April 16, 2003

Dr. John Bernard, Director
Nuclear Reactor Laboratory
Massachusetts Institute of Technology
138 Albany Street
Cambridge, MA 02139-4296

SUBJECT: ISSUANCE OF AMENDMENT NO. 35 TO AMENDED FACILITY OPERATING LICENSE NO. R-37 - MASSACHUSETTS INSTITUTE OF TECHNOLOGY (TAC NO. MB6255)

Dear Dr. Bernard:

The U.S. Nuclear Regulatory Commission has issued the enclosed Amendment No. 35 to Facility Operating License No. R-37 for the Massachusetts Institute of Technology research reactor. The amendment consists of changes to the Technical Specifications (TSs) in response to your submittal of August 22, 2002, as supplemented on October 18, 2002, and is discussed in the enclosed Safety Evaluation Report.

Sincerely,

/RA/

Alexander Adams, Senior Project Manager
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Docket No. 50-20

Enclosures: 1. Amendment No. 35
2. Safety Evaluation Report

cc:

City Manager
City Hall
Cambridge, MA 02139

Department of Environmental
Quality Engineering
100 Cambridge Street
Boston, MA 02202

Test, Research, and Training
Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

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2. Safety Evaluation Report

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOCKET NO. 50-20

AMENDMENT TO AMENDED FACILITY OPERATING LICENSE

Amendment No. 35
License No. R-37

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that

   A. The application for an amendment to Amended Facility Operating License No. R-37 filed by the Massachusetts Institute of Technology (the licensee) on August 22, 2002, as supplemented on October 18, 2002, conforms to the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the regulations of the Commission as stated in Chapter I of Title 10 of the *Code of Federal Regulations* (10 CFR);

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance that (i) the activities authorized by this amendment can be conducted without endangering the health and safety of the public and (ii) such activities will be conducted in compliance with the regulations of the Commission;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public;

   E. This amendment is issued in accordance with the regulations of the Commission as stated in 10 CFR Part 51, and all applicable requirements have been satisfied; and

   F. Prior notice of this amendment was not required by 10 CFR 2.105, and publication of notice for this amendment is not required by 10 CFR 2.106.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the enclosure to this license amendment, and paragraph 2.C.(2) of Amended Facility Operating License No. R-37 is hereby amended to read as follows:

   2.C.(2) Technical Specifications

   The Technical Specifications contained in Appendix A, as revised through Amendment No. 35, are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/

Patrick M. Madden, Section Chief
Research and Test Reactors Section
Operating Reactor Improvements Program
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation

Enclosure: Appendix A, Technical
Specification Changes

Date of Issuance: April 16, 2003

AMENDED FACILITY OPERATING LICENSE NO. R-37

DOCKET NO. 50-20

Replace the following pages of Appendix A, Technical Specifications, with the enclosed pages. The revised pages are identified by amendment number and contain vertical lines indicating the areas of change.

Remove	Insert
iv	iv
6-5	6-5
	6-65
	6-66
	6-67
	6-68

7. Radioactive Releases

Experiments shall be designed so that malfunctions and normal operations are not predicted to result in exposures in excess of the limits of 10 CFR 20 to either onsite or offsite personnel or in releases of radioactivity in excess of the 10 CFR 20 annual average concentration limits.

Basis

Accidents resulting from the step insertion of reactivity have been discussed in the SAR. It was determined that following a step increase of 1.8% ΔK/K, fuel plate temperatures would be below the clad melting temperature and significant core damage would not result. The 0.2% ΔK/K limit for movable experiments corresponds to a 20-second period, one which can be easily controlled by the reactor operator with little effect on reactor power. The limiting value for a single non-secured experiment, 0.5%ΔK/K is set conservatively below the prompt critical value for reactivity insertion and below the minimum shutdown margin. The sum of the magnitudes of the static reactivity worths of all non-secured experiments, 1.0% ΔK/K, does not exceed the minimum shutdown margin. The total worth of all movable and non-secured experiments will not reduce the minimum shutdown margin as the shutdown margin is determined with all movable experiments in the most positive reactive state.

6.7 Experiments Involving In-Core Irradiation of Fissile Materials

Applicability

This specification applies to the in-core irradiation of fissile materials. It does not apply to out-of-core irradiations.

