A Lesson in Humility….How NOT to Handle a Fresh Fuel Element

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Presentation Overview

- General Overview of the MURR® Facility
- Description of a MURR Fuel Element
- Description of the Fuel Element Handling Event
- Causal Analysis
- Corrective Actions
- Summary

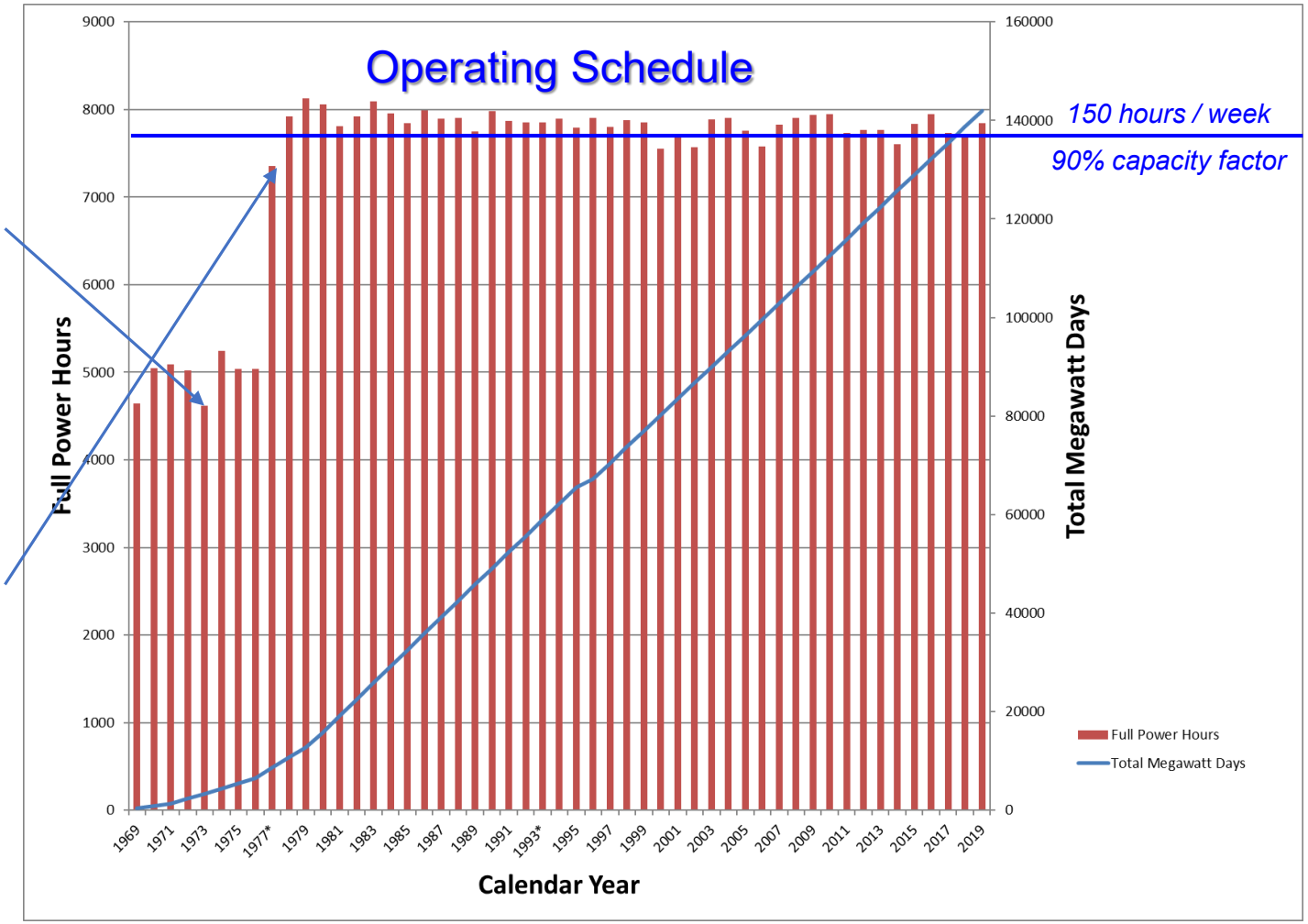
Overview of MURR

- ✓ Reactor is online 24 hours a day, 6.5 days a week, 52 weeks a year
- ✓ ~210 full-time employees and ~40 students
- ✓ In 2019, MURR produced 33 different isotopes with 2,491 shipments to 9 different countries over 3 continents
- ✓ Each and every week MURR supplies the active ingredients for five FDA-approved drugs: Quadramet®, TheraSpheres®, Lutathera®, RadioGenix® and Iodine-131
- ✓ Currently sole producer of I-131 and Mo-99 in North America

Overview of MURR

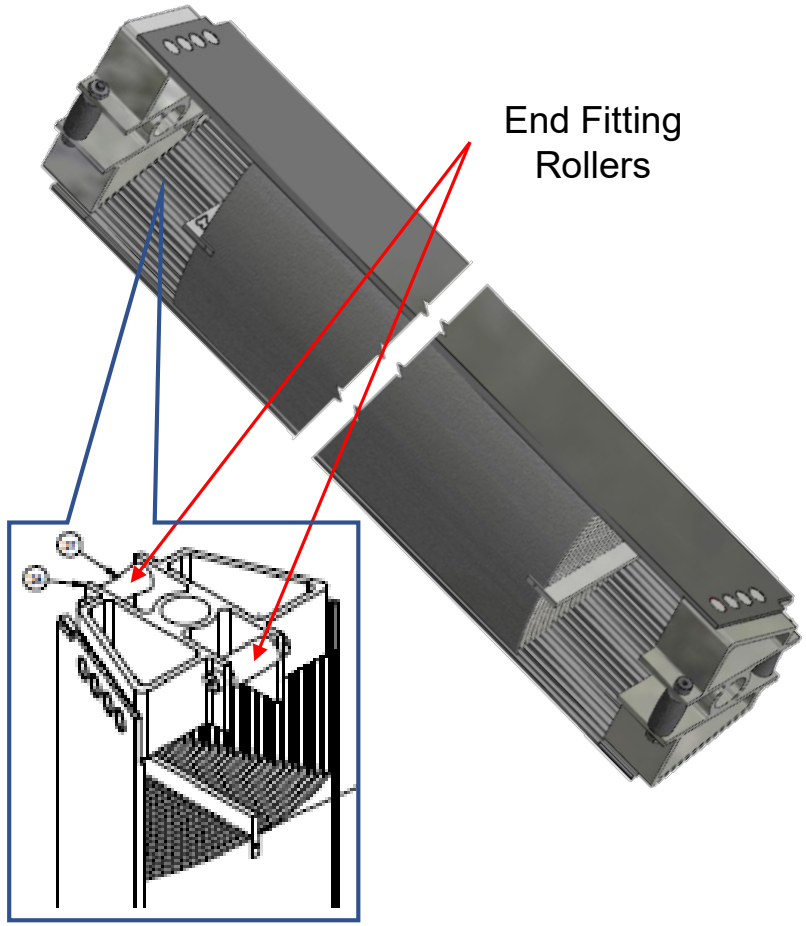
In 1974, uprated in power from 5 to 10 MW

In 1977, started 150 hours per week operation



Description of MURR Fuel Element

Description	Nominal Value
Fuel Material	
Type	Aluminide-UAl_x mostly UAl_3 Phase
Enrichment ^{235}U	93%
Thickness	**0.020 inches (0.508 mm)**
Cladding	
Material	Aluminum Alloy 6061
Thickness	**0.015 inches (0.381 mm)**
Fuel Assembly	
Number of Fuel Plates	**24**
Innermost Fuel Plate Center Radius	2.795 inches (7.099 cm)
Outermost Fuel Plate Center Radius	5.785 inches (14.694 cm)
Overall Fuel Assembly Length	**32.5 inches (82.550 cm)**
Overall Fuel Plate Length	**25.5 inches (64.770 cm)**
Overall Active Fuel Length	**24.0 inches (60.960 cm)**
Fuel Plate Thickness	**0.050 inches (1.270 mm)**
Distance Between Fuel Plates	**0.080 inches (2.032 mm)**
Nominal ^{235}U Loading	775 grams
Element Weight	**6.25 kg**



