PennState

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US Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

March 26, 2019

Re: License Amendment Request, License R-2, Docket 50-005

To Whom It May Concern,

Dear Sir / Madame:

Attached pleased find a request for amendment of the Penn State Breazeale Reactor operating license, no. R-2. This amendment will support important research involving the irradiation of very small quantities of 233U and 235U enriched up to 100%. While the reactor Technical Specifications include a limit on radioiodine production, the wording of the existing license does not provide for the irradiation of fissile materials, except in several specific forms. Therefore, a change in the wording of the license is requested, but the Technical Specifications are unaffected by this request and will not be revised. This request discusses considerations regarding radiation protection, physical security, and emergency planning.

Please be aware that this license amendment request is necessary for the support of a research project that is already funded, and is the first year of a three year period of performance. Therefore we request that this request be expedited to the extent possible.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 3/28/19

Sincerely,

Neil A. Sharkey
Vice President for Research

Signed and sworn to before me on March 28, 2019
by Neil A. Sharkey

Angelita Kay Johnson
Notary
My commission expires: 7/18/21

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Angelita Kay Johnson, Notary Public
State College Boro, Centre County
My Commission Expires July 18, 2021

cc (electronic) William Kennedy (NRC)
Stephen Lynch (NRC)
Xiaosong Yin (NRC)

Attachments

Proposed license as amended, markup copy
Proposed license as amended, clean copy

A020
NRR

RADIOACTIVE MATERIAL TO BE ADDED TO LICENSE

Element and mass numbers:

- Uranium-233 up to 1 g (9.64 mCi)
- Uranium-235 up to 1 g (2.16 uCi)

Physical form: The uranium isotopes will arrive as liquid or solid.

Chemical form: The radioactive material may be used in a number of chemical forms, including solids (e.g. oxides, hydroxides, nitrates) and liquids (e.g. dissolved in mineral acids or organic solvents).

Maximum amount to be possessed: 9.64 mCi of uranium-233 and 2.16 uCi of uranium-235.

The concentration of the material received will be below the level classified as Class A waste in accordance with 10CFR61.55.

This minor addition to The Pennsylvania State University's (PSU) allowed inventory will have no effect on the funds necessary for decommissioning. The Class A waste generated by this project will be an insignificant increase in the cost of radioactive waste generated annually under this and other PSU licenses.

PURPOSE FOR WHICH MATERIAL WILL BE USED

Licensed radioactive material at PSU is used for research and development, as defined in 10CFR70.4, and for instruction of students. The purpose of this particular amendment is to enable researchers at PSU to use up to one gram of uranium-233 and up to one gram of uranium-235 in experiments, to include the irradiation of such material in the PSU Breazeale Reactor; the irradiation of such materials with PSU's two neutron generators; chemical and radiation counting analyses of such materials; and alteration of the chemical form of the uranium materials.

The impetus behind this amendment is the increasing requests from research faculty at PSU to use these materials in experimental projects. As representative cases of the type of research that could be carried out with these materials, we provide two examples below. The first example below is an already-funded research project from the Defense Threat Reduction Agency (DTRA) to two PSU faculty members. The second example is a project that has been proposed to the Department of Energy's Nuclear Energy University Program by a group of seven PSU faculty members.

1. Detection and Characterization of Short-Lived Fission Fragments for Post-Detonation Analysis with Continuous and Monoenergetic Fast-Neutron Beams: The researchers propose to characterize a wide range of short-lived fission fragments with half-lives between approximately one second and several hours by using cyclic neutron activation analysis (CNAA) to support DTRA's research and development efforts for pre- and post-detonation nuclear forensics. They also propose to use traditional neutron activation analysis (NAA) in conjunction with tailored radiochemistry procedures for fission fragments with half-lives up to several days. Specifically, we will use monoenergetic 14-MeV and fast-neutron spectrum (~MeV) to measure independent and cumulative fission yields of short-lived fission products (FPs) from fissile and fissionable actinides to enhance precision and expediency of pre- and post-detonation nuclear-forensics non-destructive analyses. These fundamental parameters are poorly known for many FPs, especially for short-lived FPs. As a result, the measurement precision of pre- and post-detonation analyses based on detection of neutrons and gammas emitted from a sample is substantially limited. To mitigate this problem, the time-dependent delayed neutron and gamma intensities from short-lived FPs will be measured using neutron detectors and high-resolution gamma spectrometers operating in coincidence. The Pennsylvania State Breazeale Reactor (PSBR) and PNNL's Thermo-Scientific D711 deuterium-tritium (D-T) 14-MeV neutron generator will be used to induce fissions in various actinides of interest, namely Th-232, U-233, U-235, U-238, and Am-241. The PSBR's fast-neutron irradiator (FNI) provides a neutron spectrum similar to that expected from a nuclear weapon, thus providing a unique capability for these measurements. Tailored radiochemical separation will be used to isolate problematic isotopes such as Ba-139, Ce-143, Rh-105, Pr-145, and Pm-151 with weak or low-energy gamma signatures for accurate quantification. The use of radiochemistry combined with the fission-weapon-like neutron spectrum of the PSBR's FNI provides the unique opportunity to more precisely determine FP data for a realistic neutron spectrum. The final outcome of the project will be the independent and cumulative fission yields of nominally 70 short-lived FPs from each target actinide, including Zr-99, Se-86, As-85, Kr-92, and La-146, to allow for more accurate, robust, and expedient pre- and post-detonation non-destructive analyses. Measurements obtained during the course of this work will be compared with the Evaluated Nuclear Data Files (ENDF), the Joint Evaluated Fission/Fusion Files (JEFF), and theoretical nuclear-physics models.

