DOCKET: 70-113

LICENSEE: PENNSYLVANIA STATE UNIVERSITY

SUBJECT: SAFETY EVALUATION REPORT: SUBMITTAL DATED, AMENDMENT TO ADD ISOTOPES OF PLUTONIUM TO THE POSSESSION LIMITS (TAC L33189)

BACKGROUND

By cover letter dated October 13, 2011 (Ref. 1), Pennsylvania State University (PSU) submitted an application to amend special nuclear materials license SNM-95 to add isotopes of plutonium to the possession limits. Radioisotopes from spent fuel (SF), amounting to 600 microCuries (µCi), in a liquid or non-dispersible solid state, are to be used for the purposes of research and development and instructing students.

In the amendment request (Ref. 1), only the plutonium isotopes of the SF materials were listed in Item 5, "Radioactive Material to be Added to License", of the U.S. Nuclear Regulatory Commission's (NRC's) Form 313, "Application for a Materials License." The remaining byproduct radionuclides of the SF, constituting about 85 percent of the radioactivity, were listed separately under Item 6, "Purpose for Which Material Will Be Used"; these radionuclides were on a State license that was issued by the State of Pennsylvania. Title 10 of the *Code of Federal Regulations* (10 CFR) Part 8.4(f) states, in providing for the discontinuance of some of the Federal regulatory authority over source, byproduct, and SNM in states which are Agreement States, there should be no "dual regulation" with respect to those materials for the purpose of protection of the public health and safety from radiation hazards. Thus, when material regulated by the NRC is integrally mixed with Agreement State regulated material, as the SF materials exist, the NRC must regulate the mixture in its entirety until the materials are separated, which in regards to the SF materials, will not be done by the licensee. Because the SNM and byproduct materials are co-mingled in the SF materials; the byproduct materials must be on the NRC's SNM license and regulated by NRC.

The NRC staff questioned the need for an NRC license because the quantities of SNM are close to the threshold of a critical mass under 10 CFR Part 150. When the formula quantities in § 150.10 and § 150.11 are exceeded, then NRC must regulate all of the SNM possessed by the licensee. Thus, by the "unity rule" in § 150.11, given the SNM gram quantities of the possession limits, if Equation (1) is greater than unity, the SNM should be under an NRC license; if less than or equal to unity, the quantities should be under that State license.

$$\left[\frac{g_{U235}}{350g}\right] + \left[\frac{g_{U233}}{200g}\right] + \left[\frac{g_{Pu}}{200g}\right] = X \qquad (1)$$

Solving Equation 1 for *X* yields a value of 1.29. Thus, the additional materials (both the SNM and byproduct materials) should be added to the existing NRC SNM license.

The NRC informed both the State and the licensee by telephone. The State agreed to remove the byproduct materials from the State license. The licensee supplemented the application as

Reference 2, specifying the quantities of byproduct material. Thus, the license application (LA) consists of both Reference 1 and Reference 2.

RADIATION SAFETY

Multiple SF samples will be received and subdivided prior to analysis. The licensee will handle the material in a laboratory setting.

While the majority of activity is due to byproduct materials, which primarily pose an external exposure hazard, approximately 15 percent of the activity is due to transuranic radioisotopes, which primarily pose an internal exposure hazard. The SNM-95 license already includes isotopes of plutonium and the licensee also has a radiation protection program that addresses these materials. The NRC staff reviewed the license and found that many of the concerns relative to the safe use of the SF materials had already been addressed. The NRC staff focused on the remaining relevant issues, such as the security of the SF samples, contamination control practices, waste management, training of personnel for the unique hazards that may be encountered, and facilities and procedures to minimize any spills or airborne contamination during handling.

Direct Radiation Hazards

The NRC staff evaluated the possible external hazard of the entire inventory of SF material (SF inventory) requested in the LA. Using the dose conversion factors in Reference 3, the NRC staff determined that the maximum external dose rates from the SF inventory (600 µCi) would be approximately 250 mrem/h at contact, and less than 0.1 mrem/h at 1 meter. The licensee proposes to work with samples of the inventory, consisting of 0.1 µCi to 10 µCi in up to 20 milliliters (mL) of 0.1 M to 0.5M nitric acid. Dose rates associated with a single SF sample are be expected to be significantly less (less than or equal to 5 mrem/h on contact and 0.002 mrem/h at 1 meter).

