints and/or limiting conditions for operation were achieved.

(2) The last five building pressure tests are discussed here. Each of the penetrations such as the air locks, ventilation ducts, and vacuum breakers contain two closure devices that are mounted in series. Accordingly, the building pressure test is run annually in two different configurations so as to test each closure device separately. The status of the affected devices in the two configurations is given in Table 1-3. The test is performed by first placing the building in the desired configuration and then pressurizing the building to 50 inches of H_2O (~ 2 psig). The volume of the air added to the building in order to maintain 50 inches of H_2O over a period of several hours is measured as are temperatures throughout the building, relative humidity, the cycling of the reactor gasholders, and the

Table 1-1

MITR Surveillance Tests

Relevant to the Containment Building and/or Its Penetrations

#	Title	Frequency
6.1.2.1	Building Pressure Test	Annual
6.1.2.2	Main Ventilation Damper Inspection	Semi-annual
6.1.2.3	New or Repaired Containment Penetration Leak Test	As needed
6.1.2.4	Test of Vacuum Breaker Set Points	Annual
6.1.2.5	Charcoal Filter Efficiency Test	Annual
6.1.3.5	Building ΔP Indicator and Recorder Calibration	Annual
6.1.3.6	Building Over-Pressure Scram	Quarterly
6.1.4.3	Damper Closing Time	Annual
6.2.1	Main Personnel Air Lock Gaskets Deflated Scram	Quarterly
6.2.2	Basement Personnel Air Lock Gaskets Deflated Scram	Quarterly
6.3.4	Fan Interlocks and Alarms	Semi-annual
6.5.1	Cathodic Protection System Test	Semi-annual
6.5.10.2	Vacuum Breaker Calibration	Annual
3.1	Startup Checklists (Startup Interlock Tests)	Done as part of startup checklists
7.1.5	Damper Accumulator Charging and Actuator Inspection	Quarterly
7.4.2.1	Solenoid Valve Replacement	Annual

Table 1-2

MITR Procedures Used to Satisfy Technical Specification Requirements
Relevant to the Containment Building and/or Its Penetrations

Technical Specification			MITR Procedure	
TS #	Requirement	Frequency	Procedure	Frequency
3.5.2/4.2.1(a)	Building Leakage	Annual	6.1.2.1	Annual
4.2.1(b)	New Penetrations	As needed	6.1.2.3	As needed
3.5.3/4.2.3	Pressure Relief	Annual	6.1.2.5	Annual
3.5.4/4.3.1(j)	Building ΔP S/U Interlock	Prior to S/U	Startup Checklists	Prior to S/U
3.5.5/4.2.2	Vacuum Relief	Annual	6.5.10.2	Annual
3.5.6	Overpressure Scram	--	6.1.3.6	Quarterly
4.3.2(e)	Containment ΔP Calibration	Annual	6.1.3.5	Annual

Table 1-3

Configurations for MITR Building Pressure Test

Device	Configuration #1	Configuration #2
Main Intake Damper	Open	Closed
Auxiliary Intake Damper	Closed	Open
Main Exhaust Damper	Open	Closed
Auxiliary Intake Damper	Closed	Open
Main Personnel Air Lock Outer Door	Closed	Open
Main Personnel Air Lock Inner Door	Open	Closed
Basement Personnel Air Lock Outer Door	Open	Closed
Basement Personnel Air Lock Inner Door	Closed	Open
Truck Lock Outer Door	Open	Closed
Truck Lock Inner Door	Closed	Open*

*Closed in recent years because truck lock use is restricted to times when the reactor is secured.

barometric pressure. From this information, both the observed building leak rate and the total leakage are calculated. These are then compared to the allowed values which are specified in Technical Specification #3.5. (Note: An allowed leakage of 1% of the contained volume per pound of overpressure per day equates to about 155 cubic feet per hour.) Data are taken every half-hour. Table 1-4 summarizes the final results (last set of data in each test unless otherwise specified) for the last five years. (Note: The 1994 building pressure test is currently scheduled for November 1994.) In each instance, the observed leak rate has been well below the allowed.