Objective

To ensure that fissile materials experiments do not affect safe operation of the reactor and to provide for the protection of the public health and safety by ensuring the integrity of irradiated fissile materials.

Specification

1. In-core fissile materials irradiation experiments shall not contain circulating loops.
2. The physical form of the fissile materials shall be solid. The fissile materials shall be doubly encapsulated to preclude radionuclide leakage during irradiation.
3. The cross section of an in-core fissile materials experiment facility shall not exceed 16 square inches.
4. The total initial amount of U-235 in each in-core fissile materials experiment shall not exceed 100 grams. Any mixture of fissile materials is permitted provided that the off-site dose consequences are less than those of 100 grams of U-235.
5. Thermal power generated from each fissile materials experiment shall not exceed 100 kW during irradiation.
6. Each fissile materials irradiation experiment shall be monitored so that over-temperature protection is provided by an automatic reactor scram. The automatic reactor scram function will be tested each time before startup of the reactor if the reactor has been shutdown for more than 16 hours. The temperature channels shall be calibrated and trip points verified when initially installed, any time the instrument has been repaired, and at least annually.

7. Any void space between the inner and outer barriers of the double encapsulation shall be sampled at least weekly for indication of fission products during any week that the experiment is in core and the reactor power exceeds 100 kW. The finding shall be compared to a baseline and the reactor power shall be made less than 100 kW if fission product activity exceeds three times baseline.

8. Design of the fissile materials experiments shall conform to the provisions of TS#6.1 "General Experiment Criteria." Each proposed in-core fissile materials experiment shall require a documented safety review and approval by the MIT Reactor Safeguards Committee (MITRSC) or, if authorized by the MITRSC, by its Subcommittee for in-core experiments.

Basis

The MITR is licensed as a research reactor. Code of Federal Regulations 10 Part 50.2 defines a non-power reactor as a research or test reactor licensed under 10CFR50.21(c) or 50.22 for research and development. A test facility is defined in 10CFR50.2 as a nuclear reactor for which "...an application has been filed for a license authorizing operation at: (1) a thermal power level in excess of 10 megawatts; or (2) a thermal power level in excess of 1 megawatt, if the reactor is to contain: (i) a circulating loop through the core in which the applicant proposes to conduct fuel experiments; or (ii) a liquid fuel loading; or (iii) an experimental facility in the core in excess of 16 square inches in cross-section." Therefore, Technical Specifications 6.7.1, 6.7.2, and 6.7.3 are based on 50.2(2)(i), 50.2(2)(ii), and 50.2(2)(iii), respectively.

Other limits on the in-core irradiation of fissile materials specific to the MITR in-core experiments are experiment reactivity worth limit and onset of nucleate boiling (ONB). Additional requirements such as weekly sampling of cover gas in the void space and over-temperature automatic reactor scram provide redundant protection against a potential malfunction of the fissile materials irradiation experiments. The limit on U-235 content in a fissile materials irradiation experiment is derived from the Design Basis Accident (DBA) of the reactor. The effect of actinides, which are produced from U-238,

on off-site dose is analyzed. It is concluded that a limit on the initial amount of U-238 is not required.

The Design Basis Accident (DBA) chosen for the MITR assumes a blockage of five coolant flow channels that results in four fuel plates completely melted [6.7-1]. Release of the fission products to the atmosphere is calculated assuming that the fission product buildup achieved saturation. Off-site dose to the general public is then calculated from the released fission products. The maximum amount of fissile materials that can be accommodated in a fissile materials experiment should result in a maximum fission product release below that of the DBA. Using an approximation based on the U-235 content, the maximum amount of U-235 would be 506 grams (mass of U-235 per fuel element) x 4 (plates) ÷ 15 (plates per element) = 135 grams. A limit of the total initial amount of 100 grams U-235 is conservatively chosen.

Actinides are produced when U-238 is irradiated. The off-site whole body dose from actinides was calculated to be 2 mrem per kilogram of initial U-238 [6.7-2]. The maximum initial amount of U-238, which is set by the total off-site dose from both fission products and actinides releases of the fissile materials experiment, was calculated to be 31 grams. This amount is significantly higher than that of natural uranium that contains 100 grams of U-235, 0.1 kgU-235 x (0.993/0.007) = 14.2 kgU-238. Therefore, a limit on the initial amount of U-238 is not required.

