RESPONSE TO
REQUEST FOR ADDITIONAL INFORMATION
RENSSELEAR POLYTECHNIC INSTITUTE
NEW PART 70 LICENSE APPLICATION

Radiation Protection

1. Section 6.III, Measuring and Monitoring Devices, paragraph 3 mentions the calibration of radiation detection systems. Typically, calibration of instruments is performed using standards that are traceable to the National Institute of Standards and Technology. Please clarify if this is the practice at Rensselaer Polytechnic Institute (RPI). This is needed to assure adequate procedures consistent with Title 10 of the Code of Federal Regulations (10 CFR) 70.22(a)(8).

1. Instrument calibration is performed at Rensselaer in compliance with New York State Department of Health Radioactive Materials License #1035 and the New York State regulations that are analog to 10 CFR 20. Most instrument calibrations are performed by a qualified third party, but Rensselaer maintains the capability to perform in-house calibrations when necessary using established procedures generally including standards that are traceable to NIST.

2. Section 7.1 states the procedures applied at the RPI facility. Describe the contamination monitoring procedures with respect to storage of the fuel pins and personnel handling of special nuclear material (SNM). Also state what action guidelines are used for contamination monitoring as well as for release of materials from restricted areas. This is needed to assure adequate procedures consistent with 10 CFR 70.22(a)(8) and 20.1501.

2. Facilities that handle loose radioactive materials are monitored monthly for removable radioactive contamination. Although the operations described under this license application do not necessarily fall under that definition, there may be such work at the LINAC facility, and so the entire facility is on a monthly monitoring schedule. The maximum action guideline for removable contamination is generally taken to be 100 dpm/100 cm^2 for alpha emitters and 1000 dpm/100 cm^2 for beta/gamma emitters, which corresponds to the New York State standard for clean areas and/or release of material or facilities. In practice, loose contamination is maintained ALARA, and any unexpected contamination is investigated and remediated.

3. Also, with regards to Section 7.1, describe the internal exposure assessment procedures that will be utilized should there be a release of SNM. This is needed to assure adequate procedures consistent with 10 CFR 70.22(a)(8) and 20.1204.

3. Although the long operating history with this material in conjunction with the CX-22 license suggests a very low likelihood of release of SNM, in the case of any accidental release, bioassay procedures will be performed in conformance with the recommendations of NRC Reg Guide 8.9.

4. Verify that the integrity of the fuel pins should not be compromised as a result of the operations described and that there is no expected release of SNM. This is needed to assure adequate procedures are in use consistent with 10 CFR 70.22(a)(8).

4. The integrity of the fuel pins should not be compromised as a result of the operations described, and there is no expected release of SNM. There will be no mechanical handling of the fuel pins, and the history of manual fuel handling as part of the CX-22 license indicates negligible likelihood of fuel pin damage.

5. How does RPI plan to transport the fuel pins from the Walthousen Laboratory to the linear accelerator (LINAC) laboratory? This is needed to assure adequate transportation and security procedures per 10 CFR 70.22(a)(8) and 20.1802.

5. RPI plans to transport the fuel pins from the Walthousen Laboratory to the LINAC (and back) using Type A containers under the conditions specified in 10 CFR 71.22. Documentation of the RPI Quality Assurance program is currently under review by the NRC.

6. Verify that the New York License No. 1035 allows possession of low-level SNM contaminated waste. This is needed to assure adequate procedures per 10 CFR 70.22(a)(8).

6. The RPI radioactive materials licenses from the New York State Department of Health has established possession limits for SNM that would be sufficient to cover small quantities of SNM contaminated waste in the unlikely event that any is generated.

<u>Nuclear Criticality Safety (NCS)</u>

Note: A series of criticality safety calculations have been performed in response to the following requests for additional information. To prevent repetition of information, the response to each of the first four questions may note specific details associated with that question, but largely references the NCS calculations that are detailed following question 4.

1. Demonstrate subcriticality for the 64 special power excursion reactor test (SPERT) F-1 fuel pins under normal and credible abnormal conditions, including fuel damage and possible moderation. Demonstrate compliance with the double contingency principle with regard to the handling, storage, and use of these materials. Among other credible scenarios, address the following:

a. Demonstrate compliance with double contingency for the scenario involving the accidental introduction of materials other than, or in quantities exceeding, those covered by your license application.

b. Demonstrate compliance with double contingency for the scenario in which the fissionable material is rearranged (e.g., mechanically deforming the fuel pins, breaching the clad and spilling the pellets) into a more reactive configuration.