(3) The cathodic protection system was replaced in its entirety in 1992.

Table 1-4

Summary of MITR Building Leak Rate Tests

	Configuration #1				Configuration #2			
Year	Observed Leak Rate (cu ft/hr)	Observed Total Leakage (cu ft)	Allowed Leak Rate (cu ft/hr)	Allowed Total Leakage(1) (cu ft)	Observed Leak Rate (cu ft/hr)	Observed Total Leakage (cu ft)	Allowed Leak Rate (cu ft/hr)	Allowed Total Leakage(1) (cu ft)
1989(2)	102.3 ± 2.9	580 ± 19	161	925	94.9 ± 3.3	540 ± 20	164	901
1990	30.4 ± 7.0	257 ± 47	156	965	38.7 ± 4.7	235 ± 15.8	159	985
1991	45.4 ± 5.1	303 ± 62	154	1420	32.9 ± 4.3	181 ± 23	155	800
1992	45.1 ± 3.6	338 ± 30	157	1136	98.0 ± 7.8	426 ± 35	156	725
1993(3)	31.8 ± 6.9	165 ± 36.4	153	790	16.7 ± 7.0	42 ± 15	153	398

Notes:

(1) The allowed total leakage varies from year to year and with configuration because tests are of different durations. The test is run until the error analysis of the data shows that the measurements are reliable. Hence, durations vary.

(2) The 1989 data was satisfactory. Yet, the observed leak rate was higher than normal. Refurbishments were subsequently made to the inner gasket of the basement personnel air lock, to the diaphragms of the pressure relief system's valves, and to one of the vacuum breakers. Data shown are from data set #12 for the first configuration and set #11 for the second.

(3) Data for the configuration #2 of the 1993 test is given for data set #6 rather than the final data set. The latter showed a near-zero leak rate which was probably caused by a non-uniform temperature distribution in the building. The 1993 test ran late and the sun rose after the sixth data set and began heating the building.

Question #2 – Core Component Inspection

Core component inspections are performed quarterly in accordance with PM 7.4.4.2, "In-Service Inspection of Primary Core Tank and Fuel." A copy of that procedure is attached as Appendix A. Virtually all of these inspections have resulted in negative findings. That is, no deficiencies were identified. This is to be expected because (1) all core components and the core tank were new as of 1973; (2) material certifications were (and are) required for all in-core components as well as for those of the primary, D_2O, and shield systems; and (3) primary coolant water samples are analyzed prior to a reactor startup if shut down for more than sixteen hours and the coolant chemistry is maintained to strict standards.

The following, all minor, items have been noted on the core component inspections conducted during the past five years:

1. Proximity switches, which are reed switches that are activated by a magnet, are one of several indicators used to sense the 'full-in' position of the reactor's shim blades. These switches require replacement at the rate of one to two per year. (Note: The switches are inexpensive, are easy to replace, and are not required for reactor operation.)

2. Electro-magnets are used to connect the reactor's shim blades to the shim blade drives. These magnets, which are physically immersed in the reactor coolant, are electroplated to prevent corrosion. Nevertheless, the surfaces do eventually corrode. The present set of electromagnets was installed in 1988. One was replaced in 1994 because of surface corrosion. The others remain in excellent condition.

3. In 1988/1989, rust was noted in the upper portions of the core tank. This problem was summarized in the MITR FY89 Annual Report to the U.S. Nuclear Regulatory Commission and we quote from that report:

> "The upper shield access ring is a lead filled steel weldment supported by the upper shield ring situated above the upper core tank (see Figure 2-1). The inner cylindrical surface of the upper shield access ring is clad with a thin layer of 304 stainless steel and the other surfaces are protected by epoxy paint. The gasket which seals water from entering the interface between the upper shield access ring and the upper core tank had deteriorated and allowed rust to form on the non-stainless surface of the shield ring. The remedy for this situation was to remove all rust from all surfaces with a grinder and wire brush. All non-stainless surfaces on the upper shield ring, upper shield access ring, and the top shield lid were then primed and repainted with epoxy paint."

This problem has not been observed since the above corrective action was taken.

