NUCLEAR REACTOR LABORATORY

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October 18, 2002

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

Subject: Response to TAC No. MB6255, License No. R-37, Docket No. 50-20

Dear Sir or Madam:

On November 21, 2001, the Massachusetts Institute of Technology submitted a request to amend its license for Technical Specification No. 6.7 – Experiments Involving In-Core Irradiation of Fissile Materials. On August 22, 2002, the Massachusetts Institute of Technology re-submitted the amendment request in its entirety. On September 25, 2002, the U.S. Nuclear Regulatory Commission sent a request for additional information. Enclosed is our response.

Please contact either of the undersigned should further information be required.

Sincerely,

Lin-Wen Hu, Ph.D.
Utilization Engineer

John A. Bernard, Ph.D.
Director

I declare under penalty of perjury that the foregoing is true and correct.
Executed 10/18/02 (Date)   Signature

cc: USNRC - Senior Project Manager
NRR/ONDD

USNRC - Region 1 – Project Scientist,
Effluents Radiation Protection Section (ERPS)
FRSSB/DRSS

A020

Reply to NRC Questions TAC No. MB6255

1. Refer to the paragraph on the top of page 3 of the Safety Review #0-01-11. In order for both events to occur, two foreign objects both of the correct size would have to be dropped into the core tank, be undetected, and cause simultaneous blockage of five coolant channels and the fissile materials irradiation facility. This is not considered credible

2. a) Thermocouples will be installed for temperature measurements Each fissile material experiment specimen will have more than one thermocouple installed to provide redundancy in case of a failure.

   b) A test and calibration requirement is added (TS# 6.7.6). The proposed wording now reads "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."

3. The instrument reading is recorded hourly by the reactor operator. Any trend that is indicative of a sustained increase is investigated. The 100 kcpm set point avoids false alarms caused by the carryover of water droplets from the core purge filtration system and at the same time provides a safety margin to the off-site dose EAL. The Abnormal Operating Procedure for a high radiation core purge alarm requires a reactor shutdown for a reading greater than 200 kcpm. 200 kcpm corresponds to an effluent concentration that is approximately 45% of the permissible level.

4. a) Yes. We do mean the values in Table 2, Column 1, Effluent Concentration in Air.

   b) The proposed wording for TS#6.1.7 is intended for both normal operation and accident conditions. The reactor's effluent concentrations are reported to NRC as annual averages. If a burst of radiation were released in an accident, the emergency operating procedures would be followed to determine the extent of the radiation release. Such an occurrence would be reported as outlined in 10 CFR 20.

5. a) The analysis of fission product gas releases was performed assuming a single failure because of defects of the barriers, not because of overheating of the fissile materials. Therefore, the primary coolant would provide a barrier for fission product particulate release and would trap most of the iodine. Note that this scenario is different from that of the DBA, which assumes coolant channel blockage and subsequent fuel melting.

   b) In the event that this pathway does result in an Iodine release, the maximum off-site dose to the thyroid would be less than the 99 mrem that has been calculated for the DBA because the amount of material in the experiment is less than the amount assumed in the DBA.

Page

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% $\Delta K/K$, fuel plate temperatures would be below the clad melting temperature and significant core damage would not result. The 0.2% $\Delta K/K$ 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% $\Delta K/K$ 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% $\Delta K/K$, 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 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 10 CFR 50.21(c) or 50.22 for research and development. A test facility is defined in 10 CFR 50.2 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 fuel 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 kilograms. This amount is significantly higher than that of natural uranium that contains 100 grams of U-235, 0.1 kgU-235×(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 gas inventory produced from a fissile materials irradiation 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 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.