Title 10 of the *Code* of *Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

1. The specific calculations of subcriticality are noted in the general response below. The scenarios considered largely address the double contingency principle and the scenarios described. All normal configurations are considered, including accidental flooding of the normal configuration of fuel, and rearrangement of fuel into its most reactive (moderated) configuration, which is a pitch wider than the normal configuration. In regards to sub-part a, the most reactive configuration is repeated, while incorporating the maximum quantity of SNM that is permitted to be licensed by the State of New York (greater than the quantity for which RPI is currently licensed). In regards to sub-part b, mechanical deformation of fuel into a more compact arrangement was shown to be a less reactive configuration. A bounding condition for rearrangement was taken to be the total mass of uranium, plus the inclusion of a plutonium-beryllium neutron source, into a spherical infinitely reflected configuration.

2. State whether the basis for subcriticality relies on explicit criticality calculations. If the basis does rely on calculation, submit a criticality code validation. State and justify your maximum allowable calculated k_{eff} value, including the use of an appropriate minimum margin of subcriticality. Title 10 of the *Code* of *Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

2. Explicit criticality calculations have been performed using the MCNP code. A summary of the calculated k_{eff} values is included in the general response below. The MCNP input files associated with a select set of these calculations are included for validation. To assure subcriticality, the maximum value of k_{eff} is no greater than 0.9. This was deemed acceptable as it was the standard that the NRC applies to the maximum accident condition addressed in the CX-22 reactor license.

3. Justify the most reactive credible moderation and reflection conditions used in your criticality calculations. Since lead can be a more effective reflector than water under certain conditions, if your calculations involve lead, show that this material is within the area of applicability of your calculation. Title 10 of the *Code* of *Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

3. Criticality safety calculations have been performed including water moderator and reflectors of infinite water and lead. All configurations maintain k_{eff} less than 0.9.

4. Demonstrate subcriticality for the interaction of the 64 SPERT F-1 fuel pins with any additional SNM present in your LINAC facility. You stated in your application that your inventory includes several plutonium-beryllium sources and other enriched uranium, in addition to the 64 SPERT F·1 fuel pins covered by your license application. You also stated that your license application will not cover these additional materials. However, the neutron interaction of these materials with the SPERT pins needs to be addressed. Title 10 of the *Code of Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

4. As noted in regards to NCS question 1, sub-part a, NCS calculations have been performed for both the actual SNM items that RPI possesses under its license from the State of New York, as well as the maximum quantity of SNM that may be licensed by the state in the future.

General information regarding NCS Questions 1 through 4:

The following documents 18 explicit cases that were considered for criticality calculation. Where the inclusion of “PuBe source” or “uranium discs” are noted, these refer to actual material in the possession of RPI at the LINAC. The scenarios that include 350g of U-235 or 200g of Pu distributed throughout the assembly are references to the maximum quantities of SNM that may be licensed by the State of New York. Exceeding either one of these quantities (or a relative mixture of them) would mean circumventing the radioactive materials licensing process.

The entries in the right-hand column of the table below are references to the select set of input files that have been attached for validation.

As noted, no value of k_{eff} in any of the considered scenarios exceeds a value of 0.9 (the maximum k_{eff} found was 0.85), which was deemed acceptable based upon the standard applied in the Safety Evaluation Report for the CX-22 license.