The reactor core tank is surrounded by the heavy water (D_2O) reflector tank which is in turn encased by the graphite reflector. Hence, it is not possible to inspect or observe the D_2O reflector tank on a routine basis. The inner surface of the D_2O tank is, of course, exposed to heavy water. The quality (pH, chloride, conductivity) of that water is monitored and a deuterated mixed-bed ion column is used to maintain its purity. Hence, no corrosion would be expected on the inner surface of the D_2O tank. The outer surface adjoins the graphite reflector which is kept under a blanket of inert (helium) or non-reactive (CO_2) gas. Hence, no corrosion would be expected on the outer surface of that tank.

Three inspections have been conducted of the graphite reflector and the exterior surface of the D_2O tank. One was performed in 1986 and the others in 1987 and 1989. In all cases, access was achieved by first removing one of the experiment ports that extends downward into the graphite region and then installing a periscope (military surplus) in the vacated space. In addition, special tools were constructed for obtaining samples. The procedure used was as follows:

1. The 3GV2 experimental port was removed to obtain access to the normally sealed graphite region.
2. A periscope was inserted in the 3GV2 opening.
3. A visual inspection was made of the graphite, the exterior of the reflector tank, and the exterior of the 3GV2 thimble.
4. Photographs were taken through the periscope.
5. The periscope was removed.
6. Several samples of graphite were taken.
7. Scrapings of the surface of the reflector tank were taken.
8. The 3GV2 thimble was reinstalled.
9. The reflector region was resealed.

The first inspection was performed over the period 1 December 1986 – 29 December 1986. At that time, the exterior surface of the reflector tank was found to be uniformly covered with a corrosion layer. This layer appeared to be only a few mils deep. Samples showed it to be a white powder that had a granular consistency. It was possible to make a scratch in this layer by using an aluminum tool. A γ-spectrum showed that the following nuclides were present: Cr-51, Co-58, Co-60, Fe-59, Zn-65, and K-40 (in approximate order of abundance). Cr, Fe, and Zn are all used as alloying elements in 6061 aluminum – the material from which the reflector tank was made. Further analysis of the samples showed them to be aluminum oxide. A small area of the reflector tank surface was then polished so as to remove all traces of the oxide layer.

The second inspection of the graphite region occurred about a year later, late in 1987. The original oxide layer was still present. The area of the tank that had been polished was examined and no visible changes were noted. In particular, there was neither any visible change to the polished area nor any oxide build-up on it.

The results of both inspections were provided to the MIT Reactor Safeguards Committee (MITRSC) and to several members of the MIT faculty who specialize in corrosion. One of these was Prof. Ronald M. Latanision who is an internationally recognized expert on the subject. The conclusion of the MITRSC was as follows:

> "It is believed that this oxide layer formed shortly after the initial operation of the MITR-II in 1975. A small amount of moisture may have been present in the graphite reflector region and it would have condensed on the outer wall of the reflector tank. In any event, the layer is stable and not growing. Also, it is only a few mils thick."

A third inspection of the graphite region was made in December 1989. The findings were identical to those in 1987. No further inspections have been made or are planned. It should be noted that this oxide layer may have a beneficial effect in that it may passivate the metal surface.

Question #3 – Review of Radiation Damage Mechanisms to Aluminum

The review to which we referred on page seven of the original submission (03/31/94) was performed by the faculty and staff who are involved in the planning for the reactor's relicensing. As such the review was in the form of an extended discussion with the principal participants being Professors Harling, Lanning, and Meyer, all of MIT. Several students were assigned special problems on the topic of radiation-induced damage mechanisms to aluminum. As part of these projects, they prepared term papers and identified useful references in the literature. One of those students, Mr. Jyh-Tzong Hwang, produced a well-written report entitled "A Study of MITR-II Core Tank Aging for Relicensing Consideration" and we are enclosing a copy as a separate document. Please recognize that it is a student report and not a published paper.