2. Development and Testing of a Micro-scale Molten Salt Fuel Irradiation and Examination Capability: This project will develop and test an apparatus and experimental system for the irradiation and examination of small-scale quantities of molten salt fuel. Post-irradiation examination (PIE) of small quantities of salt can still yield important transport and speciation information while greatly decreasing the salt radioactivity, and thus the difficulty and cost, of PIE. This project will require development of a low-activation furnace that can fit in a large irradiation dry tube facility at the research reactor and be capable of maintaining salt capsules at temperatures of up to ~700°C in a test reactor environment. The capability we develop will be applicable to a variety of thermal and fast spectrum salt reactor concepts. We will demonstrate the experimental system by irradiating various chloride salt compositions (fueled and unfueled) of interest to the Industrial Partner's chloride salt fast reactor concept along with coupons of standard structural materials. The neutron flux of the irradiation will be approximately 9.0E11 n/cm2s above 0.1 MeV. We will develop an appropriate plan for PIE to determine corrosion and plating on the coupons, as well as volatile fission product formation. The setup will be tested at University 1's research reactor, and subsequent examination at the reactor's hot cell facilities. Further characterization will be done at University 2's chemistry and materials laboratory, which regularly performs microscopy and elemental analyses on radioactive samples. This project will develop and provide an initial demonstration of a capability applicable to a variety of salt compositions. The project will also provide a route to train the next generation of nuclear researchers with experience in handling and manipulating radioactive materials.

Because of the significant demand for the use of uranium-233 and uranium-235 in sub-gram quantities for projects like these, we are requesting a license amendment.

To ensure the safe and secure use of these materials, the general procedures for the use of this material are:

1. Uranium-233 and uranium-235 samples will be received from suppliers as non-dispersible solids or as liquids by EHS, surveyed as required by 10CFR20.1906, and the inner container surveyed for contamination. The material will be added to PSU's inventory and then transferred to the researcher in charge of the material.
2. Samples will be stored to prevent unauthorized access or removal.
3. The liquid samples may be subdivided into multiple samples prior to analysis. If performed, the equipment used will be promptly surveyed and decontaminated as necessary.
4. All work with uncontained radioactive material will be performed over absorbent bench paper with a plastic backing in an effluent hood or glove box. Researchers will wear laboratory coats, safety glasses, and gloves. The area where the work is performed will be surveyed for radioactive contamination after each use of the material.
5. After analysis, the samples will be securely stored until the research is complete.
6. Samples will then be disposed in accordance with 10CFR61 and waste vendor requirements.

RADIATION PROTECTION

At the end of this project, all equipment and facilities will be surveyed and decontaminated or released in accordance with "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," NRC, April 1993. This process is identical to closeouts of other laboratories that have used radioactive materials at other locations on campus. At PSU twenty to forty of these closeouts are performed each year. Equipment that cannot be decontaminated will be disposed as radioactive waste. Records required for decommissioning are retained as required by 10 CFR 70.25(g) in Environmental Health and Safety (EHS) offices in the Academic Projects Building. PSU's decommissioning cost estimate is updated every three years. If the situation warrants due to contamination issues, changes in the cost estimate will be made during the next scheduled review.

Individuals responsible for radiation safety program

PSU is committed to having qualified individuals in its radiation protection program. The Radiation Safety Officer (RSO) is Yuanqing Guo, Ph.D. Dr. Guo is a Certified Health Physicist with about thirty years of experience as a health physicist. Dr. Guo serves on the University Isotopes Committee and pre-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 is used as a resource for radiation safety by radiation workers. He is responsible for establishing and implementing the radiation protection program.

Dr. Guo has overseen students working with over 70 mCi of uncontained high energy beta emitters, volatile and non-volatile photon emitters, the production of curie quantities of encapsulated solid, liquid, and gaseous beta/gamma emitters, and work with curie quantities of sealed sources. Dr. Guo has not worked with plutonium, but has worked with uCi amounts of uncontained curium-244.

Aaron Wilmot, the Assistant Radiation Safety Officer and alternate RSO, is a Certified Health Physicist with thirteen years of experience in the radiation protection field. Mr. Wilmot will be assisting with the oversight of this project.

The primary Authorized Users for projects using these materials will typically be PSU faculty members and/or the director of the PSU Radiation Science and Engineering Center (RSEC). The current RSEC Directorsis Kenan Unlu, Ph.D., who is also a PSU Professor of Nuclear Engineering. He has been authorized to supervise use of radioactive material at PSU since 2004 and has had about 30 years 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.

