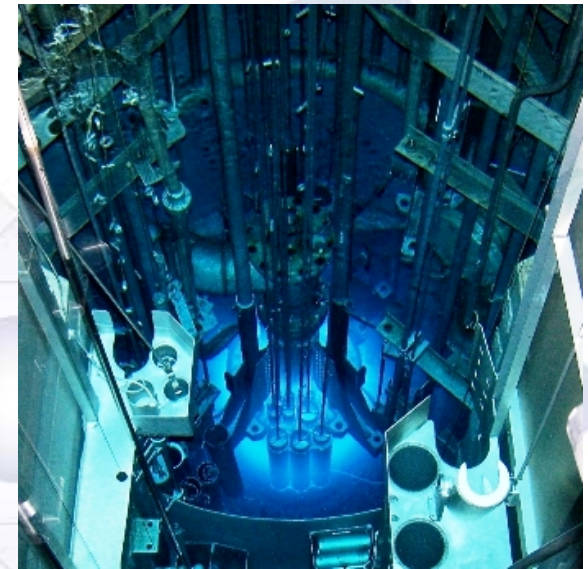


Conversion of the University of Missouri-Columbia Research Reactor (MURR) from HEU to LEU Fuel



Presentation Topics

- Facility Overview
- Key Reactor Parameters
- Confirmation of Overall Objective
- Background
- Regulatory Options
- Path Forward

Facility Overview

Location:

On the University of Missouri main campus in Columbia, Missouri. (~200 km West of St. Louis)

History:

- First critical on October 13, 1966 (Licensed at 5 MW)
- Up-rated and licensed at 10 MW in 1974
- Started ≥ 150 hours/week operation in September 1977
- Goal for conversion to LEU fuel is July 2016

Purpose:

Multi-disciplinary research and education facility also providing a broad range of analytical and irradiation services.

Key Reactor Parameters

- MURR is a pressurized, reflected, heterogeneous, open pool-type, which is light-water moderated and cooled.
 - Maximum power – **10 MW_{th}**
 - Peak flux in center test hole – **6.0E14 n/cm²-s**
 - Core – **8 fuel assemblies (775 grams of U-235/assembly)**
 - Control blades – **5 total: 4 Boral shim-safety, 1 SS regulating**
 - Reflectors – **beryllium and graphite**
 - Forced primary coolant flow rate – **3,750 gpm (237 lps)**
 - Forced pool coolant flow rate – **1,200 gpm (76 lps)**
 - Primary coolant temps – **120 °F (49 °C) in, 136 °F (58 °C) out**
 - Primary coolant system pressure – **85 psia (586 kPa)**
 - Pool coolant temps – **100 °F (38 °C) in, 106 °F (41 °C) out**
 - Beamports – **three 4-inch (10 cm), three 6-inch (15 cm)**

Confirmation of Overall Objective

- Key Cornerstones
 - ✓ Modify MURR License Consistent with NRC HEU-LEU Objectives
 - ✓ Maintain Current MURR Research Reactor Status
 - ✓ Minimize Regulatory Risk
 - ✓ Timeliness of Licensing Actions

Driver for Change

- MURR currently operates at a thermal power level of 10 MW using HEU aluminide dispersion fuel loaded to a density of 1.52 grams of HEU/cc.
- Because of its compact core design, MURR can not perform its mission with any currently qualified LEU fuels.
- The US Department of Energy (DOE) Reduced Enrichment for Research and Test Reactors (RERTR) Program supports the minimization and, to the extent possible, elimination of the use of HEU in civilian applications by working to convert research reactors and radioisotope production processes throughout the world to LEU.

Driver for Change

- MURR is cooperating with the RERTR Program to convert MURR from HEU to an LEU U-10Mo monolithic foil fuel with a density of 15.2 grams of LEU/cc. This fuel is in the process of being developed and qualified.
- Non-power reactors authorized to possess and use HEU fuel are required by 10 CFR § 50.64 to convert to LEU fuel if federal funding is available, unless specifically exempted because of a *unique* purpose.
- In order for MURR to maintain the same level and spectrum of key neutron fluxes at 10 MW with HEU fuel, a power uprate to at least 12 MW with LEU fuel is required.

8 Comparison of Fluxes & Reaction Rates LEU to HEU Fuel - 10 MW

Metric	Neutron Energy Range					
	≤ 1 eV		> 1 eV		Sum	
LEU Core 10 MW, Week 79, Day 2 Critical Bank 23.481 inches withdrawn, Regulating Blade 15 inches withdrawn						
S-32 (n,p) reactions in FT Tube B 13-15"	n/a	n/a	95%	$\pm 0.3\%$	95%	$\pm 0.3\%$
Flux in FT Tube B 13-15"	87%	$\pm 0.1\%$	93%	$\pm 0.1\%$		
Ir-191 (n, γ) reactions in FT Tube C 17-20"	87%	$\pm 0.3\%$	93%	$\pm 1.5\%$	87%	$\pm 0.3\%$
Ir-193 (n, γ) reactions in FT Tube C 17-20"	87%	$\pm 0.3\%$	88%	$\pm 1.9\%$	87%	$\pm 0.5\%$
Flux in Ir wires of FT Tube C 17-20"	87%	$\pm 0.3\%$	92%	$\pm 0.4\%$		
Flux in Wedge #3 Row 1 P-Tube Bottom 3"	86%	$\pm 0.1\%$	91%	$\pm 0.2\%$		
Si-30 (n, γ) reactions in Green-5 Position	88%	$\pm 0.0\%$	90%	$\pm 1.4\%$	88%	$\pm 0.1\%$
Flux in Green-5 Position	88%	$\pm 0.0\%$	91%	$\pm 0.1\%$		