Case	Description	K_{eff}	Input file
Experimental setups:			
1	Fuel assembly (64 pins) in LSDS	0.10(5)	
2	Fuel assembly (52 pins) + PuBe source in LSDS, PuBe source in center (replaces 12 pins)	0.09(2)	
Entire LSDS in water:			
3	Same as 1, but entire LSDS submerged water	0.73(2)	case3.inp
4	Same as 2, but entire LSDS submerged water	0.71(6)	case4.inp
Spherical arrangement of HM :			
5	heavy metal of 64 fuel pin + PuBe source as sphere and reflected by water	0.50(6)	case5.inp
FA cases in water:			
6	Fuel assembly in water, infinite reflected	0.63(9)	case6.inp
7	Fuel assembly in water, infinite reflected, optimal pitch with highest k (2.75 cm)	0.79(5)	
8	64 fuel pins + PuBe source in water, infinite reflected	0.67(1)	
9	64 fuel pins + PuBe source + 10 U-235 discs in water, infinite reflected	0.67(2)	
10	Fuel assembly (64 pins) in water, infinite reflected; optimal pitch; cylindrical arrangement of fuel pins; additional center pin: 350 g U-235	0.81(7)	
11	Same as 10, but 4 additional center pins containing a total mass of 350 g U-235	0.84(7)	
12	Same as 10, but 9 additional center pins containing a total mass of 350 g U-235	0.85(6)	
13	Fuel assembly (64 pins) in water, infinite reflected (optimal pitch, cylindrical arrangement of fuel pins); additional center pin: 200 g Pu-239	0.81(5)	
14	Same as 13, but 4 additional center pins containing a total mass of 200 g Pu-239	0.83(8)	
15	Same as 13, but 9 additional center pins containing a total mass of 200 g Pu-239	0.85(3)	
17	Fuel assembly (64 pins) in water, infinite reflected (optimal pitch, cylindrical arrangement of fuel pins); total amount of 350 g U-235 added to the 64 fuel pins	0.82(7)	case17.inp
18	Fuel assembly (64 pins) in water, infinite reflected (optimal pitch, cylindrical arrangement of fuel pins); total amount of 200 g Pu-239 added to the 64 fuel pins	0.82(5)	case18.inp

MCNP5 version: MCNP5_RSICC, 1.51; ENDF/B 7 cross section
MCNP validation through running the criticality benchmarks set delivered with RSICC MCNP5 version (VALIDATION_CRITICALITY)
optimal pitch: the optimal pitch, i.e. the pitch with the highest criticality was found by step-by-step increasing the pitch until criticality peaks.

5. Provide a commitment in your license application that all individuals handling, or having responsibility and oversight for the safe handling, storage, and use of the SPERT F-1 fuel pins, shall receive prior training in nuclear critically training. While the education and experience requirements appear appropriate, there is no mention of NCS in the training program described in your license application. Title 10 of the *Code of Federal Regulations* 70.22(a)(7) and (a)(8) require a description of proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

5. Nuclear criticality safety training will be incorporated into the job and procedure specific training provided to all individuals handling, or having responsibility and oversight for the safe handling, storage, and use of the SPERT F-1 fuel pins. This training will be completed before individuals begin work with this material.

6. Clarify whether your area radiation monitors will meet the requirements of 10 CFR 70.24, and whether you commit to follow American National Standard Institute/American Nuclear Society-8.3-1997. Provide commitments in your license application describing how you will meet 10 CFR 70.24, or provide a request for exemption from the requirements of 10 CFR 70.24 in accordance with 10 CFR 70.17. Title 10 of the *Code of Federal Regulations* 70.24(a) requires the installation and maintenance of a criticality monitoring system in all areas when in possession of specified quantities of fissionable materials. Your requested possession limits exceed the quantities specified in 10 CFR 70.24(a).

6. While we do plan to provide radiation monitoring for the fuel storage location, we request exemption from the specific requirements of 10 CFR 70.24. Fuel pins will be stored in cadmium-lined steel tubes with a minimum center-to-center separation of 8.5 inches, and with no more than 15 SPERT F-1 fuel pins per tube mounted on a steel wall rack. This arrangement, as specified in the Technical Specifications of the CX-22 license, ensures that the infinite multiplication factor is less than 0.9 when the storage device is fully flooded with water. We believe that this is sufficiently protective of accidental criticality to warrant an exemption from 10 CFR 70.24.

7. Clarify whether the LINAC facility contains water-based fire suppression systems. If so, address the possible moderation of the 64 SPERT F-1 fuel rods following activation of the fire suppression system. Title 10 of the *Code of Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

7. The LINAC facility contains no water-based fire suppression systems.

8. Describe the elements of your facility program(s) for ensuring NCS, including training, periodic audits and inspections, your evaluation and change review process, and the staff that will perform these duties. Title 10 of the *Code of Federal Regulations* 70.22(a)(7) and (a)(8) require a description of proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

8. The activities covered by this license will fall under the jurisdiction of the RPI Campus Radiation Safety Program. Several of the elements modified as appropriate by the conditions present. For instance, the general radiation safety training does not currently include criticality safety instruction, as it is not applicable to any of our current operations. The training program will be revised to include the NCS topics that are appropriate to the licensed activities, and all LINAC personnel will be required to complete it before operations commence. The radiation safety program includes monthly audits of radioactive material use areas by the Office of Radiation and Nuclear Safety. That review includes the proper storage and use of permitted radioactive materials, and will likewise apply to these licensed activities. Evaluation of proposed changes is

the purview of the Radiation and Nuclear Safety Committee, which would also apply to these licensed activities.

