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January 17, 2017

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

REFERENCE: Docket 50-186
University of Missouri-Columbia Research Reactor
Amended Facility Operating License No. R-103

SUBJECT: Proposed Licensing Approach for an Experimental Facility at the University of Missouri-Columbia Research Reactor to Produce Molybdenum-99

Dear Sir or Madam:

The University of Missouri-Columbia Research Reactor (MURR) is in the design and safety review stages of plans for producing molybdenum-99 (Mo-99) using the Selective Gas Extraction (SGE) method. The Mo-99 will be extracted without using the typical, industry method of chemical dissolution of low-enriched uranium (LEU) targets.

Representatives from MURR and U.S. Nuclear Regulatory Commission (NRC) Staff met on April 27, 2015 and June 2, 2016 to discuss MURR's approach to licensing the SGE experimental facility. During those meetings, representatives from MURR's research and development partners also presented a detailed technical overview of the project during a closed, proprietary session. At the end of the April 2015 meeting, the NRC suggested that MURR submit a written document outlining how MURR proposes to license the SGE experimental facility and the bases for that approach. On September 11, 2015, MURR submitted a summary letter that provided MURR's summary of the proposed SGE licensing approach and the bases for requesting NRC approval of this experiment pursuant to 10 C.F.R. § 50.90 by amending MURR's existing Facility Operating License No. R-103. The September 11, 2015 Letter outlined why MURR

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believes that the SGE activities at MURR will (1) be classified as an "experiment," (2) not require MURR to be categorized as a "testing facility," (3) not cause MURR to be categorized as a "production facility," (4) not require a Construction Permit per 10 C.F.R. § 50.90, and (5) not increase MURR's reactor core power level, which is limited to 10 MWt.

During the June 2, 2016 meeting, MURR presented a project update and restated our intended licensing path, consistent with our September 11, 2015 letter. Also at that meeting, MURR proposed a 2-part licensing submission (In-Pool vs. Ex-Pool activities) for efficiency so that the in-pool review could commence upon receipt. MURR left the June 2, 2016 meeting with the understanding that (1) the NRC was amenable to a 2-part submission, (2) the NRC would consider whether a construction permit is necessary based on any "material alterations" proposed by MURR, and (3) the NRC staff felt strongly at the time that the ex-pool activities would require a "Production Facility" license.

With this background MURR is requesting a formal response from the NRC to the following five questions. With each question, MURR has stated its position and associated basis for consideration by the NRC.

A. Will a Construction Permit be required? (10 C.F.R. § 50.23)

It is MURR's position that the SGE project scope does not require a Construction Permit.

Analysis:

Although implementation of the SGE experimental facility at MURR will require a license amendment, a Construction Permit is not required because implementation and subsequent operation of the experiment will not constitute a "material alteration" to the MURR facility per 10 C.F.R. § 50.92(a). The reasons for this position are described below.

The main components of the SGE experimental facility will consist of LEU target assemblies, a separate and dedicated cooling system for heat removal, hot cells that will be used for processing the irradiated targets, and ancillary equipment to support these systems.

NRC regulation 10 C.F.R. § 50.92(a), Issuance of Amendment states, in part:

> (a) In determining whether an amendment to a license, construction permit, or early site permit will be issued to the applicant, the Commission will be guided by the considerations which govern the issuance of initial licenses, construction permits, or early site permits to the extent applicable and appropriate. *If the application involves the material alteration of a licensed facility, a construction permit will be issued before the issuance of the amendment to the license . . .*
>
> (Emphasis added.)

The NRC has provided no regulatory definition of "material alteration." The NRC Staff considered establishing one in 1995 and 1996, but abandoned the effort because of "little regulatory need to clarify the term."[1] As the NRC's Executive Director for Operations explained in SECY-96-024,

> *In only one instance has a construction permit been issued before an amendment of an operating license, that is, an amendment to the operating license of a research reactor at the University of Maryland. The material alteration was the complete removal of existing control rods, rod drive mechanisms, core instrumentation, and control room equipment and replacement with those of a different design. The change rendered major portions of the safety analysis inapplicable.*[2]

The Staff concluded that there was an "apparent lack of need and industry or public interest in this topic."[3] The NRC has since not provided a regulatory definition of "material alteration."