The NRC staff concludes that the external radiation hazards associated with the SF inventory to be manageable because a person would have to work with the SF inventory, not just a single SF sample, for more than 1,000 hours in a year to exceed the monitoring thresholds for external dose or to exceed the public dose limit.

Internal Hazard

Based on the Annual Limits of Intake (ALI) in Appendix B of 10 CFR Part 20, the NRC staff estimates that the total inventory of materials comprises approximately 6,200 ALI for inhalation or 52 ALI for ingestion. The potential for intentional or accidental ingestion of a SF sample is low, given established laboratory practices. The risk of inhalation is considered credible in that a spill during handling could occur that would result in airborne contamination. Based on the airborne release fractions and respirable fractions in Reference 4, the probable maximum dose resulting from spilling the contents of one SF sample container would be no more than 11 mrem. A dose of 620 mrem was estimated for the unlikely event of a spill involving the SF inventory (multiple samples). The NRC staff concluded that any internal dose is significantly below the monitoring thresholds for occupational workers or public dose limit due to the small quantities of materials involved and established laboratory practices.

The NRC staff concludes that the limited quantities of radioactive materials in the SF inventory limit the potential hazards and personnel doses to manageable levels.

Controls for Personnel Exposure

Personnel monitoring is not anticipated to be required by the licensee for people handling the SF materials or samples. Regardless, radiation workers at the Radiation Science and Engineering Center (RSEC), where the material will be used, are required to wear external monitoring dosimeters that measure gamma and beta dose supplied by a vendor with current National Voluntary Laboratory Accreditation Program accreditation. Consistent with Reference 5, the licensee does not need to evaluate regular room air sampling and monitoring for internal occupational radiation exposure because researchers will not handle dispersible radioactive materials in quantities that total more than 10,000 ALIs annually for inhalation.

Should an incident occur that potentially results in airborne contamination, research will be halted until corrective actions are implemented and procedures revised to prevent recurrence. Nose swabs will be taken to determine if there was a potential uptake of radioactive material. If an uptake is suspected, urine and fecal samples will be obtained, and sent to an outside certified laboratory for analysis to determine internal exposure. No airborne radioactive material areas are expected from the handling of the SF materials.

When not in a sealed container, SF samples will be handled over plastic-backed absorbent paper (bench paper) in an effluent hood or glove box whenever the materials are not in a sealed container. Researchers will wear gloves, lab coat, and eye protection whenever working with uncontained SF samples. The use of uncontained SF samples will occur in an area without other individuals present who are not involved with aspects of the research. Access to rooms where the materials will be handled will be controlled by the professor in charge of the research, consistent with the requirements in 10 CFR Part 20.1801. Work performed to manipulate the SF samples will be performed with dedicated equipment that will not be released for other projects until surveyed and decontaminated as necessary. Researchers will regularly survey themselves and the work area during use of the SF materials using a pancake Geiger-Mueller (GM) probe and 100 cm^2 alpha probe. SF samples will be placed into small robust containers and surveyed for contamination prior to analysis. When transported between the preparation room and the counting laboratory, the SF samples will be placed in a secure over-pack with suitable padding to prevent damage in the event that the container is dropped. Transporting the SF samples between buildings in a motor vehicle will occur in accordance with NRC and Department of Transportation (DOT) regulations.

Storage containers will be surveyed for contamination prior to being placed into storage and upon removal from storage. The SF samples will be secured from unauthorized access at all times by either surveillance, when in use, or by being locked in either a room or within a locked storage area when not in use. Similar high-impact resistant containers will be used as secondary containers when SF samples are transported between laboratories.

The NRC staff finds that the SF materials are of limited quantity and should not exceed personnel monitoring thresholds consistent with the licensee's plans for monitoring assuming normal laboratory practices. Also, the described actions, should radioactive materials be released, assures that uptakes by individuals will be adequately characterized. Adequate controls will be in place to assure the materials will be securely stored and utilized to minimize unintentional exposures to workers or the public.

