Attachment 2

North Carolina State University

PULSTAR Reactor

License and Technical Specification Changes for

License Amendment Request for Fueled Experiments

4-DEC-2018

R-120 LICENSE CHANGE

Requested Change to 2.B.(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 up to 25 kilograms of contained uranium-235 enriched to les s than 20 percent in the isotope uranium- 235 in the form of reactor fuel; up to 20 grams of contained uranium-235 of any enrichment in the form of fission chambers; ~~up to 2 grams of contained uranium-235 of any enrichment in the form of foils~~ *up to 34 grams of Uranium-235, 1 gram of Neptunium-237, and 5 grams of Plutonium-239 for fueled experiments*; up to 200 grams of plutonium-239 in the form of plutonium-beryllium neutron sources; and to possess, but not separate, such special nuclear material as may be produced by the operation of the facility.

1.2 Definitions

1.2.9 Experiment: Any operation, hardware, or target (excluding devices such as detectors, foils, etc.) that is designed to investigate non-routine reactor characteristics or that is intended for irradiation within the pool, on or in abeam tube or irradiation facility, and that is not rigidly secured to a core or shield structure so as to be a part of their design. Specific categories of experiments include:

a. **Tried Experiment**: Tried experiments are those experiments that have been previously performed in this reactor. Specifically, a tried experiment has similar size, shape, composition and location of an experiment previously approved and performed in the reactor.

b. **Secured Experiment**: A secured experiment is any experiment, experimental facility, or component of an experiment that is held in a stationary position relative to the reactor by mechanical means. The restraining forces must be substantially greater than those to which the experiment might be subjected by hydraulic, pneumatic, buoyant, or other forces which are normal to the operating environment of the experiment, or by forces which can arise as a result of credible malfunctions.

c. **Non-Secured Experiment**: A non-secured experiment is an experiment that does not meet the criteria for being a "secured" experiment.

d. **Movable Experiment**: A movable experiment is one where it is intended that all or part of the experiment may be moved in or near the core or into and out of the reactor while the reactor is operating.

e. ~~**Fueled Experiment**: A fueled experiment is an experiment which contains fissionable material.~~

e. Fueled Experiment: A fueled experiment is defined as an experiment involving any of the following:

- Neutron irradiation of uranium exceeding 1.9 x 10^6 fissions per second or 1.6 x 10^{11} fissions
- Neutron irradiation of any amount of neptunium or plutonium
- A planned release of fission gases or halogens

Fueled experiments exclude:

- Fissionable material not subjected to neutron fluence.
- Detectors containing fissionable material used in the operation of the reactor or used in an experiment, sealed sources, and fuel used in operation of the reactor.

Examples of excluded materials include manufactured detectors, sealed sources with registration certificates generated by the NRC and Agreement States, special form radioactive material as defined in 10 CFR Part 71, and PULSTAR reactor fuel elements in cladding. Sealed sources are defined as sources encased in a capsule designed to prevent leakage or escape of the material from the intended use of the source or potential minor mishaps.

3.5 Radiation Monitoring

Equipment Applicability

This specification applies to the availability of radiation monitoring equipment which must be operable during reactor operation.

Objective

To assure that radiation monitoring equipment is available for evaluation of radiation conditions in restricted and unrestricted areas.

Specification

The reactor shall not be operated unless the radiation monitoring equipment listed below and in Table 3.5-1 is operable.[1][2][3][8]

a. Three fixed area monitors operating in the Reactor Building with their setpoints as listed in Table 3.5-1.[1][3][4]

b. Particulate and gas building exhaust monitors continuously sampling air in the facility exhaust stack with their setpoints as listed in Table 3.5-1.[1][3][4]

c. The Radiation Rack Recorder.[5]

d. Vented fueled experiment exhaust gas monitor continuously monitors the exhaust gas with the setpoints as listed in Table 3.5-1.[6][7][8]

e. Vented fueled experiment flow rate monitor with a setpoint that does not exceed 3 lpm [7][8]

Table 3.5-1: Required Radiation Area Monitors

Monitor	Alert Setpoint	Alarm Setpoint
Control Room	≤ 2 mR/hr	≤ 5 mR/hr
Over-the-Pool	≤ 5 mR/hr	≤ 100 mR/hr
West Wall	≤ 5 mR/hr	≤ 100 mR/hr
Stack Gas	≤ ~~1000~~ 3000 Ar-41 AEC[6]	≤ ~~5,000~~3300 Ar-41 AEC[6]
Stack Particulate	≤ ~~1000~~ 8000 Co-60 AEC[6]	≤ ~~5,000~~8500 Co-60 AEC[6]
Vented Fueled Experiment Exhaust Gas	≤ 1.0×10^7 Fission gas AEC[6][7]	≤ 1.4×10^7 Fission gas AEC[6][7]

(1) For periods of time, not to exceed ninety days, for maintenance to the radiation monitoring channel, the intent of this specification will be satisfied if one of the installed channels is replaced with a gamma-sensitive instrument which has its own alarm audible or observable in the control room. Refer to SAR Section 5.

(2) The Over-the-Pool Monitor may be bypassed for less than two minutes during return of a pneumatic capsule from the core to the unloading station or five minutes during removal of experiments from the reactor pool. Refer to SAR Section 5.

(3) Stack Gas and Particulate are based on the AEC quantities present in the ventilation flow stream as it exits the stack. Refer to SAR Section 10 for setpoint bases for the radiation monitoring equipment.

(4) May be bypassed for less than one minute immediately after starting the pneumatic blower system.

(5) During repair and/or maintenance of the recorder not to exceed 90 days, the specified area and effluent monitor readings shall be recorded manually at a nominal interval of 30 minutes when the reactor is not shutdown. Refer to SAR Section 5.