The alterations at the University of Maryland that compelled a construction permit involved significant modifications to the reactor itself and its support systems, and major revisions to the associated accident analyses. This is not the case for the SGE experiment. In contrast to the University of Maryland example, the SGE experiment does not involve complete removal of major SSCs such as control rods or core instrumentation. The neutron producing core region of MURR will be minimally affected by the addition of the equipment for the experiment because the targets are located in the graphite reflector region of the reactor. The installation and operation of this experiment, with its target assemblies, target cooling system, and associated instruments and controls, will better ensure that existing structure, system, or component (SSC) along with the design bases function of an existing SSC as described in the MURR SAR, will not be adversely affected by the SGE. The mission of MURR will be further enhanced and not transformed as a result of the SGE experimental facility.

The SGE experimental facility is more closely aligned with modifications made to the MITR, which in Amendment No. 31 (dated December 21, 1999) added a complex fission converter, containing a subcritical array of fuel that could not maintain a self-supporting chain reaction. (Like MURR, MITR also considered its activities to represent an "experiment.") The experiments at both MITR and MURR are designed to reside in or adjacent to the reactor reflector region. Both are designed with independent cooling systems, and both incorporate the use of LEU in the experiment. For MITR, the NRC did not consider the addition of a fission converter tank containing fuel elements located adjacent to the reactor's graphite

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1 SECY-96-024, "Semiannual Status Report on Implementation of Regulatory Review Group Recommendations," at 5 (Feb. 2, 1996).

2 *Id.*

3 *Id.*

reflector in the region previously occupied by the thermal column as a "material alteration" of the MITR facility. This facility had a reactivity effect on the MITR, had a separate forced cooling system, instrumentation and control inputs to the MITR reactor safety system and required Technical Specification changes. The MURR proposal will implement similar concepts and equipment, instrumentation and control inputs to the MURR reactor safety system and require Technical Specification changes. As such, the MURR proposal does not constitute a "material alteration" under NRC precedent.

B. Will a change be required to MURR's licensed maximum operating power limit of 10 MWt due to the heat produced from the irradiation of the LEU targets?

It is MURR's position that no change to MURR's licensed maximum operating power limit of 10 MWt is required.

Analysis:

Amended Facility Operating License No. R-103 limits MURR to operate at a maximum steady-state reactor power level of 10 MWt. MURR uses the following calorimetric procedure to determine and maintain reactor power within the licensed limit using both primary and pool coolant system flow rates and differential temperatures:

Reactor Power Level = [((total average primary coolant flow of each loop – primary demineralizer flow) x $(T_h - T_c)_{primary}$) + ((average pool coolant flow) x $(T_h - T_c)_{pool}$)] x (a unit conversion factor)

An additional backup calorimetric procedure, using secondary coolant system flow rate and differential temperature, is also performed:

Reactor Power Level = [(secondary coolant flow) x $(T_h - T_c)_{secondary}$] x (a unit conversion factor)

The SGE experimental facility will generate approximately 562 kW_t from two (2) target assemblies. A dedicated cooling system will provide forced flow to each target assembly. This system will draw coolant from the MURR reactor pool, pump it through dedicated heat exchangers which will lower the temperature of the coolant to the required value, then circulate the coolant through the target assemblies. The coolant leaving the target assemblies will then reenter the reactor pool at, or slightly above, the temperature of the bulk reactor pool water. Because the system is designed such that no heat is removed from the pool coolant system, the power generated by the target assemblies will not be part of MURR's 10 MWt reactor power level limit. MURR's secondary coolant system, which cools both the

primary and pool coolant systems, will provide the cooling water to the SGE experimental facility heat exchangers.

The SGE experimental facility cooling system is instrumented with flow, pressure and temperature monitoring equipment. Flow to each target assembly is measured by flow elements. Temperature is measured at four (4) separate locations: heat exchanger inlet heat exchanger outlet, target assembly inlets and target assembly outlets. Secondary coolant to the SGE experimental facility cooling system will also be instrumented with heat exchanger inlet and outlet temperature elements and a flow element.

