

SAFETY EVALUATION REPORT

DOCKET NO: 70-938
LICENSE NO: SNM-986
LICENSEE: MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SUBJECT: LICENSE AMENDMENT REQUEST, LICENSE SNM-986
(DOCKET 07000938) (COST ACTIVITY CODE 000222/07000938)

BACKGROUND

Massachusetts Institute of Technology (MIT) possesses a license to use Special Nuclear Materials (SNM) for research and training at various campus locations. The SNM and source material is only used at the following locations: the MIT Campus, Cambridge, Massachusetts (MA) and the Bates Linear Accelerator, Middleton, MA. The Nuclear Reactor Laboratory (NRL) and other laboratories where material under this license is used are located on the main campus. The Bates Linear Accelerator is 20 miles north of Boston in Middleton, MA (Essex County). MIT describes its proposed uses of SNM as limited to research experiments and calibration of equipment, for example, using licensed material for instrument detector calibrations, to produce solid and liquid standards, and use of foils in experiments using the MIT Research Reactor (MITR).

On December 14, 2017 (Agencywide Documents Access and Management System [ADAMS] Accession Number ML17086A514), SNM-986 was renewed for a 10 year period. On March 25, 2016 (ADAMS ML16081A294), MIT submitted a timely filed application for renewal. The request was made pursuant to the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR), Section 70.33, "Applications for Renewal of Licenses," and 10 CFR Paragraph 70.38(a), "Expiration and Termination of Licenses." In the application, MIT committed to continued storage of a portion of the material on the license, including 2400 kilograms (kgs) of natural uranium. This was a continuation of a storage commitment from the previous renewal (ADAMS ML060090242). During the course of the recent renewal, there was a renewed interest in utilizing this material. On October 25, 2017 (ADAMS ML17300A001), MIT submitted a License Amendment Request (LAR) to reinstate the use of natural uranium, in the form of solid natural uranium rods, identified on the license under Item 6.H.

REGULATORY REQUIREMENTS

Section 70.34 of 10 CFR, "Amendment of Licenses," states that applications for amendment shall be filed in accordance with 10 CFR 70.21(a) and shall specify the respects in which the licensee desires his license to be amended.

Paragraph 70.22(a)(2) of 10 CFR, "Contents of Applications," states that each application for a license shall contain the activity for which the SNM is requested, and the general plan for carrying out the activity.

PROPOSED CHANGES

On October 25, 2017, MIT submitted a LAR to allow the use of 2515 kg of natural uranium in the MIT Graphite Exponential Pile (MGEP). The bulk of this material has previously been

designated for storage only. This Safety Evaluation Report documents the U.S. Nuclear Regulatory Commission staff's review of that amendment request. MIT also submitted a copy of their Agreement State License with the Commonwealth of Massachusetts, which was amended to accept 107 kgs of depleted uranium that has been listed on license SNM-986 (ADAMS ML17300A098).

DISCUSSION

In the renewal application submitted in 2016 (ADAMS ML16081A294), one of the material items in MIT's possession was 2,515 kgs of aluminum clad, natural uranium slugs. The application requested to use 115 kgs of this material in the MITR (R-37, Docket 05-0020) and at the Bates Linear Accelerator at Middleton, MA for shielding and radiation detector experiments. This was a continuation of usage from the previous renewal. Also continued was that the balance of 2,400 kgs of this material was to be designated for storage only. This was among several other materials designated for storage only.

Chapter 1.7 of the application, stated storage of material was only within the NRL or in the Blanket Test Vault. Regarding the 2,400 kgs of natural uranium, Chapter 16.1.2 of the application stated the material would be stored in either the MGEP or in the vault. The MGEP resides within the restricted area of the NRL. Other than an annual inventory, for the purposes of reporting to the Nuclear Material Management Safeguards System (NMMSS), this material would not be used. During the course of license renewal, a renewed interest in using these materials in the nuclear engineering curriculum arose, resulting in the LAR. There is no request to change the location of use of these materials; only that they can be utilized in neutronic studies in the MGEP, within the confines of the NRL. The MGEP will be used to supplement reactor physics education and to perform fundamental reactor physics research.