The NRC staff finds that the licensee will maintain individual doses below regulatory limits consistent with Part 20.1201 and 1301.

The NRC staff finds that the doses will be monitored with surveys and dose calculations consistent with the requirements in Part 20.1204 and 1302 and the Survey and Monitoring requirements in 10 CFR Part 20, Subpart F.

The NRC staff finds the applicant's commitments regarding personnel exposure are sufficient to meet the regulatory requirements, and are, therefore, acceptable.

Contamination Control

Research using unsealed dispersible materials will be performed in an effluent hood or glove box. Hoods are operated at greater than 80 feet per minute face velocity or else removed from service. Individuals verify proper air flow direction and approximate air flow rate prior to each use. Glove boxes are operated at a negative pressure relative to the ambient environment when in use. The negative pressure is verified prior to each use of the device and periodically during operation. All work handling uncontained materials will be performed over bench paper to inhibit spillage and facilitate cleaning of any inadvertently spilled material.

License conditions in SNM-95 state that hands, feet, and clothing shall be monitored when leaving an area where the SF materials will be used, and personnel shall not exit an area if personal clothing or skin is contaminated above background levels except with approval of the University's Health Physicist (HP). Surface contamination surveys in laboratories shall be conducted daily when un-encapsulated SNM is used (staff recommends this specific condition be modified to clarify it applies to the SF material as well). Routine radiation surveys shall be conducted monthly in areas where radioactive materials are used or stored.

Should contamination be identified, licensee procedures mandate that readily disposable materials be placed into the radioactive waste containers. Items not readily disposed will be decontaminated with commercially available cleaning solutions. Personnel who become contaminated will have the contaminated area washed with tap water and the Radiation Safety Officer (RSO) notified. Strong soaps will be used to facilitate decontamination, if necessary, with care taken to not damage the skin.

Whenever radioactive contamination is found, the laboratory supervisor and RSO will be immediately notified and the area decontaminated and surveyed in a manner that is consistent with Reference 6. These guidelines are also utilized for release of materials from restricted areas to unrestricted areas. Objects being released are surveyed with a pancake GM detector and swipes taken and counted in a liquid scintillation counter.

Spills, if they occur, would be of small volume. The spill would be immediately covered with absorbent paper, then placed in radioactive waste containers. Decontamination will then proceed as described previously.

Based on the descriptions regarding contamination control, the NRC staff concludes that the licensee has acceptable contamination controls within an established radiation protection program, that fulfills, as applicable, the requirement for a radiation protection program in 10 CFR Part 20.1101. The use of engineered controls, such as hoods or glove boxes, to minimize the potential for airborne contamination meets the requirements in 10 CFR Part 20.1701. Contamination will be identified via surveys and monitored till adequately

addressed as required by 10 CFR Part 20.1501. NRC staff finds the applicant's commitments regarding contamination control are sufficient to assure the regulatory requirements will be met.

Waste Management

The licensee is expecting to receive the SF materials at concentrations that would qualify it as Class A waste when being disposed. Since there are no plans to further concentrate the SF material, the resulting waste will also be classified as Class A waste. Upon completing the research, all SF materials will be packaged into waste shipment containers in consultation with radioactive waste material vendors. Contaminated laboratory waste will be promptly dispatched in waste containers and transferred to the licensee's Environmental Health and Safety secure radioactive waste storage facility where it will eventually be shipped to a disposal facility in accordance with NRC and DOT requirements.

The licensee does not anticipate any airborne effluent treatment or monitoring for the SF samples, based on evaluations that releases will not exceed the constraint on air emissions in 10 CFR 20.1101(d). There are no liquid effluents anticipated from use of the SF samples; any spills will be of small volume (e.g., less than 20 ml) and would be contained using absorbing materials and eventually disposed of as solid waste. The NRC staff finds that the waste management plan for SF material meets the requirements of 10 CFR Part 20.2001.

Personnel Qualifications

The application provides information regarding specific individuals who will oversee the work. Each such person has extensive experience and qualifications.