MURR will use the same type of calorimetric procedure to determine SGE experimental facility power (individual target assembly power and total power) using coolant system flow rates and differential temperatures:

Target Assembly A Power = [(target assembly coolant flow rate) x (target assembly differential temperature - $T_h - T_c$)] x (a unit conversion factor)

Target Assembly B Power = [(target assembly coolant flow rate) x (target assembly differential temperature - $T_h - T_c$)] x (a unit conversion factor)

SGE Experimental Facility Total Power = Target Assembly A Power + Target Assembly B Power

An additional backup calorimetric procedure, using secondary coolant system flow rate and differential temperature across the SGE experimental facility heat exchanger, will also performed:

SGE Experimental Facility Total Power = [(secondary coolant flow rate through SGE experimental heat exchanger) x $(T_h - T_c)_{secondary}$] x (a unit conversion factor)

Redundant N-16 power level monitoring systems will also be installed on the primary coolant system piping exiting the reactor core. The N-16 monitoring systems will be calibrated at 100% reactor power operation without the SGE experimental facility operating. This will provide an additional method to the currently installed nuclear instrumentation to monitor reactor power.

C. Will a Production Facility license be required?

It is MURR's position that the in-pool activities would not constitute a production facility, but that the ex-pool activities would constitute a production facility.

Analysis:

The NRC defines "produce," in the context of special nuclear material (SNM), in 10 C.F.R. § 50.2:

> *Produce*, when used in relation to special nuclear material, means (1) to manufacture, make, produce, or refine special nuclear material; (2) to separate special nuclear material from other substances in which such material may be contained; or (3) to make or to produce new special nuclear material.

The NRC also defines "production facility," in 10 C.F.R. § 50.2:

> *Production facility* means:
>
> (1) Any nuclear reactor designed or used primarily for the formation of plutonium or uranium-233; or
>
> (2) Any facility designed or used for the separation of the isotopes of plutonium, except laboratory scale facilities designed or used for experimental or analytical purposes only; or
>
> (3) Any facility designed or used for the processing of irradiated materials containing special nuclear material [subject to certain exceptions].

The SGE experiment involves irradiating low-enriched uranium (LEU) targets in the reflector region of the reactor (the in-pool phase). Following irradiation, the targets would be moved to hot cells (*i.e.*, radiation-shielded work boxes) where the Mo-99 would be collected and extracted (the ex-pool phase).

The In-Pool activities of simply irradiating LEU targets in the reflector region of the reactor will not place the MURR facility within any of the three definitions of a "production facility" provided in the regulations. The In-Pool activities do not fall within the first definition of "production facility" because MURR and the In-Core activities will continue to not be "designed or used primarily for the formation of plutonium or uranium 233." Likewise MURR and the In-Pool activities do not fall within the second definition, because they will not be "designed for the separation of isotopes of plutonium." In regard to the third definition, MURR and the In-Pool activities will not become a facility designed or used for the processing of irradiated material containing SNM.

However, the irradiated targets will contain SNM. Thus, the Ex-Pool activities—which involve processing the irradiated targets to extract the Mo-99—will be designed or used for processing of irradiated material containing SNM and, as such, satisfy the third definition. Therefore, the Ex-Pool activities would constitute a "production facility" as defined at § 50.2.

Accordingly, MURR plans to submit a license amendment request seeking addition of the production facility to its existing license, R-103, which also authorizes its existing utilization facility.

D. Will a change from a class 104c license (10 CFR 50.21) to class 103 (10 CFR 50.22) be required? (non-commercial vs. commercial)

MURR's position is that no change in class of license (104c) will be required.

Analysis:

MURR's existing license was issued pursuant to Section 104(c) of the AEA and 10 CFR 50.21(c) which authorize issuance of licenses to non-commercial facilities "useful in the conduct of research and development." As summarized in Attachment 1 to this letter, MURR is and will remain a research-focused educational institution. Per Commission regulations at 10 CFR 50.22, such facilities are not considered commercial unless "more than 50 percent of the annual cost of owning and operating the facility" is devoted to commercial purposes. In other words, annual facility *costs*, not annual facility outputs, are the measure of commercial status.