The current faculty members who are associated with the awarded and proposed projects listed above are Dr. Marek Flaska and Dr. Amanda Johnsen. Dr. Flaska has almost two years of experience working with radioactive materials at the Oak Ridge and Idaho National Laboratories. The materials included a variety of gamma-ray sources for calibration and radiation-detector characterization, as well as various neutron sources such as Cf-252, Pu-Be, and Am-Be. In addition, Dr. Flaska spent 8 years at the University of Michigan where he worked, in addition to the aforementioned gamma-ray and neutron sources, with a D-T fusion neutron generator he was in charge of. Finally, he is currently at PSU where he spent last three years, again working with radioactive sources similar to those mentioned above. He also serves on the PSU University Isotopes Committee. Dr. Johnsen has over eight years of experience working in radiological facilities at national laboratories with up to gram quantities of actinides. She has worked with

actinide separations, stock solution purifications, inert atmosphere glove boxes, and has supervised research conducted in radiological hot cells. At PSU, she has over six years of experience irradiating materials in the PSU Breazeale Reactor, as well as performing radiochemical and other analyses on those materials. She also serves on the PSU University Isotopes Committee (see Item 10). To prevent any conflict of interest, she has and will continue to recuse herself from evaluating any authorizations that she has written or to which she has contributed.

Individuals who will be using the radioactive material described in this application are typically in the PSU College of Engineering or one of the other academic colleges. PSU Radiation Safety personnel are in the PSU Office of Physical Plant, which is completely independent from the academic colleges. All Health Physicists (HPs) have the authority, and duty, to stop any work with radioactive material which they view as inappropriate, dangerous, contrary to regulations, or contrary to PSU requirements. Only the University Isotopes Committee (UIC, Penn State's radiation safety committee), in consultation with the RSO, can reauthorize continuation of work with radioactive materials.

Training for individuals working with this material

Each person working with this radioactive material will have completed PSU's standard training which is provided to all users of radioactive material as described in this license. In addition, persons using this material will receive individual hands on training by the RSO or Assistant RSO on handling and surveying techniques. PSU has designed and implemented a training program for employees and students that complies with 10CFR19 and 20. This program has been approved by the University Isotopes Committee and the RSO.

All individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem will receive instruction in accordance with 10CFR19.12. In addition, all individuals who will work with radioactive material will receive prior training by PSU Radiation Safety personnel that covers the following topics: Nomenclature; Radioactivity and Radiation; Types of Radiation; Radiation Units; Background Radiation; Biological Effects of Radiation; Half-Life and Decay; Radiation Safety Protection Techniques; Radiation Surveys; Radiation Dose and Exposure; Radiation Dose Limits; ALARA Considerations; Dosimetry and Bioassays; Radioactive Material Authorizations and Ordering Radioactive Material; Radioactive Material Security; Radioactive Waste; University, State, and Federal Regulations; and Repercussions of Violations of Regulations. A passing grade of 70% is required on the exam.

Individuals working with the SNM discussed in this license amendment will also receive additional instruction specific to that material. This personal training will be provided by the RSO or Assistant RSO. It will cover at least the following topics:

- Specific locations where material may be used,
- Requirement to adhere to approved procedures while using the material,
- Postings and labeling required for this material,
- Security requirements of this radioactive material,
- Access and egress controls,
- Requirements for receipt of this material,
- Inventory control and documentation,
- Annual limits of intake of these materials,
- The specific dangers for ingestion or inhalation,
- 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) required whenever handling this material,
- 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 Geiger-Müller 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 this material until he/she physically demonstrates to the RSO or Assistant RSO the ability to safely handle this material, perform comprehensive surveys after use, and demonstrate decontamination processes. This demonstration follows the standard procedure established by the University Isotopes Committee for work with amounts or types of radioactive material more hazardous than the norm. Documentation of this training will be retained. Individuals working with this material will receive refresher training at least every two years. At that time the training program will be evaluated for its effectiveness and adequacy.

This material will be used at the Radiation Science and Engineering Center (RSEC) or the Academic Projects Building at University Park, PA 16802. The RSEC has many suitable laboratories available for using this amount of material. In the event that specialized equipment not available at the RSEC is needed to analyze the material, it will be used in a suitable laboratory at University Park, PA approved by the Radiation Safety Officer (RSO). Any laboratory approved will have equipment and facilities suitable for the needs of these tasks such as work benches, sinks, doors, available space for waste storage, secure space for sample storage, radiation detection meters to survey for contamination, bench paper, and personal protective materials and equipment. Although multiple suitable laboratories are available for this work the exact locations have not yet been determined and will be approved by the RSO prior to beginning work.

Work with this material in un-encapsulated form will be performed in an area without other individuals present who are not involved with aspects of this research. Researchers will wear laboratory coats, disposable gloves, and safety glasses whenever working with this uncontained material. Contamination detection equipment will be present and in use whenever this radioactive material is handled.