Description of Fuel Handling Event

- On the evening of August 23, 2020, using the decades-old practice of employing a loop of rope through the fuel element upper end fitting, the on-shift crew lowered fresh elements one at a time into their respective reactor pool storage locations.
- When a fuel element is securely in its storage position, one end of the rope is dropped into the water while the other end is slowly pulled up out of the water. Normally, the rope that is looped through the fuel element end fitting easily comes through the element roller gap and is brought back to the pool surface.
- However, during the handling evolution of fuel element MO-993, the rope became stuck (pinched) beside one of the rollers.
- At this point, the Lead Senior Reactor Operator (LSRO) called the Acting Reactor Manager to discuss the issue and obtain an approved plan of action.

Description of Fuel Handling Event

- Previously, on January 22, 2017, a similar situation had occurred and the reactor operators resolved this by using the fuel handling tool to move the fuel element into the fuel element inspection rig.
- The fuel element was then unlatched from the fuel handling tool and the element was elevated near the pool surface using the inspection rig. Once the fuel element was near the surface, the reactor operators were able to free the rope from the element.
- The Acting Reactor Manager and LSRO decided to free the rope using this same method. Additionally, the Acting Reactor Manager instructed the LSRO to ensure that the rope did not interfere with latching of the fuel element.
- The fuel element was latched with the fuel handling tool and moved to the fuel inspection element rig; however, the rope did interfere with latching of the element to a point that the fuel element would not unlatch from the fuel tool.

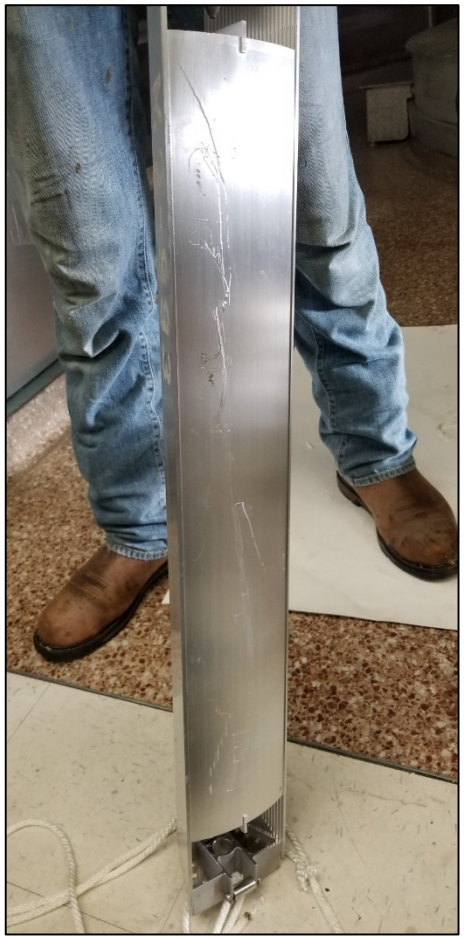
Description of Fuel Handling Event

- The LSRO and crew decided to hand lift the fuel handling tool with the fuel element latched onto it while simultaneously raising the fuel element inspection rig.
- The fuel handling tool is approximately 30 feet long with a buoyancy-assist tank, heavy and not designed to be manipulated out of the pool. When the operators tried to manually support most of the fuel tool's length and weight vertically, they lost control of the fuel tool with the fuel element attached.
- The fuel handling tool and element dropped until the rope tied between the top of the fuel tool and the overhead crane became taut, allowing the fuel tool with the latched fuel element to swing within the reactor pool and collide with the side of the pool and other equipment in the pool, thus damaging the element.
- After this occurred, the LSRO called the Acting Reactor Manager again. The Acting Reactor Manager notified the other Reactor Operations managers and the Associate Director, Facilities Operations (Fuel Contract PI).