Less than 50% of the annual cost of owning and operating MURR is devoted to commercial purposes. MURR fully intends to continue its practice of expending greater than 50% of its owning and operating budget towards research and education. This SGE project will further contribute to MURR's ability to fund research and educational activities at the University of Missouri.

Thus, according to the long-standing codified NRC standard, which reflects the NRC's intent to provide wide latitude to educational reactor facilities, and is consistent with Congressional direction to impose only "minimum" regulation on educational reactor facilities,[4] MURR's license would remain class 104c.

[4] "The Commission is *directed* to impose only such *minimum amount of regulation* of the licensee as the Commission finds will permit the Commission to fulfill its obligations under this Act to promote the common defense and security and to protect the health and safety of the public and will permit the conduct of widespread and diverse research and development." AEA § 104(c) (emphasis added).

This letter does not constitute MURR's licensing request, but is intended to request the NRC to identify areas of regulatory concern, if any, for MURR to address in its subsequent formal request.

We would appreciate your response at your earliest convenience as we plan to submit our license amendment request early this year, 2017.

Respectfully submitted,

Ralph A. Butler, P.E.
Director

xc: Reactor Advisory Committee
Reactor Safety Subcommittee
Dr. Garnett S. Stokes, Provost
Dr. Mark McIntosh, Interim Vice Chancellor for Research
Mr. Alexander Adams, U.S. Nuclear Regulatory Commission
Mr. Geoffrey Wertz, U.S. Nuclear Regulatory Commission
Mr. Steven Lynch, U.S. Nuclear Regulatory Commission

Attachment:
1. Background and Overview of MURR Reactor Core and Reflector Regions

ATTACHMENT 1

Background and Overview of MURR Reactor Core and Reflector Regions

I. Background

The University of Missouri-Columbia Research Reactor (MURR) holds Amended Facility Operating License No. R-103, issued on October 11, 1966, pursuant to 10 C.F.R. Part 50, authorizing the University of Missouri (MU) to operate the facility as a research reactor, initially up to a maximum steady-state power level of 5 MWt. On July 9, 1974, Amendment No. 2 was issued by the NRC authorizing the University to operate the research reactor at steady-state power levels up to 10 MWt.

MURR is a multi-disciplinary research reactor and education facility providing a broad range of analytical, radiographic and irradiation services to the research community and the commercial sector. MURR staff and colleagues perform research for improving medical diagnostic tools and finding ways to battle cancer and other diseases with radioisotopes. MURR is a leader in radiopharmaceutical research that is used for detecting and treating cancer and other chronic human diseases.

MURR's focus on interdisciplinary research and development also contributes to the University's educational mission, providing rich research and training opportunities for an international population of graduate and undergraduate students. MURR-based projects cover such disciplines as anthropology and archaeology, chemistry, engineering (chemical, electrical, mechanical and nuclear), geology, materials science, medical and life sciences (including cancer diagnostics, treatment and prevention), nutrition, physics and veterinary medicine. In addition to MU students, over a five-year period MURR typically accommodates an average of over 300 faculty/research scientists and approximately 150 graduate students from the MU System (*including the Columbia, Rolla, St. Louis and Kansas City campuses*) and over 100 students from other universities who performed research involving the facility.

As an integral component of MU's campus-wide interdisciplinary research and education initiatives, MURR scientists provide lectures and demonstrations for approximately 30 MU classes each year that illustrate scientific and engineering concepts. MURR scientists and engineers conduct facility tours for over 1,000 persons each year from state, national, and international groups, professional and student chapters of organizations (*e.g., the Institute of Nuclear Materials Management*), secondary science and math classes, government and industry. MURR scientists also participate in more extensive laboratory experiences to support classes at MU and other schools for students in Chemistry/Radiochemistry, Physics and Engineering.

MURR proposes adding an additional experimental facility, the General Atomics' (GA) SGE experiment, with which target assemblies containing low-enriched uranium (LEU) will be irradiated to produce fission product Mo-99. This experiment will expand MURR's research and developmental curriculum and supply an essential isotope to the medical community.

II. MURR Reactor Core and Reflector Regions