STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
Rhode Island Atomic Energy Commission
16 Reactor Road
Narragansett, RI 02882-1165
Telephone # 401-789-9391

March 24, 2014

Mr. Patrick Boyle, Project Manager
Research and Test Reactors Licensing Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING THE RINSC REACTOR LICENSE RENEWAL (TAC NO. ME1598)

Mr. Boyle,

Attached is the response the request for additional information (RAI) regarding the Rhode Island Nuclear Science Center (RINSC) reactor license dated March 20, 2014.

The response includes one enclosure. The enclosure contains our responses to the RAIs.

Respectfully,

Cameron Goodwin, PhD, Director
Rhode Island Nuclear Science Center

I certify under penalty of perjury that the representations made above are true and correct.

Executed on: 3/24/14 By:

1. The RAI response The RAI response discussed the potential for argon-41 (Ar-41) build-up and the features relied upon to prevent the Ar-41 from entering the room. The potential exists for the rabbit tubing to fail in the room.
    a. Provide an analysis for the concentration of Ar-41 that could be produced during operation of the system and resulting dose consequence should this Ar-41 be discharged into the room.
    b. Provide a description of the equipment in the room that would alert personnel in the room to this hazard should a failure of the system occur.
2. Discuss the consequence of a sample encapsulation failing upon return to the rabbit terminus with emphasis on how airborne contaminants are managed since the rabbit terminus is not located within a fume hood.

Response to Questions 1 and 2.

Two pneumatic tubes are provided for rapid movement of small experimental specimens (up to 1-inch in diameter and 6 inches long) to and from the high flux region adjacent to the core in the high power section of the pool. The samples are sent from and returned to a large lead cave located in Room 305 outside of the confinement. The specimens are placed in a small polyethylene holder ("rabbit") that is placed into a receiver. The rabbit travels through the inner concentric aluminum tube (perforated for airflow). The tube extends from the station into the pool down to the reactor. A 2-inch inner tube guides the rabbit (approximately 1 inch in diameter by 6 inches long). The 3-inch outer tube (water tight) is connected through suitable solenoid air control valves to the exhauster (rabbit blower). The control air is maintained via the solenoid cabinet operation. The exhaust gases are sent through a HEPA filter to the reactor room exhaust system to the stack via the 4.5-HP rabbit system blower which provides a 200-cfm flow. Solenoid valves direct flow through the inner tube to either send or receive a rabbit. The sending unit positions the rabbit for transfer to the terminus at the end of the tube near the core. The receiving unit holds the rabbit after irradiation. The maximum speed of the rabbit is about 50 feet per second. Two rabbits can be sent to the terminal in each system with a payload of about 2 pounds. Manual ball valves are located in the rabbit and air lines in case of a tube leak below the pool water elevation. The valves can be manually closed to prevent pool drainage or siphoning. The rabbits can receive irradiation for certain lengths of time by presetting the automatic mode system timer. The rabbits are returned to the receiver when the time period ends. Manual sending and receiving of rabbits also can be performed by the experimenter. The controls are located on the wall adjacent to the receiver. The operator has overall control of the system. Radiation levels near the receiver are measured by the local "vamps" which provide an audible alarm and flashing light when "returned" rabbits exceed preset radiation levels.

The terminus of the rabbit system has never been located in a fume hood however, the main concerns with moving the rabbit station outside the confinement is the monitoring of Ar-41 and experiments containing fissionable materials.

Experiments with fissionable materials

An experiment containing fissionable materials has the potential to release fission fragments if the container it is in fails. An administrative control will be in place that requires all rabbit experiments that contain fissionable materials be doubly encapsulated. Should the encapsulation fail a second administrative control will require all rabbit experiments be opened inside the confinement room. This will ensure that any release of fission products will be handled by the confinement's air handling system.

Ar-41

There is potential for Ar-41 buildup in the rabbit station room. Ar-41 poses an immersion hazard so it is important to have the air monitored in the room at all times. This is done with a semi portable survey meter that is left on at all times.

The rabbit return station is directly tied to the rabbit return box. The box is approximately 4 x 3 x 6 feet and is lined with 4 inches of lead. The majority of the air that flows through the system is drawn by the rabbit blower into the confinement off gas system. A small amount may exit through the end of the rabbit pipes where they terminate above the rabbit return box.

The end of the rabbit system that terminates near the core is where any Ar in the system could be activated. The amount of Ar that is activated is dependent on the time the air is adjacent to the core, and the volume of the air that is present.

To calculate the amount of argon that is activated we start by calculating the volume of the terminus which is also the volume of the air. The terminus is 3.75 cm in radius and 60 cm long. Its volume is 2693 cm^3. Air is made of ~1% Argon by volume. The volume of the Ar in the terminus is 26.93 cm^3. The number of target Ar-40 atoms is found by starting with the ideal gas equation:

$$PV = NK_bT$$

Where P = 101.5 kPa, V is 26.9 cm^3, T= 300 K and K_b= 1.38 x10^{-23} $m^2kg\ s^{-1}$. Solving for N yields N= 6.58X10^{20} target atoms.

The number of target Ar-40 atoms that are activated is dependent on the time each sample of Ar-40 is spent at the terminus. The blower system removes 220 cfm of air from the rabbit system. This translates to:

$$220\ \frac{ft^3}{min} x 28{,}316 \frac{cm^3}{ft^3} = 6.23x10^6\ \frac{cm^3}{min}$$

or a turnover rate in the terminus of:

$$\frac{2693\ cm^3}{6.23x10^6 \frac{cm^3}{min}} * 60 \frac{s}{min} = .02s$$

To be conservative an activation time of 1 s was used. The amount of Ar-40 that is activated is given by:

$$A = N\sigma\phi(1 - e^{-\lambda t_a})$$

where N = 6.58x10^{20}, σ = 0.65 x 10^{-24} cm^2, ϕ= 2.83 x 10^{12}n/cm^2 s , λ= ln[2]/1.83 hrs, and t_a= 1/3600 hrs. The total activity of the Ar-41 is 1.27 x 10^5 Bq.

If that activity is transported directly to the rabbit station room and mixed well with the air in the room, assuming no air can escape the room, than the Derived Air Concentration would be:

$$DAC = \frac{A}{Volume} = \frac{0.127\ MBq}{176 m^3} = 7.2x10^{-4}\ \text{MBq/m}^3$$

According to the EPA's Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factor For Inhalation, Submersion, and Ingestion the limiting DAC for Ar-41 is 0.1 MBq/m^3. The dose rate associated with the calculated concentration is 0.15 mrem/hr.