Work with uncontained radioactive material under this amendment will be performed over laboratory bench paper (absorbent paper with plastic backing) within an effluent hood or glove box. Work with sealed containers of this material will not require work within a hood or glove box after the container has been surveyed and found to have no external contamination. Effluent hoods and glove boxes will be

checked for operability prior to each use. Work performed to sub-sample or otherwise manipulate the material will be performed with dedicated equipment (pipets, syringes, holders, etc.) that will not be released for other projects until surveyed and decontaminated as necessary. The vials/containers holding the radioactive material for this procedure will be held in the equivalent of an appropriately sized test tube rack to ensure that the vials/containers cannot be accidentally knocked over.

In the event of contamination, personnel will follow PSU's standard procedures. PSU's procedure requires that readily disposable materials will be placed into the radioactive waste container. Items that are not readily disposable will be decontaminated with commercially available cleaning solutions that have been found to work with this sort of material. Products such as Scrubbing Bubbles, Formula 409, Fantastic, L.A. Awesome, or Lysol's Tile/Tub Cleaner have all been shown to be effective decontamination solutions in laboratory settings. The material is sprayed/foamed onto the contaminated area, wiped with disposable paper towels, resurveyed to detect beta/gamma emissions, allowed to dry, and resurveyed for alpha contamination.

Personal protective equipment that becomes contaminated will be disposed or decontaminated as is appropriate for the amount and type of contamination and the PPE that became contaminated. If skin, hair, or personal clothing become contaminated, personnel will follow PSU's standard procedures. The affected area is immediately blotted dry then washed with copious amounts of water and the RSO notified. If decontamination with tap water is not successful stronger soaps and decontamination materials will be used with special care taken to not damage the skin. Depending upon circumstances, the spill material may be neutralized. In the event of a liquid spill not onto absorbent paper, the spill will be immediately covered with absorbent paper to absorb as much liquid as possible. This material will then be placed in the radioactive waste containers and decontamination will proceed.

Whenever radioactive contamination is found, the laboratory supervisor and RSO will be immediately notified, and the area will be decontaminated and resurveyed in accordance with "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (NRC, 1993). If decontamination is not possible, the contaminated area or equipment will be disposed of or, with the permission of the RSO, the contamination will be encapsulated until the equipment is no longer needed. Equipment containing encapsulated radioactive material will be obviously labeled and inventoried in PSU's decommissioning plan until disposed.

When transported between the preparation room and the counting laboratory the material will be placed in a secure over-pack with suitable padding (e.g. paper towels or plastic bubble-wrap) to prevent damage in the event that the container is dropped. If the material needs to be transported by motor vehicle between buildings, the material will be transported in accordance with NRC and Department of Transportation (DOT) regulations.

PSU has policies to ensure that equipment and materials removed from restricted areas to unrestricted areas are not contaminated above the specified release levels in 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. Potentially contaminated objects for unrestricted use are surveyed to detect the presence of fixed or removable contamination prior to removal from the laboratory. Objects will be surveyed with a pancake GM and wipes will be taken to be counted in a liquid scintillation counter.

Access to the rooms where this radioactive material will be used is controlled by the professor in charge of the research. PSU Radiation Safety staff have access at all times. The room(s) will be posted for use of radioactive material in accordance with 10CFR20.1902. All radioactive material will be labeled in accordance with 10CFR20.1904 and University requirements. Areas in which uncontained radioactive material is used will be clearly demarcated with yellow "radioactive material" tape or signs. Radioactive waste will be placed in PSU's standard radioactive waste containers supplied by the Radiation Safety office. Containers for solid waste are 18 gallon metal cans double-lined with plastic bags. Liquid waste is normally stored in robust 10 liter plastic containers supplied by the Radiation Safety office. Solid and liquid containers have been used and reused many times in the last twenty-five years and there have been no reports of leaks regardless of the contents. Waste will always be secure from unauthorized removal or access. When a waste container is full, it is transferred to secure EHS radioactive material storage facilities in the Academic Projects Building in compliance with DOT and NRC regulations.

Radiation Safety Program

As stated in PSU's renewal application, use of all specifically licensed radioactive material at PSU is regulated by the University's radiation safety committee, called the University Isotopes Committee (UIC). All work with radioactive material must comply with the UIC approved "Rules and Procedures for the Use of Radioactive Material at the Pennsylvania State University." This document has been previously submitted to the NRC.

Equipment

Penn State's Environmental Health and Safety (EHS) office and the users of this material have numerous portable and stationary instruments to monitor radiation and contamination levels for this material. This equipment includes liquid scintillation counters, numerous pancake style Geiger-Müller meters, two 100 cm^2 ZnS(Ag) alpha probes, and numerous meters for measuring radiation levels.