The limit on the thermal power generated from the fissile materials experiment is primarily imposed by the onset of nucleate boiling (ONB), which is one of the criteria in TS #6.1. Each in-core fissile materials experiment design will be reviewed to ensure that ONB would not occur during steady-state operation. However, 100 kW, which is less than the average thermal power per fuel element of 200 kW, is used to set an upper bound for any fissile materials irradiation experiment.

The inner barrier of the double encapsulation is monitored for over-temperature.

The scram setpoint is experiment-dependent and will be chosen to avoid rapid mechanical and/or chemical degradation of the barrier. The scram setpoint will be documented in the safety review that is required by provision 8 of this technical specification.

Fission product gas release is an unlikely accident scenario. An analysis is performed assuming that, as a result of multiple failures, the entire fission product inventory produced from a fissile materials experiment is released through the reactor ventilation system. The fission product gases analyzed here are the noble gas nuclides including Kr-85m, Kr-87, Kr-88, Xe-131m, Xe-133m, Xe-133, and Xe-135. The fission product gas inventory is assumed to be at equilibrium at 100 kW (maximum allowable power of a fissile materials irradiation experiment) and is released within one week. The interval of one week is chosen because that is the frequency for the void space sampling. This is a conservative assumption because a shorter interval will result in a much higher core purge monitor reading and hence increase the probability of detection. The analysis concludes that (a) the core purge monitor should detect a higher reading, 44 kcpm over background, if the fission product gases were to escape the barriers, an increase equivalent to approximately twice that of a normal background reading, and (b) if the entire fission product gas inventory leaks from a fissile materials irradiation experiment and is released to the atmosphere through the stack, the total inhalation dose is calculated to be about 17 mrem. The inhalation dose of 17 mrem is much lower than the 100 mrem annual limit for the general public defined by 10 CFR 20. There will be no additional thyroid dose because none of the fission product gases affect the thyroid.

References

6.7-1 MITR Staff, “Safety Analysis Report for the MIT Research Reactor (MITR-II),” Report No. MITNE-115, 22 Oct. 1970.

6.7-2 File Memo “Actinides Off-Site Dose Calculations During DBA,” Oct. 2001.

6.7-3 File Memo “Off-Site Dose Calculations for Fission Product Gases Release,” August 2002.

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 35 TO

AMENDED FACILITY OPERATING LICENSE NO. R-37

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DOCKET NO. 50-20

1.0 INTRODUCTION

By letter dated August 22, 2002, the Massachusetts Institute of Technology (the licensee) submitted a request for amendment of the Technical Specifications (TSs), Appendix A, to Facility Operating License No. R-37 for the Massachusetts Institute of Technology research reactor. The amendment would allow experiments involving in-core irradiation of fissile materials. The request provides for the following changes:

1. Create a new Technical Specification, No. 6.7, providing general requirements for in-core irradiation of fissile materials.

2. Revise Technical Specification No. 6.1.7, concerning general experiment criteria related to radioactive releases.

On September 25, 2002, the staff sent a Request for Additional Information (RAI) to the licensee. Their response was received by letter dated October 18, 2002. This Safety Evaluation Report takes into consideration the application and the response to the RAIs.

2.0 EVALUATION

MIT is proposing to conduct experiments involving the irradiation of up to 100 grams of U-235 in-core (or any mixture of fissile materials provided that the off-site dose consequences are less than those of 100 grams of U-235.) In order to assess the off-site dose consequences resulting from a failure of the experiment, it is assumed that the entire 100 grams are melted as a result of coolant flow blockage and the fission products released to the atmosphere. In order to bound the problem, the Safety Review considers the consequences of the Design Basis Accident (DBA) (also referred to as the Maximum Hypothetical Accident [MHA]) previously analyzed in the MIT Safety Analysis Report. The DBA assumed the blockage of five coolant flow channels resulting in the complete melting of four fuel plates. (Coolant flows around six parallel fuel plates. A coolant flow blockage would result in the total loss of flow around each of the four middle plates. The two outer plates would still have flow along the outside area and would not melt.) The total mass of U-235 in the four fuel plates is 135 grams.

The results of the DBA calculations were that, at the nearest point of public access, twenty-one meters, the whole body dose in the first two hours following the release of fission products would be 247 mrem and the thyroid dose would be 134 mrem.