The proposed amendment would permit the full 2515 kgs of natural uranium to be used at the MGEP within the MIT Reactor facility for experimental studies. The materials subject to this amendment request consist of 1288 natural uranium metal slugs that are just over 1.0875 inches diameter and 8.375 inches long. The MGEP was built in 1957 and is a 30 ton stack of nuclear grade graphite blocks that is approximately a 12 foot box with holes for material insertion. The slugs will be placed into the array of holes, with up to 10 slugs per hole. This pile of graphite blocks, together with the natural uranium slugs, forms the MGEP.

To support the amendment, MIT submitted a summary description of the facility and the results of its criticality analysis, as well as a discussion of radiological safety, fire safety, and security. The submittal included MIT-NRL-17-02, "Criticality Safety Study and Radiological Dose Analysis for MIT Graphite Exponential Pile (MGEP)," Rev. 3, dated September 2017 (ADAMS ML17300A004); and MIT-NRL-16-04, "Criticality Study for Storage of Natural Uranium Fuel Slugs in the Exponential Graphite Pile," Rev. 1, dated September 2016 (ADAMS ML17300A003). These include descriptions of calculations performed using the MCNP5 code with the ENDF/B-VII.0 continuous energy cross section library. The licensee's analyses modeled the graphite pile containing up to 1440 slugs (this is in excess of what is possessed) in the pile (10 slugs in each of the 144 holes in the 12 foot by 12 foot array), both fully flooded by ordinary water and flooded with up to 50 cm above ground by heavy water. The licensee also modeled arrays of the slugs being stored outside the MGEP while flooded by ordinary and heavy water.

Within the pile, the natural uranium slugs are moderated by approximately 30 tons of nuclear grade graphite. A neutron-generating source can be inserted in two positions within the MGEP; at the pedestal, or bottom, and at the center of the pile. MIT performed a dose rate analysis using the MCNP addressed above, which modeled with a Californium-252 reference source of approximately 11 millicuries (mCi). The neutron emission rate for a source of this activity is 5×10^7 neutrons per second (n/s) and projects a dose rate of less than 20 milliRem per hour (mRem/hr) from any surface of the MGEP. This represents a radiation area, as defined by 10 CFR 20.1003. For the use of the MGEP described in the LAR, MIT will use a Plutonium-Beryllium (PuBe) source of 1 Curie (Ci) activity.

FINDINGS

The staff noted that the licensee's calculations are very conservative, in modeling a quantity of uranium (1440 slugs) exceeding the total inventory (1288 slugs), and in modeling the MGEP, flooded with either ordinary or heavy water. Natural uranium is considered source material, not SNM, and cannot be made critical with only light-water moderation. In the case of heavy water, the amount included would exceed the total inventory stored in multiple drums. The licensee has a limited quantity of heavy water, which is stored in 50-gallon drums. If all the heavy water drums were to leak, the total volume released would not be sufficient to flood the room to 50 cm deep. Therefore, the conditions modeled are not physically possible to achieve.

While it is possible to achieve criticality for natural uranium with either graphite or heavy water moderation, the MGEP has a fixed configuration that is designed to remain subcritical. Even with these very conservative assumptions, the licensee's calculations resulted in k_{eff} values substantially less than the license limit of 0.9. The addition of ordinary or heavy water to the MGEP array only resulted in a slight increase in k_{eff} , with the maximum not exceeding a k_{eff} of 0.86. The staff performed a bounding confirmatory analysis that produced results a few percent higher than the licensee's, but still demonstrably conservative. Storage outside the MGEP produced slightly higher, but still subcritical results.

The slugs consist of cylinders of solid metal, impervious to liquids. The MGEP itself contains a series of holes for storage of the slugs, which makes it free-draining. Even if liquids could be held up in the MGEP, the size of the slugs and holes is such that there is little available space for water. Based on the fact that the material consists of natural uranium metal, the limited quantities of heavy water, and the configuration of the graphite pile, and considering the very conservative modeling assumptions in the licensee's analysis, the staff has reasonable assurance that the material will be handled safely and will remain safely subcritical under normal and credible abnormal conditions.

Any operational conditions beyond those outlined in the LAR shall require a documented criticality safety analysis and be reviewed and approved by the Massachusetts Institute of Technology – Reactor Safeguards Committee. In addition to the Criticality Officer (CO), at least one individual must be qualified in nuclear criticality safety and must be involved in evaluating operational changes that could affect criticality safety of licensed material. Section 4.1.2 of the renewal application places all SNM within the restricted area under the authority of the CO, and states that in the event of a disagreement with a Principal Investigator (PI), the more conservative guidance will be followed. The material use requested in this LAR is limited to the NRL and any operational conditions beyond those outlined in this LAR should be reviewed with staff for consideration of license amendment.