Radiation Surveys

Radiation surveys are not necessary for the level of radioactive material requested under this amendment in order to comply with the requirements of 10CFR20, Subpart F. That said, radiation and contamination surveys are performed at least quarterly by EHS in all areas in which radioactive material has been in use since the last quarterly survey and audit. These audits check for radiation and contamination levels as well as looking for compliance with other NRC and PSU requirements. The meters used by EHS for radiation measurements are calibrated annually with a cesium-137 NIST traceable calibration source. Documentation of EHS surveys and calibrations are retained in accordance with 10CFR20.2103. Radiation and contamination surveys are performed in compliance with RSO approved written procedures.

Contamination Surveys

Contamination surveys are performed by PSU's researchers after each use of radioactive material. In addition, for the material in this license amendment, the researcher will survey sample containers prior to placing them in storage and immediately upon removal from storage. These surveys are the main method of identifying un-intentional releases, spills, and contamination.

The primary contamination detection equipment for this material during actual use will be a pancake style GM probe attached to a meter (the typical meter at Penn State is a Ludlum Model #3 with a Ludlum 44-9 probe). The meter and probe are sensitive to the alpha, beta, and gamma radiation which will be emitted

from this material. This meter/probe combination will be able to detect about 25 alpha dpm in the 12 cm square active area of the probe (about 180 alpha per minute in 100 square cm.). At completion of work with uncontained material, the area will also be surveyed with a 100 square centimeter open area alpha probe equivalent to Ludlum's model 43-90. This ZnS(Ag) probe has a 20% efficiency for Pu-239 alpha particles and a background rate of 0 - 3 counts per minute. The minimum detectable count rate for this meter will be about 10 - 20 counts per minute, which provides a minimum detectable activity (mda) of 50 - 100 alphas per minute per 100 square cm.

Contamination survey meters are calibrated to monitor the amount of contamination present in counts per minute. The operator is required to check the battery and the operability of each meter prior to each use with a small check source. Alpha meters are supplied with a small exempt alpha source for this calibration check. Operators will convert cpm to particles per minute based upon the calibration factor on the specific meter.

Additionally, after each use of un-contained material, researchers will use filter paper or cloth wipes to wipe an area of about 100 square centimeters. These wipes will be counted in a liquid scintillation counter. The LSC will have an efficiency of approximately 100% for all the radionuclides in this material and will have a minimum detectable activity of about 30 emissions per minute. Wipe samples will be obtained from work surface, equipment used, and the floor in the immediate vicinity. If the net contamination detected by the LSC is over about 200 cpm, the energy spectrum of the emissions will be able to determine if the contamination is alpha, beta, or photon emissions.

If contamination is found, the researcher will immediately contact EHS for assistance in decontamination and follow-up surveys. In areas where radioactive contamination is found, attempts will be made to decontaminate to background levels in accordance with standard PSU practice. If decontamination to background levels is not possible the area will be decontaminated in accordance with "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (NRC, April 1993) as discussed elsewhere in this application.

In the event of an unintentional release or spread of radioactive material, researchers are instructed to stop the spill, warn others in the area, contact the RSO, isolate the area, and minimize exposure and the spread of contamination. EHS will respond to aid in the cleanup and perform the post decontamination survey. Confirmatory contamination surveys and regulatory compliance audits are performed and documented quarterly by EHS staff wherever radioactive material has been used since the previous quarter. These surveys will utilize pancake GM and alpha probes. Additionally wipes will be taken for analysis in a liquid scintillation counter.

External Occupational Exposure

Personal external radiation monitoring is not necessary for the level of radioactive material requested under this amendment in order to comply with the requirements of 10CFR20.1502. If the situation warrants, monitoring will be performed to comply with 10CFR20.1502(a) utilizing gamma and beta detection dosimeters with current NVLAP accreditation. Radiation workers in the RSEC are issued, and required to wear, NVLAP accredited personal dosimeters (currently supplied by Landauer) while working with radioactive material. Dosimetry results are reviewed by the RSO, and maintained in the EHS offices. Radiation workers are notified if their results indicate they received more than 100 mrem in a quarter or year. Annual reports are made to individuals in accordance with 10CFR19.13(b). An investigation to

determine the cause of the exposure will be instigated whenever an individual exceeds 10% of the applicable annual limit in accordance with PSU's ALARA procedures.

Internal Occupational Exposure

As stated in Regulatory Guide 8.25 Section 1.1 (June 1992), Penn State will evaluate the need for regular room air sampling and monitoring for internal occupational radiation exposure when a researcher will handle dispersible radioactive materials in quantities that during a year will total more than 10,000 times the ALIs for inhalation (the sum of the fractions of the ALI's of each nuclide rule applies). If the need arises, Penn State will monitor the ambient air of radiation workers with personal breathing zone monitors. Air sampling equipment will be calibrated and maintained in accordance with manufacturer's instructions. No airborne radioactive material areas are expected from the use of this material.

If an incident occurs that potentially results in airborne contamination, the research will be immediately halted until corrective actions are implemented and procedures revised to prevent recurrence. If such an event occurs, nose swabs will be taken and analyzed to determine if there was a possibility of airborne contamination. If nose swabs indicate the presence of radioactive material, urine and fecal samples will be obtained to determine internal exposure. These samples will be sent to an outside certified laboratory for analysis.