The same calculations are repeated by the licensee for the melting of 100 grams of U-235 in the fissile experiment. At the same point of public access, the whole body dose in the first two hours following the release of fission products will be 184 mrem and the thyroid dose will be 99 mrem. The calculations are consistent to the extent that the off-site doses resulting from the melting of 100 grams of U-235 in an experiment are about 74% of the off-site doses resulting from the melting of 135 grams of U-235 fuel (100/135 = 0.74.) Thus the staff concludes that the off-site dose consequences are bounded by the previously-found acceptable DBA and therefore are acceptable to the staff.

The licensee states that "simultaneous occurrence of the DBA and failure of an in-core fissile material experiment are not considered credible because coolant channel blockage of both a fissile material experiment and a fuel element is extremely unlikely." There are no calculations to support this claim, but it should be remembered that the DBA is not an accident which is considered to be credible; the DBA only serves to provide a boundary for radiological consequences which exceed any accident considered to be credible. In effect, a coolant channel blockage of both a fissile material experiment and a fuel element would require two simultaneous DBAs. The staff finds that it is reasonable to assume that both the experiment and fuel elements will not fail simultaneously.

The licensee has proposed to create a new Technical Specification 6.7, "Experiments Involving In-Core Irradiation of Fissile Materials." In addition to imposing conditions on the physical structure of the experiment, the eight specifications in TS 6.7 include a limit on the amount of fissile material, a limit on the power generated from the fissile material, an automatic scram which provides over-temperature protection, and the sampling of fission products in the encapsulated experiment.

Imposing a limit on the amount of fissile material in the experiment results in a maximum fission product release from a failed experiment which is below that of the Design Basis Accident. Limiting the thermal power generated from the fissile material ensures that the Onset of Nulceate Boiling, with its attendant degrading effect on heat transfer capability, will not occur. The over-temperature scram, provided by thermocouples in the experiment encapsulation, will protect against degradation of the encapsulation. The weekly sampling of fission product gases will provide an indication of possible sample degradation. Each of these additional TSs provide confidence that a fissile materials experiment can be performed safely and are acceptable to the staff.

The current TS 6.1.7 reads as follows:

a. Experiments shall be designed so that operation or malfunction is not predicted to result in exposures or releases of radioactivity in excess of the limits of 10 CFR 20 to either onsite or offsite personnel.

b. The total radioactive materials inventory of an experiment or credibly coupled experiments shall be limited such that the dose in unrestricted areas resulting from release of this inventory at its calculated maximum value shall not exceed that of the Design Basis Accident (Section 5.3.1 of the SAR).

The proposed revision reads as follows:

a. Experiments shall be designed so that malfunctions and normal operations are not predicted to result in exposures in excess of the limits of 10 CFR 20 to either onsite or offsite personnel or in releases of radioactivity in excess of the 10 CFR 20 annual average concentration limits.

The proposed revision takes into account that the release of radioactive materials is limited by both the initiating event and its associated release path, whereas the current TS implies that the maximum radioactive inventory is released regardless of the initiating event and its release path. Credible releases take account of actual pathways (containment leakage, natural depletion within the containment, release from fuel to reactor coolant system) and are therefore less restrictive. The staff finds that it is reasonable to take actual pathways into consideration when calculating off-site doses.

The staff finds that the licensee's application provide acceptable assurance that the in-core irradiation of fissile materials can be performed with minimum additional risk to the public health and safety.

3.0 ENVIRONMENTAL CONSIDERATION

This amendment involves changes in the installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 or changes in inspection and surveillance requirements. The staff has determined that this amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released off site, and no significant increase in individual or cumulative occupational radiation exposure. Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared with the issuance of this amendment.

4.0 CONCLUSION

The staff has concluded, on the basis of the considerations discussed above, that (1) because the amendment does not involve a significant increase in the probability or consequences of accidents previously evaluated, or create the possibility of a new or different kind of accident from any accident previously evaluated, and does not involve a significant reduction in a margin of safety, the amendment does not involve a significant hazards consideration; (2) there is reasonable assurance that the health and safety of the public will not be endangered by the proposed changes; and (3) such changes are in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or the health and safety of the public.

Principal Contributor: Warren Eresian

Date: April 16, 2003