Description of Fuel Handling Event

- Before the managers arrived at the facility, the LSRO attempted to open the latching fingers on the fuel handling tool with a flat tip screwdriver to free the fuel element. This caused bending of the top of Plate 24, thus resulting in partial closure of the coolant gap between Plates 23 and 24.
- The Acting Reactor Manager, the other Reactor Operations managers, and Mechanical Support Staff arrived at the facility that morning to implement recovery actions, which included freeing the damaged fuel element from the fuel handling tool.
- After the casual analysis was performed and corrective actions identified, DOE/INL was informed of the event – although not promptly enough.
- The damaged fuel element was eventually shipped back to BWX Technologies.

Description of Fuel Handling Event




Causal Analysis

In human performance terms, this event was caused by many latent conditions. The initiating action, the rope becoming stuck in the fuel element, moved the reactor operators from skills-based performance (the "routine" movement of fresh fuel to the reactor pool) into rule-based performance (using the fuel inspection rig to free the rope), which increased the probably for error. Then, the fuel handling tool becoming stuck on the fuel element changed the operators into knowledge-based performance, which increased the probably for error even more.

The following are specific-identified causes for the fuel handling event:

1. Use of rope to lower a fresh fuel element into the reactor pool (the initiating action of this event was the rope getting stuck beside one of the fuel element rollers).
2. Lack of a formal procedure for moving fresh fuel from dry storage to the reactor pool.

Causal Analysis

3. Lack of written guidance on what to do if a problem occurs during fuel handling.
4. Lack of management oversight when a problem occurred during the handling of nuclear fuel. The only oversight was provided by the LSRO who was also directly involved (hands on) in attempting to free the rope.
5. Decreased organizational sensitivity to handling nuclear fuel.
6. The initial fuel handling and subsequent attempt to free the stuck rope from the fuel element occurred during a weekend night shift.
7. Lack of controlling error-likely situations and not stopping when unsure.

Corrective Actions

1. The use of rope to lower fresh fuel elements into the reactor pool was immediately stopped. (CA#1&2)
2. A basket was designed and fabricated to lower fresh fuel elements into the reactor pool. (CA#1&2)
3. Two Standing Orders, SO 20-09 and 20-10, were immediately issued to provide detailed guidance/steps on how to handle fresh fuel elements and to explain the importance of this evolution. (CA#3,4,5&6) Some of the significant changes/additions were:
   - ✓ A Reactor Operations manager shall be onsite and aware of any fuel movements
   - ✓ If any abnormality occurs during fuel handling, (1) the fuel element shall be placed in a safe condition, (2) all fuel movements shall cease, and (3) the onsite Reactor Operations' manager shall be immediately contacted
   - ✓ Fuel handling will occur during dayshift, unless specifically approved by the Reactor Manager

Corrective Actions

4. Reactor Operations operating procedure OP-RO-250, “In-Pool Fuel Handling,” was revised to permanently implement SOs 20-09 and 20-10 AND a requirement was added to notify the fuel owner within 48 hours if any damage to a fuel element, fresh or irradiated, has occurred. (CA#3,4,5&6)
5. Specific fuel handling sensitivity and human performance training for all of Reactor Operations was completed on November 30, 2020. (CA#5&7)
6. Human performance refresher training is now scheduled every 2 years for reactor operators, including Reactor Operations management. This has been entered into the MURR Commitment Tracking System as commitment CT-114. (CA#7)
7. Finally…present a Lessons Learned presentation regarding the fuel element handling event at the 2021 TRTR Annual Conference.

Summary

- When is routine not routine? Anytime it involves handling nuclear fuel.
- When ANY issue with a fuel element occurs immediately stop and gather all of the right people to outline a corrective action plan – there is absolutely no need to rush to correct the situation.
- Individuals involved were not new nor inexperienced – this may lead to a situation where they will not ask for assistance until its too late.
- Initial AND recurring human performance training is essential for any group conducting critical tasks, such as handling nuclear fuel.
- Any fuel issues shall promptly (within 48 hours) be reported to DOE/INL office.


Thanks for your attention, questions?