No procedures have been prepared for summing internal and external exposures at PSU because both internal and external exposures are expected to be well below the requirements of 10CFR20.1202.

Effluent Air Monitoring

Effluent air monitoring is not planned for this situation. Exhaust from the effluent hood will be monitored if calculations indicate that releases may be in excess of the limits in *10CFR20* Appendix B or the constraint on air emissions found in 10CFR20.1101(d). Preliminary calculations indicate that PSU will be able to easily comply with this constraint.

Respiratory Protection Program

Penn State has no respiratory protection program for radioactive material use and will not use personal respirators for protection against airborne radioactive material. Work with this radioactive material will be performed in an effluent hood or glove box whenever the material is not in a sealed container.

Waste Management

At the completion of the research, waste products from the use of the uranium-233 and uranium-235 material will be packaged into waste shipment containers in consultation with radioactive waste material vendors.

Potentially contaminated laboratory waste (bench paper, pipet tips, gloves, etc.) will be promptly placed into radioactive waste containers. When filled, these containers will be transferred to the EHS secure radioactive waste storage facility in accordance with DOT regulations. This waste will be shipped for disposal in accordance with waste broker and NRC requirements.

The concentration of the material received will be below the level classified as Class A waste in accordance with 10CFR61.55. Since there are no plans of any sort to concentrate this material, the resulting waste will be classified as Class A waste.

Criticality Calculations

The amount of radioactive material available for use under this license is of forms and amounts to preclude the possibility of forming a critical mass. The addition of < 1 g uranium-233 and < 1 g uranium-235 has no significant effect on the potential for criticality with the material already authorized under this license.

Accident Analysis

The maximum likely accident is the complete dropping/spillage of one of the samples that we receive from the supplier. Each sample will have < 1 g of uranium-233 or < 1 g uranium-235.

Procedures and practices used to minimize the adverse impact of such a spillage are:

1. Procedures require that each sample will be surveyed before placing into storage and when removing from storage.
2. Procedures require that each sample is stored in an over-pack (secondary container) while being transported.
3. Procedures require that the researcher wear gloves, lab coat, and eye protection whenever working with un-contained material.
4. Procedures require that work with un-contained material is performed over plastic backed absorbent paper in an effluent hood or glove box.
5. Procedures require that the researchers regularly survey themselves and the work area during use of radioactive material using a pancake GM probe
6. Procedures require that the researchers survey themselves and the work area after each use of radioactive material using a pancake Geiger-Müller probe and a 100 square cm alpha probe.
7. Over-packs or secondary containers provide extra structural integrity to the actual containers.
8. Researchers will be trained in proper notification and spill response procedures.
9. Researchers will have decontamination and spill mitigation supplies available.
10. In the event of a significant contamination event, PSU may hire an outside vendor to aid or perform the decontamination.

Procedures to be followed if a spill occurs include:

1. Researcher will immediately stop the spill by covering it with absorbent paper,
2. Researcher will isolate the area to prevent the spread of contamination,
3. Researcher will warn others in the area and contact EHS for assistance,
4. Researcher will allow no one to leave the area until complete personal surveys have been performed,
5. Researcher will minimize exposure by decontaminating the area with EHS assistance.

COMPLIANCE WITH TS 3.7 RADIOIODINE LIMITS

Fission product inventory in fueled experiments is limited by TS 3.7(f):

> Each fueled experiment SHALL be controlled such that the total inventory of iodine isotopes 131 through 135 in the experiment is no greater than 1.5 curies. In addition, any fueled experiment which would generate more than 5 millicuries (mCi) of I-131 through I-135 SHALL be reviewed to ensure that in the case on an accident, the total release of iodine will not exceed that postulated for the MHA (see Safety Analysis Report, Chapter 13).

Past experience at the Breazeale reactor has demonstrated that we can safely comply with these experimental limits. In 2015, a thermo-acoustic sensor containing UO_2 was tested at the facility. The radioiodine inventory vs. operations time was calculated, and the operations schedule was designed to prevent the total iodine inventory from exceeding 1.5 Ci. (See Figure 1).