The use of a one Ci PuBe source for use within the MGEP for the purposes described will generate a radiation field. This source will generate significantly less neutrons (1.2×10^6 n/s) than the Californium source, which would mean a substantially smaller dose rate field than evaluated using the Cf-252 reference source, but would remain treated as a radiation area. The restricted area where the MGEP is located is posted "Caution Radioactive Materials" area. Whenever the MGEP will be used for experiments, a radiation survey will be performed by the Reactor Radiation Protection Program Staff to determine the required regulatory posting. The area will be isolated with the use of a barrier and the "Caution Radiation Area" posting will be posted at the boundary (area at which levels are below 5 millirem per hour). Since reactor staff control the use of the neutron sources, the area will be posted when the neutron source is delivered and placed in the graphite pile. The area will be de-posted when the source is retrieved and placed back into storage. Whenever a source is inserted into the pile, in either position, MIT commits to proper postings and barriers. The use of any neutron source must be under the supervision of the Reactor Radiation Protection Staff.

As a restricted area, students will be supervised at all times. Unescorted access is granted only following fingerprinting and Federal Bureau of Investigation criminal history validation, as well as completion of radiation safety training. MIT has committed to a two-person rule for any unsupervised use of the MGEP. Access to the MGEP is limited by the placement of a secure metal shroud which will be in place whenever the MGEP is unattended. Any experimental procedures requiring the insertion or removal of the uranium slugs can only be conducted under direct supervision of a PI. Any natural uranium slugs not in the MGEP or in the BTF Vault may be stored in the locked B-12 Utility Box adjacent to the MGEP (within the NRL).

The request to use these materials, as described by the LAR, do not affect the fixed site physical protection requirements, as evaluated during the recent license renewal. There is no change in location or storage of these materials. The physical security requirements of 10 CFR 73.67(f) are applicable to MIT because of the amount of material they are authorized to possess in materials license SNM-986. The NRC staff finds the Plan meets the requirement of 10 CFR 73.67(f)(1), to store or use the material only within a controlled access area.

ENVIRONMENTAL REVIEW

MIT uses its license for research and development and for educational purposes. Pursuant to 10 CFR Paragraph 51.22(c)(14)(v), the issuance of amendments to licenses for materials licenses issued under 10 CFR Part 70 (among others) for research and development and for educational purposes is a category of actions which the NRC has determined does not individually or cumulatively have a significant effect on the human environment and thus, no environmental assessment or environmental impact is required, provided that:

- (i) There is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite.
- (ii) There is no significant increase in individual or cumulative occupational radiation exposure.
- (iii) There is no significant construction impact.
- (iv) There is no significant increase in the potential for or consequences from radiological accidents.

There are no effluents or offsite releases or significant increase in radiation exposure to workers or members of the public associated with this request. Therefore, pursuant to 10 CFR 51.22(c)(14)(v), no environmental impact statement or environmental assessment need be prepared in connection with the approval of this LAR. For the reasons described above, MIT's request meets the criteria for a 10 CFR 51.22(c)(14)(v) categorical exclusion.

CONCLUSIONS

Based on the form and nature of the material and limited quantity and configuration of special moderator (heavy water and graphite), the staff has reasonable assurance that the 2,515 kgs of natural uranium will remain safely subcritical under normal and credible abnormal conditions at the MGEP. The staff therefore recommends approval of the proposed amendment. The license will also be amended to delete depleted uranium from SNM-986, as it has been added to License Number 60-0094, Docket Number 14-2647, the Agreement State License possessed by MIT with the Commonwealth Of Massachusetts.

The NRC staff reviewed the licensee's amendment request as submitted on October 25, 2017. The NRC staff concludes that the information and regulatory commitments provided by MIT in their license application provide reasonable assurance of adequate safety for the proposed material use and that this will not have an adverse impact on the public health and safety, the common defense and security, or the environment; and meet the applicable requirements in 10 CFR Parts 19, 20, 36, 51, 70, 73, and 74.

RECOMMENDATION

The NRC staff recommends that the amendment request for reinstatement of utilization of Item 6.H to be used as described. Also, the staff recommends the deletion of Item 6.I from SNM-986, as it has been appropriately added to the state license.

Principal Contributors:

Christopher S. Tripp
Tyrone D. Naquin