Comparison of Fluxes & Reaction Rates LEU to HEU Fuel - 12 MW

Metric	Neutron Energy Range					
	≤ 1 eV		> 1 eV		Sum	
LEU Core 12 MW, Week 79, Day 2						
Critical Bank 23.481 inches withdrawn, Regulating Blade 15 inches withdrawn						
S-32 (n,p) reactions in FT Tube B 13-15"	n/a	n/a	113%	$\pm 0.3\%$	113%	$\pm 0.3\%$
Flux in FT Tube B 13-15"	104%	$\pm 0.1\%$	112%	$\pm 0.1\%$		
Ir-191 (n, γ) reactions in FT Tube C 17-20"	104%	$\pm 0.4\%$	112%	$\pm 1.8\%$	105%	$\pm 0.4\%$
Ir-193 (n, γ) reactions in FT Tube C 17-20"	104%	$\pm 0.4\%$	106%	$\pm 2.3\%$	105%	$\pm 0.7\%$
Flux in Ir wires of FT Tube C 17-20"	105%	$\pm 0.4\%$	110%	$\pm 0.5\%$		
Flux in Wedge #3 Row 1 P-Tube Bottom 3"	104%	$\pm 0.1\%$	110%	$\pm 0.2\%$		
Si-30 (n, γ) reactions in Green-5 Position	105%	$\pm 0.0\%$	108%	$\pm 1.7\%$	105%	$\pm 0.2\%$
Flux in Green-5 Position	105%	$\pm 0.0\%$	109%	$\pm 0.1\%$		

Background

- Regulatory Posture of MURR
 - ✓ Definition of a Class 104c Facility Under 10 CFR 50.21 and Associated Requirements
 - ✓ Definition of a Non-Power Reactor Under 10 CFR 50 and Associated Requirements

Background

- Under 10 CFR 50, “Domestic Licensing of Production and Utilization Facilities,” the MURR is classified as a *non-power reactor*.
- 10 CFR § 50.2 defines a *non-power reactor* as a research or test reactor licensed under §§ 50.21(c) or 50.22 of Part 50 for research and development.
- MURR is classified as a *research reactor*, as defined in 10 CFR §§ 170.3 and 171.5.
- Under § 50.21, the MURR is licensed as a Class 104c facility - Amended Facility License No. R-103 (NRC Docket No. 50-186).

Background

- 10 CFR § 50.2 defines a *testing facility* (or *test reactor*) as a nuclear reactor which is of a type described in § 50.21(c) of Part 50 and for which an application has been filed for a license authorizing operation at:
 - (1) A thermal power level in excess of 10 megawatts; or
 - (2) A thermal power level in excess of 1 megawatt, if the reactor is to contain:
 - (i) A circulating loop through the core in which the applicant proposes to conduct fuel experiments; or
 - (ii) A liquid fuel loading; or
 - (iii) An experimental facility in the core in excess of 16 square inches in cross-section.

Background

- The proposed MURR power uprate to overcome the conversion flux penalty will result in a thermal power level greater than criterion (1), but MURR does not seek any of the operating states of criterion (2).

Regulatory Options

- It appears that the following three regulatory paths or options are available for the MURR to uprate in power greater than 10 MW to overcome the flux conversion penalty:
 1. Apply for an exemption from the *testing facility* classification based on the need to increase power in order to maintain the same performance as the current HEU fuel; or
 2. Petition for rule making to revise the definition of a *testing facility*; or
 3. License the facility as a *testing facility*.

Atomic Energy Act of 1954, as Amended

Section 31, “Research Assistance,” states:

a. The Commission is directed to exercise its powers in such manner as to insure the continued conduct of research and development and training activities in the fields specified below, by private or public institutions or persons, and to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in such fields. To this end the Commission is authorized and directed to make arrangements (including contracts, agreements, and loans) for the conduct of research and development activities relating to-

Atomic Energy Act of 1954, as Amended

- (1) nuclear processes;
- (2) the theory and production of atomic energy, including processes, materials, and devices related to such production;
- (3) utilization of special nuclear material and radioactive material for medical, biological, agricultural, health, or military purposes;

Atomic Energy Act of 1954, as Amended

- (4) utilization of special nuclear material, atomic energy, and radioactive material and processes entailed in the utilization or production of atomic energy or such material for all other purposes, including industrial or commercial uses, the generation of usable energy, and the demonstration of advances in the commercial or industrial application of atomic energy;
- (5) the protection of health and the promotion of safety during research and production activities; and
- (6) the preservation and enhancement of a viable environment by developing more efficient methods to meet the national energy needs.

Path Forward

- Regulatory and Licensee Actions
- Review Process
- Timetables

Path Forward

- Regulatory and Licensee Actions
 - ✓ What actions are required of the NRC?
 - ✓ What actions are required of MURR?
- Review Process
 - ✓ What does the review process consist of?
 - ✓ Review process dependent on option taken.
- Timetables
 - ✓ Conversion of MURR is targeted for July 2016
 - ✓ Submittal date dependent on option taken.
 - ✓ How long will process take, dependent on option taken.