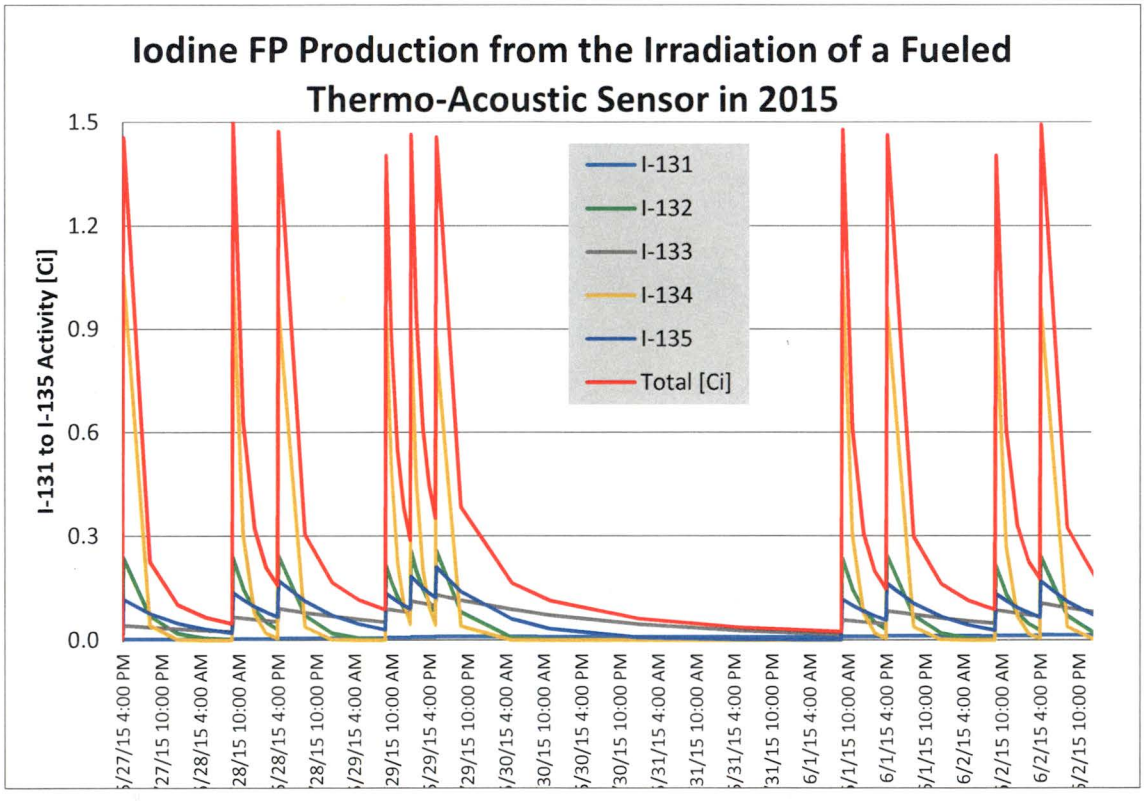

Figure 1 - Iodine inventory vs. operations time for a past experiment involving a UO_2 fueled thermo-acoustic sensor

PHYSICAL SECURITY

The SNM will be located within the security boundary of the PSU RSEC, which has an NRC-approved physical security plan (PSP) which meets the requirements of 10CFR part 73 and is designed to protect a quantity of fissile material much larger than the additional amount proposed via this amendment.

In addition to the safeguards measures described in the RSEC PSP, when not in use, both irradiated and unirradiated SNM will be locked in a safe or other lockable storage area when not in use, in a vital protected area with 24-hour surveillance and access only available to individuals who have passed an NRC-approved background investigation process.

EMERGENCY PLANNING

The irradiation of small (<1.0 g) quantities of fissile isotope does not affect the reactor Emergency Plan, provided that experiment procedure is designed to restrict the fission product inventory to within the limits prescribed by the Technical Specifications. The RSEC is equipped with area radiation monitors, air radiation monitors, portable survey meters and contamination monitors, and other apparatus to be used in the detection and cleanup of spilled or leaked material. Experiments with irradiated material will be performed in a hood to control spills and airborne losses. Hood filter specifications are to be determined.

Conclusion

The Principal Investigators, the Radiation Safety Officer, and the University Isotopes Committee (UIC) feel that the training and experience of the individuals mentioned above and the facilities and operating procedures are adequate to prevent exposure of personnel or the release of radioactive material during handling. The accidental release of radioactive material is always possible, but detailed operator training, frequent Radiation Safety oversight, and frequent surveying should prevent contamination incidents. In addition, the UIC and RSO feel that sufficient controls have been implemented to immediately detect and promptly mitigate the release of radioactive material.

End of application

UNITED STATES NUCLEAR REGULATORY COMMISSION

PENNSYLVANIA STATE UNIVERSITY

DOCKET NO. 50-005

PENN STATE BREAZEALE REACTOR

RENEWED FACILITY OPERATING LICENSE

License No. R-2

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

A The application for renewal of Facility Operating License No. R-2 filed by the Pennsylvania State University (the licensee) dated December 6, 2005, as supplemented by letters dated October 31, 2008, and April 2, June 11, September 1, and October 21, 2009, (the application) , complies with the standards and requirements of the Atomic Energy Act of 1954 , as amended (the Act), and the Commission's rules and regulations set forth in Title 10, Chapter 1, of the *Code of Federal Regulations;*

B. Construction of the Penn State Breazeale Reactor (the facility) was completed in substantial conformity with Construction Permit No. CPRR-71 dated October 2, 1 962, the provisions of the Act, and the rules and regulations ofthe Commission ;

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

D. There is reasonable assurance that (i) the activities authorized by this renewed license can be conducted at the designated location without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the rules and regulations of the Commission;

E. The licensee is technically and financially qualified to engage in the activities authorized by this license in accordance with the rules and regulations of the Commission;

F. The licensee is a nonprofit educational institution and will use the facility for the conduct of educational activities, and has satisfied the applicable provisions of 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements ," of the Commission's regulations;

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

H. The issuance of this renewed license is in accordance with 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the Commission's regulations and all applicable requirements ; and

I. The receipt, possession and use of byproduct and special nuclear materials as authorized by this renewed license will be in accordance with the Commission's regulations in 10 CFR Part 30 and 10 CFR Part 70.