(6) Airborne Effluent Concentrations (AEC) values from 10 CFR Part 20 Appendix B, Table 2. Fission gas AEC for a vented fueled experiment is $4x10^{-8}$ µCi/ml.

(7) Experiment exhaust in liters per minute.

(8) Additional monitors required for a vented fueled experiment.

Bases

A continued evaluation of the radiation levels within the Reactor Building will be made to assure the safety of personnel. This is accomplished by the area monitoring system of the type described in Section 5 of the SAR.

Evaluation of the continued discharge air to the environment will be made using the information recorded from the particulate and gas monitors.

When the radiation levels reach the alarm setpoint on any single area, or stack exhaust monitor, the building will be automatically placed in confinement as described in SAR Section 5.

To prevent unnecessary initiation of the evacuation confinement system during the return of a pneumatic capsule from the core to the unloading station or during removal of experiments from the reactor pool, the Over-the-Pool Monitor may be bypassed during the specified time interval. Refer to SAR Section 5.

For vented fueled experiments, the fission gases and flow rate are monitored. Upon reaching a setpoint, the vented fueled experiment exhaust is automatically isolated and the confinement system is initiated.

3.8 Operations with Fueled Experiments

Applicability

This specification applies to the operation of the reactor with any fueled experiment.

Objective

The objective is to prevent damage to the reactor or excessive release of radioactive materials in the event of an experiment failure.

Specifications

Fueled experiments shall meet the following conditions and limitations:

a. Specification 3.2 pertaining to experiment reactivity worth shall be met.

b. Specifications 3.5 and 3.6 pertaining to operation of the radiation monitoring system and ventilation system shall be met during reactor operation or if moving or handling an irradiated fueled experiment.

c. Specification 3.7 pertaining to limitations on experiments shall be met, with the exception that containers used for vented fueled experiment shall meet specification 3.8.d.iv.1.

d. Fissionable materials used in fueled experiments shall meet the following:

   i. Fissionable material physical form shall be solid, powder, or liquid.

   ii. Fission rate less than or equal to 9.6×10^{9} fissions per second.

   iii. Total number of fissions less than or equal to 1.8×10^{16}.

   iv. Vented fueled experiments shall meet the following:
      1. Fission gases and halogens may be released. All other materials shall be contained.
      2. Monitoring of the exhaust flow rate. Maximum flow rate shall be less than or equal to three (3) liters per minute (lpm).
      3. The experiment exhaust shall have a minimum decay time of thirty (30) minutes before being exhausted by the reactor building ventilation system.
      4. Filtration of exhaust for particulates and halogens[(1)].

5. Monitoring of the experiment exhaust gas for radioactivity
6. Monitoring for halogens in the stack particulate radiation monitoring channel

e. Specification 5.3 pertaining to criticality control for fueled experiments in storage shall be met.

f. Specifications 6.2.3 and 6.5 pertaining to the review of experiments shall be met.

(1) Filter removal efficiency shall be certified by the supplier to be 0.95 or greater at flow rates at 3 lpm or less.

Bases

The limitations given in Specification 3.8 ensure that:

a. Fueled experiments performed in experimental facilities at the reactor prevent damage to the reactor or excessive release of radioactive materials in the event of an experiment failure.

b. Radiation doses from accidental or planned releases of airborne activity do not exceed three percent (3%) of the annual limits given in 10 CFR Part 20.

Specification 3.8 a provides reactivity control during irradiation.

Specification 3.8 b provides for radiation monitoring and ventilation system operation, including actuation of the confinement mode of operation should an accidental release occur during irradiation and handling of a fueled experiment.

Specification 3.8 c and 3.8.d.i provide for experimental controls to prevent release of fissionable materials and fission products.

Specification 3.8 d. ii limits radiation dose from the release of fission products to a Total Effective Dose-Equivalent (TEDE) of 0.003 rem in public areas outside the reactor building, a TEDE of 0.15 rem inside the reactor building, and a Total Organ Dose-Equivalent to the thyroid (TODE) of 1.5 rem inside the reactor building.

Specification 3.8.d.iii limits the production of long-lived fission products for safety and security concerns to levels below those given for Category 2 Quantities of Concern in 10 CFR Part 37.

Specification 3.8.d.iv provides controls for planned releases from vented experiments needed to ensure that radiation dose does not exceed three percent of the annual radiation dose limits given in 10 CFR Part 20.

Specification 3.8 e ensures that fueled experiments are stored in sub-critical configurations.

Specification 3.8 f ensures that fueled experiments are reviewed, approved, and documented as required by Specifications 6.2.3 and 6.5.

4.4 Radiation Monitoring

Equipment Applicability

This specification applies to the surveillance requirements for the area and stack effluent, and vented fueled experiment exhaust monitoring equipment ~~radiation monitoring equipment~~.

Objective

The objective is to assure that the radiation monitoring equipment is operable.

Specification

a. The area and stack, and vented fueled experiment radiation monitoring systems shall be calibrated annually but at intervals not to exceed fifteen (15) months.

b. The setpoints shall be verified weekly, but at intervals not to exceed ten (10) days.

c. The vented fueled experiment flow meter shall be calibrated annually but at intervals not to exceed fifteen (15) months.

d. Filter removal efficiency for iodine adsorption shall be certified by the supplier to be 0.95 or greater at flow rates of 3 lpm or less.

e. Filter replacement for vented fueled experiments shall be biennual (2 years) but at intervals not to exceed thirty (30) months.

Bases

These systems provide continuous radiation monitoring of the Reactor Building with a check of readings performed prior to and during reactor operations. The vented fueled experiment monitoring system includes an exhaust gas radiation monitor and flow rate monitor.

Therefore, the weekly verification of the setpoints in conjunction with the annual calibration is adequate to identify long term variations in the system operating characteristics.