9. Provide a description of the NCS controls and limits that ensure subcriticality under normal and credible abnormal conditions, and the measures that will be used to ensure that these controls will be available and reliable to perform their safety function(s) when needed. Title 10 of the *Code of Federal Regulations* 70.22(a)(7) and (a)(8) require a description of equipment and facilities and proposed procedures to protect health and minimize danger to life or property, which includes avoiding accidental criticality. This information is needed to ensure adequate protection against the consequences of accidental criticality.

9. Given the activities described in the license application, no engineering controls are necessary or implemented to ensure subcriticality. The possession limits of the license provide the necessary limits to prevent accidental criticality.

<u>Fire Safety</u>

1. Describe the facility's floor, ceiling, and roof construction; electrical installation; emergency lighting; life safety/egress routes; ventilation and lightning protection. This information is pursuant to the requirements in 10 CFR 70.22(a)(7) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

1. The floors and walls of the facility are constructed with thick concrete, and the ceiling/roof consists of an earthen berm. These construction features are primarily for the radiation protection associated with the accelerator machine. Emergency lighting systems are available throughout the facility.

   A map of the LINAC facility was included with the license application submission. That map is reproduced below, with the emergency exits more explicitly labeled.

   During LINAC operation, the LINAC target room is exhausted at a rate of 25,000 cfm to prevent the buildup of possible air contaminants.

   The electrical equipment in the LINAC facility is heavily grounded, but there is no specific lightning protection system.

2. What nationally recognized codes does the Life Safety Shop follow for the inspection, testing, and maintenance of fire protection systems present in the LINAC Laboratory Facility? If none, please describe frequencies. This information is pursuant to the requirements in 10 CFR 70.22(a)(7) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

2. The National Fire Protection Association (NFPA 72 - National Fire Alarm and Signaling Code) are used for the inspection testing and maintenance of the fire protection systems currently present in the LINAC Facility.

3. Describe, by fire area (room), any potential combustible loading, possible fire scenarios, the potential consequences, and any mitigative controls. This information is pursuant to the requirements in 10 CFR 70.22(a)(7) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

3. There is no excessive combustible loading identified in most of the fire areas of the LINAC. The one unique fire area is the equipment rooms for the drivers of the accelerator itself, which contain high voltage equipment, and large banks of capacitors and power supplies. This are is protected by a CO_2 fire suppression system to mitigate the impact of any fire that may develop in that area.

4. Are there any hazardous chemicals or processes which may contribute to the fire hazards in radiological areas? This information is pursuant to the requirements in 10 CFR 70.22(a)(7) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

4. Neither storage nor use areas feature storage or use of combustible hazardous chemicals.

5. Is the facility compliant with the National Fire Protection Agency (NFPA) 45, Standard for Fire Protection in Laboratory Facilities, and/or NFPA 801, Standard for Fire Protection for Facilities Handling Radioactive Materials? This information is pursuant to the requirements in 10 CFR 70.22(a)(7) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

5. All facilities at RPI, including the LINAC, are inspected annually by, and against the standards of, the New York State Office of Fire Prevention and Control. Although RPI believes that this results in operations substantially in compliance with NFPA 45 and/or NFPA 801, it does not explicitly measure its operations against those standards.

6. Describe the frequency and scope of any training for facility workers in response to a fire (fire extinguisher. safe shutdown, evacuation, etc.). This information is pursuant to the requirements in 10 CFR 70.22(a)(8) and the acceptance criteria found in NUREG-1520, Rev. 1, Section 7.4.3.

6. Staff and other users of the LINAC facility are instructed to evacuate the building in case of emergency, and are not trained in the use of fire extinguishers or other mitigative equipment. As an accelerator facility, safe shutdown in an emergency can be obtained by cutting the power to the machine using a clearly labeled “Emergency Stop” button. Power is also cut to the machine in the event of activation of any alarm.