The RSO is a Certified HP with 30 years of experience. Mr. Boeldt serves on the University's Isotopes Committee and reviews all applications for the use of radioactive material to ensure the proposed work will not be dangerous to personnel or the environment and is in conformance with regulations. He has overseen students working with 70 milliCurie (mCi) of uncontained high energy beta emitters; volatile and non-volatile photon emitters; the production of Curie quantities encapsulated solid, liquid, and gaseous beta/gamma emitters; and work with Curie quantity sealed sources.

Mark Linsley, the Associate HP and alternate RSO, is also a Certified HP with over 20 years of experience.

The primary Authorized User for this project is Kenan Unlu, PhD. Dr. Unlu is a professor of nuclear engineering and has been authorized to supervise use of radioactive material for the past 8 years and has 30 years of overall experience working with radioactive material. He has supervised use of unsealed radioactive materials in a laboratory setting in mCi amounts of beta and photon emitters.

Dr. Amanda Johnsen will provide direct oversight of use of the SF materials. Dr. Johnsen has over 8 years of experience working in radiological facilities at national laboratories with up to gram quantities of actinides.

Individuals who will be using the SF material are in the College of Engineering or the College of Earth and Mineral Sciences.

Health Physics personnel are not associated with the group overseeing the project, but nonetheless have authority to stop work with radioactive material that is viewed as inappropriate, dangerous, or contrary to regulations. If work is stopped, only the University Isotopes Committee, in consultation with the RSO, can reauthorize continuation of work with radioactive materials.

The NRC staff finds that the licensee has both experienced individuals with adequate work experience in the field of health physics overseeing the use of the SF samples, and a radiation protection program, thus, meeting the requirements in 10 CFR Part 70.23(a)(2).

The NRC staff finds the applicant's commitments meet the regulatory requirements for personnel qualifications.

Training

Each person working with the SF material will have completed the licensee's standard training that is provided to all users of radioactive material. In addition, persons using the SF material receive individual hands-on training by the RSO or Associate HP on handling and surveying techniques. Dry runs, without the SF material, will be done until the RSO is satisfied that the SF material can be safely handled.

The licensee has a training program, approved by the University Isotopes Committee and the RSO, for employees and students that complies with 10 CFR Part 19 and Part 20. All individuals who, in the course of employment, are likely to receive in a year an occupational dose in excess of 100 mrem, receive instruction in accordance with 10 CFR Part 19.12. Individuals who work with radioactive material receive training by HP personnel that informs users of the risk of using radioactive material (e.g., hazards, techniques to reduce exposures, regulations, repercussions of violations, etc.). Individuals working with the SF material will receive additional instruction, by the RSO or Associate HP, covering, at a minimum, the following topics:

- specific locations where material may be used
- requirement to adhere to approved procedures
- postings and labeling
- security
- access and egress controls
- receipt of the SF material
- inventory control and documentation
- annual limits of intake of these materials
- specific dangers for ingestion or inhalation
- specific radiation hazards, exposure limits, and health risks, specific to this material
- transporting material between authorized laboratories and buildings
- procedures allowed during use of this material
- personal protective equipment (PPE)
- special precautions to use while handling the material
- where to position the hood sash while working with radioactive material
- radiation detection meter selection and operation
- measuring applicable radiation levels
- measuring contamination levels with and alpha probes
- techniques for surveying personnel and the laboratory facility

- spill or other emergency response,
- who to contact in case of an emergency,
- how to contact spill/emergency responders,
- contamination control and contamination limits,
- decontamination processes and techniques,
- waste handling requirements for this material,
- effluent hood operation and operational check,
- glove box techniques and operational check (if applicable), and the
- public relations aspects of working with this material.

No individual will work with the SF material until they demonstrate to the RSO or Associate HP an ability to safely handle the material, perform comprehensive surveys after use, and demonstrate decontamination processes. The demonstration follows the standard procedure established by the University Isotopes Committee for work with amounts or types of radioactive material more hazardous than is typical. Documentation of the training will be retained. Individuals receive refresher training at least every 2 years.

The staff finds that the qualifications and training of personnel that will oversee or use the SF material are sufficient to assure the requirements in 10 CFR Part 19.12 and 10 CFR Part 70.23(a)(2) are met, and are, therefore, acceptable.