There is one item in Mr. Hwang's report that may cause some confusion. On page 10 of the report, a set of empirical relations are given that fit experimental data obtained by Weeks et al. for an aluminum component that was removed from the High Flux Beam Reactor (HFBR) at ORNL. These equations are useful for assessing expected changes in mechanical properties. They are not necessarily useful for determining absolute values of a given property. For example, the empirical relation for the elongation (elasticity) is:

$$\%E = 10.7 - 0.69 * \left(\phi_{tn} * 10^{-23}\right) \tag{1}$$

Mr. Hwang uses this relation to estimate the %E for the MIT Research Reactor's core tank and concludes (see p. 13, middle of page) that, if the reactor were relicensed at 10 MW and then operated for 20 years, the %E would be slightly below the minimum ASME-recommended figure of 10%. While this is an arithmetically correct conclusion, it is irrelevant to the MIT Research Reactor. To see this, use Equation (1) to calculate the %E for unirradiated material. In that case, ϕ_{tn} is 0.0 and the %E is 10.7%, a figure that is only slightly above the recommended minimum. Evidently, the material used for the study from which Equation (1) was derived had an unusually low value of elasticity at the outset. The %E for the material (6061-T6 wrought aluminum alloy) from which the MITR core and reflector tanks were made ranges from 12%-17% (Source: Handbook of Engineering Fundamentals, O. W. Eshbach and M. Souders, eds., 3rd edition, Wiley Engineering Handbook Series, p. 1383.) The value of Equation (1) to the MITR is that it provides a means for estimating the change in elasticity as a result of radiation damage. If one assumes that the present license is extended to the year 2001, and that the power level remains at 5 MW, then the maximum expected thermal fluence to the core tank would be $3.22 \cdot 10^{22}\, n / cm^2$ and the change in %E from the unirradiated state would be 0.22%. This would not be significant.

Question #4 – Reactor Control and Radiation Detection Electronics

The maintenance of all reactor systems, including the reactor control and radiation detection electronics, is an on-going activity. The reactor audit process, which was described in our original submission dated 03/31/94, is used to identify systems that warrant upgrading or replacement. For example, in the mid-1970s, the frequency of scrams that resulted from instrument malfunctions was judged to be excessive. The solution was to replace the fission and ion chambers that provided signals to the nuclear safety system with integral lead chambers. The port plugs that held these chambers were also replaced or refurbished at that time. Similarly, maintenance support for the temperature recorder for the various process systems was judged to be excessive in the mid-1980s and that recorder was replaced. Table 4-1 lists recent upgrades to the reactor control and radiation detection electronics. Also listed are upgrades that are in progress and ones that are planned. For those that are in progress, the expected completion date is given.

Table 4-1

Upgrades to the Reactor Control and Radiation Detection Electronics

A. Completed Upgrades (1990-1994)

1. Auxiliary Core Purge Radiation Monitor (1990)
2. Core Outlet Temperature Recorder (1992)
3. CO_2/Helium Gasholder Level Recorder (1992)
4. Radiation Monitor Recorder for Effluent Radiation Detectors (1993)
5. Radiation Monitor Recorder for Interior Radiation Detectors (1994)
6. Differential-Pressure Flow Transmitters for the Secondary, D_2O, and Shield Coolant Flows (1994)
7. Flow Recorder for the Secondary, D_2O, and Shield Coolant Flows (1994)
8. Equipment for the Calibration of Temperature Sensors (1994)
9. Toxic Gas (Ammonia) Detection System (1994)

B. Upgrades in Progress

1. Stack Area Radiation Monitor (11/94)
2. Effluent Radiation Detectors (2/95)
3. Expanded Closed-Circuit TV Surveillance System for Containment Building Entrances and Interior (2/95)

C. Planned Upgrades

1. Redesign and replacement of nuclear safety system. (Funding approved; contract to be issued 10/94)
2. Procurement of new fission chambers for the new safety system. (Funding approved; contract to be issued 10/94)
3. Replacement of recorders and sensors for primary flow, ΔT, and thermal power. (Funding requested)
4. Replacement and possible upgrade of emergency power supply batteries. (Under discussion)

Appendix A

PM 7.4.4.2, "In-Service Inspection of Primary Core Tank and Fuel"