2. Facility Operating License No. R-2 is hereby renewed in its entirety to read as follows:

A. This renewed license applies to the TRIGA Mark III nuclear reactor (the reactor) that is owned by Pennsylvania State University (PSU or the licensee), located at University Park, Pennsylvania, and described in the licensee's application , as supplemented.

B. Subject to the conditions and requirements incorporated herein, the Commission hereby licenses Pennsylvania State University:

1. Pursuant to subsection 104c of the Act, and Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," of the *Code of Federal Regulations* (10 CFR Part 50), to possess, use, and operate the reactor as a utilization facility at the designated location in accordance with the procedures and limitations described in the application and this renewed license.

2. Pursuant to the Act and 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," to receive, possess, and use in connection with operation of the reactor:

a. up to 9.0 kilograms of contained uranium-235 enriched to less than 20% in the form of fuel elements, ~~and~~ up to 50 grams of contained uranium-235 of any enrichment in forms such as fission detectors or fission foils, and up to 1 g of enriched uranium-235 and 1 g uranium-233 in any physical form for use in experiments; and

b. to possess and use, but not to separate such special nuclear material as may be produced by operation of the reactor.

3. Pursuant to the Act and 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material," to receive, possess, and use in connection with operation of the reactor: (1) two sealed 50-curie antimony-beryllium neutron sources, either or both of which may be used for reactor start-up, (2) a sealed 0.235 milligram californium-252 neutron source, and (3) a sealed 3-curie americium-beryllium neutron source.

4. Pursuant to the Act and 10 CFR Part 30 to possess, use, and transfer but not to separate, except for byproduct material produced in non-fueled experiments, such byproduct material as may be produced by operation of the reactor.

C. This renewed license shall be deemed to contain and is subject to the conditions specified in Parts 20, 30, 50, 51, 55, 70, and 73 of the Commission's regulations; is subject to all applicable provisions of the Act and rules, regulations, and orders of the Commission now or hereafter in effect; and is subject to the additional conditions specified below:

Maximum Power Level

1. The licensee is authorized to operate the reactor at a steady-state power level of 1.0 megawatt (thermal). The maximum power level shall not exceed 1.1 megawatts (thermal) when operated in the manual control mode, the automatic control mode, or the square wave mode. In pulsing mode, reactivity insertions shall not exceed 2.45%111</k.

Technical Specifications

2. The technical specifications contained in Appendix A are hereby incorporated in the license. The licensee shall operate the reactor in accordance with the technical specifications.

Additional Conditions

3. The licensee shall fully implement and maintain in effect all provisions of the Commission-approved physical security plan, including amendments and changes made pursuant to the authority of 10 CFR 50.90 and 10 CFR 50.54(p). The approved physical security plan consists of a Pennsylvania State University document, withheld from public disclosure pursuant to 10 CFR 73.21, entitled, "The Physical Security Plan for the Pennsylvania State University Breazeale Reactor," dated June 11, 1990, as revised.

D. This renewed license is effective as of the date of issuance and shall expire at midnight twenty years from the date of issuance .

FOR THE NUCLEAR REGULATORY COMMISSION

Eric J. eds, Director
Office of Nuclear Reactor Regulation

Attachment:
Appendix A, Technical Specifications

Date of Issuance : November 19, 2009

PROPOSED LICENSE

UNITED STATES NUCLEAR REGULATORY COMMISSION

PENNSYLVANIA STATE UNIVERSITY

DOCKET NO. 50-005

PENN STATE BREAZEALE REACTOR

RENEWED FACILITY OPERATING LICENSE

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

D. There is reasonable assurance that (i) the activities authorized by this renewed license can be conducted at the designated location without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the rules and regulations of the Commission;

E. The licensee is technically and financially qualified to engage in the activities authorized by this license in accordance with the rules and regulations of the Commission;

F. The licensee is a nonprofit educational institution and will use the facility for the conduct of educational activities, and has satisfied the applicable provisions of 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements ," of the Commission's regulations;

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

H. The issuance of this renewed license is in accordance with 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the Commission's regulations and all applicable requirements ; and

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D. This renewed license is effective as of the date of issuance and shall expire at midnight twenty years from the date of issuance .

FOR THE NUCLEAR REGULATORY COMMISSION

Eric J. eds, Director
Office of Nuclear Reactor Regulation

Attachment:
Appendix A, Technical Specifications

Date of Issuance : November 19, 2009

FACILITY OPERATING LICENSE R-2

APPENDIX A

TECHNICAL SPECIFICATIONS FOR THE PENNSYLVANIA STATE UNIVERSITY BREAZEALE REACTOR

DOCKET NO. 50-005

NOVEMBER 2009