CHEMICAL SAFETY

By the Standard Review Plan (Ref. 7), the review of chemical safety is in terms of meeting the performance requirements of § 70.61. According to § 70.60, Subpart H of Part 70 does not apply to the licensee. The NRC staff reviewed chemical safety from the perspective of affecting items that contain the SF samples or mitigate accidental spills.

The liquid SF samples consist of minute quantities (1 mL to 20 mL) of radionuclides dissolved in 0.1M to 0.5M nitric acid. This concentration of acid is low enough so as not to pose any unusual safety hazards, such as fuming or dissolving of bench paper that would inhibiting spills. Nitric acid, in the same concentrations, is routinely used in university laboratories.

Radioactive material will be stored in high strength screw-top containers and will not be susceptible to chemical degradation. Representative SF samples of containers will be tested for ease of handling, leak tightness, chemical susceptibility, and mechanical strength by the researcher and RSO prior to use. When the containers are used as secondary (over-pack) containers rather than primary containers, the inner container will be a leak-tight container that will not react chemically with the radioactive material and the inner container.

The NRC staff finds that the chemical makeup of the SF samples to not pose a safety hazard.

ENVIRONMENTAL REVIEW

The staff has determined that amendment of SNM-95 belongs to a category of actions which the Commission has declared to be a categorical exclusion after first finding that the category of actions does not individually or cumulatively have a significant effect on the human environment. The regulation at 10 CFR 51.22(c)(14) allows for a categorical exclusion for amendment of materials licenses issued pursuant to 10 CFR Part 70 authorizing use of radioactive materials for research and development and for educational purposes.

Title 10 CFR 70.4 defines research and development as (1) theoretical analysis, exploration, or experimentation, or (2) the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes—including the experimental production and testing of models, devices, equipment, materials, and processes. The SNM authorized to be possessed and used by this license amendment is to be used for the conduct of research and development activities specified in Section 31 of the Atomic Energy Act.

The action of amending SNM-95 license is eligible for categorical exclusion. Therefore, in accordance with 10 CFR 51.22(c)(14), neither an Environmental Assessment nor an Environmental Impact Statement is required for this action.

FINDINGS

Based on the NRC staff's evaluation of the hazards and program elements in place at PSU, the NRC staff finds that the facilities and procedures are reasonable for possession and use of the requested quantities of spent fuel in accordance with 10 CFR 70.23(a)(3) and (4).

For the purpose of clarification, the NRC staff recommends a modification to License Condition 15 as follows:

> Surface contamination surveys in laboratories shall be conducted daily when un-encapsulated SNM or spent fuel is used. Routine radiation surveys shall be conducted monthly in areas where radioactive materials are used and/or stored.

CONCLUSION

Upon review of the LA, the NRC staff concludes that the changes are consistent with applicable regulatory requirements. Accordingly, approval of the amendment request is recommended.

REFERENCES

1. Letter from Henry C. Foley, Pennsylvania State University, Application to Amend Special Nuclear Materials License SNM-95, October 13, 2011, (Agencywide Documents Access and Management System [ADAMS]) Accession Number ML11294A215.

2. Letter from Eric Boeldt, Supplemental information for license amendment Submitted October 13, 2011," ADAMS Accession Number ML12059A097.

3. D. Delacroix, et al., Radiation Protection Dosimetery: Radionuclide and Radiation Protection Data Handbook, Vol. 98, No. 1. 2002. Nuclear Technology Publishing, P.O. Box 7, Ashford, Kent, TN2 1 YW, England.

4. U.S. Department of Energy, "Airborne Release Fractions/Rates and Respirable Fractions For Nonreactor Nuclear Facilities," Vol. 1, "Analysis of Experimental Data," DOE-HDBK-3010-94. December 1994.

5. U.S. Nuclear Regulatory Commission, "Air Sampling In The Workplace," Regulatory Guide 8.25, Revision 1, June 1992.

6. U.S. NRC, Branch Technical Position “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,” April 1993.

7. U.S. NRC, “Standard Review Plan,” NUREG-1520, Rev. 1. May, 2010.

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