10 Years at the Maryland University Training Reactor: A Retrospective

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10 years ago the Maryland University Training Reactor was nearly shut down for decommissioning. Since then a new staff has overhauled the reactor and implemented a number of improvements to reactor operations and usage. This presentation will describe these upgrades and lessons learned as the Maryland University Training Reactor was returned to being a valuable resource for science and education.

1. Introduction

The Maryland University Training Reactor (MUTR) is the centerpiece of University of Maryland Radiation Facilities in College Park, Maryland. The MUTR is a 250 kW TRIGA (Training Research Isotopes - General Atomics) conversion reactor used for education, training, and research. 5 experimental facilities provide access to neutrons and gamma rays for experimenters, while the excellent safety properties of TRIGA reactors make it ideal for supporting student training programs. This paper details the efforts of the MUTR staff to modernize the reactor facility while improving its utilization over the last 10 years.

2. History

The first nuclear reactor at the University of Maryland, the University of Maryland Reactor (UMR), was a 10 kW MTR reactor constructed in 1960 to support the school's new Nuclear Engineering program. The reactor was designed and built by Allis-Chalmers and utilized highly enriched plate fuel. The reactor program got off to a strong start and supported 14 PhD or MS theses by 1966. In 1969 planning began to upgrade the reactor to its current 250 kW TRIGA core, both to improve experimental capabilities, and to remove the burden of highly enriched fuel.

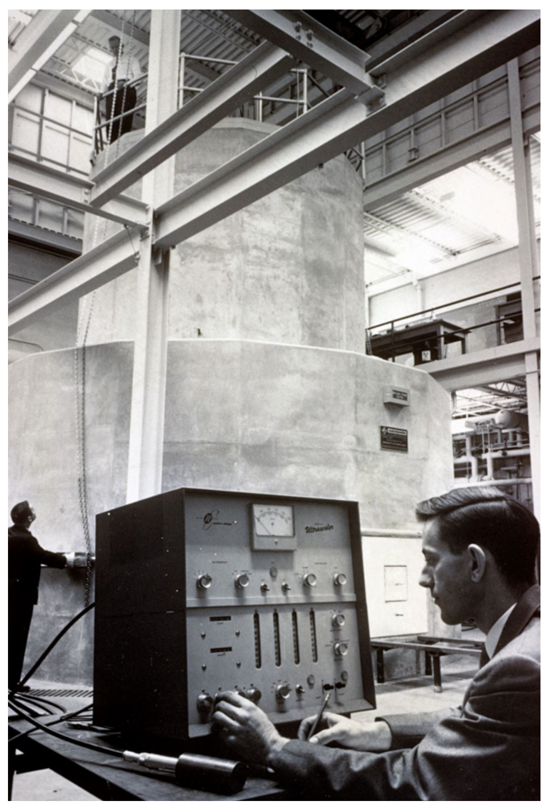

Figure 1: The University of Maryland Reactor shortly after construction.

The conversion process was completed in 1974, and the upgraded reactor became known as the Maryland University Training Reactor. Despite the upgrades, usage of the reactor declined, and it averaged less than 1 hour of full-power operations per week through most of its history. In 2002, University of Maryland's Nuclear Engineering program was dissolved and the MUTR moved to the Materials Science and Engineering Department (MSE).

Without a Nuclear Engineering Program, and following several regulatory violations and a significant contamination incident, pressure began to mount from the university administration to decommission the reactor. Ultimately, the decision was made in 2013 to appoint a new facility director who would be given the chance to revitalize the facility.

3. Facility Restoration

In order to provide a more inviting and safer environment for students and researchers the facility restoration began with the disposal of over 40 years' worth of radioactive samples, and cleanout of unnecessary equipment. An investment of more than $400,000 from the university enabled asbestos remediation, painting and new flooring, new furniture, and the installation of LED lighting. Repairs and upgrades to the HVAC systems not only improved staff comfort, but also the reliability of instrumentation and control systems which are no longer subject to wide temperature variations. With these upgrades, as can be seen in the photos below, the reactor facility is now bright and clean, presenting far fewer impediments to its usage.

Figure 2: The MUTR Experimental Floor before (left) and after (right) renovations.

4. Licensing

Another major focus in 2013 was the completion of the reactor relicensing, which had been ongoing since 2000. The relicensing was completed in December 2016 after a nearly 17 year effort and allowed the MUTR to receive additional fuel.

5. Reactor Fuel

One of the challenges facing the MUTR is that after nearly 50 years of operation without refueling, the reactor is no longer able to reach its full licensed power of 250 kW. The US Department of Energy's (DOE) University Fuel Services Program stepped in to provide additional fuel, however, at that time, the TRIGA fuel production line was shut down, and no new TRIGA fuel was available. Therefore, it was decided to return lightly used fuel from long-term storage at Idaho National Laboratory which could be reused at the MUTR.

The MUTR was the first reactor to receive any of this lightly used fuel when it was delivered in March of 2017. The delivery of the new fuel also presented the opportunity to use an underwater camera in the reactor pool; at that time, it was discovered that approximately half of the MUTR fuel was not properly seated in the grid plate as shown below. Although no cause for the improper seating could be determined at the time, the safety consequences were determined to be minimal, and the reactor continued operating.

Figure 3: Fuel is transferred from a shipping cask to the MUTR in March 2017.

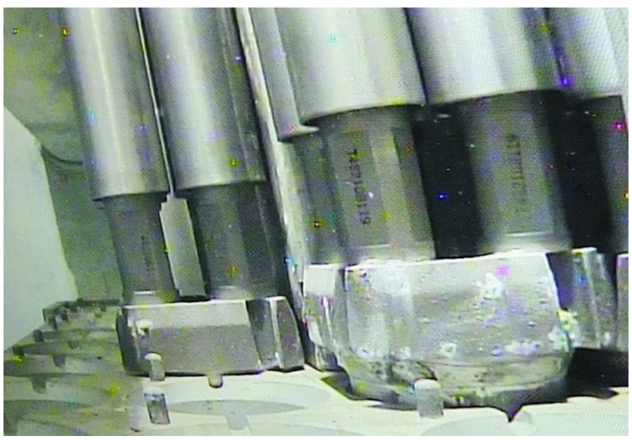

Figure 4: The MUTR core showing a properly position fuel bundle (left) and one not fully seated in the grid plate (right) as found in 2017.

The fuel received in 2017 was initially licensed only for storage and could not be added to the reactor core. A license amendment to allow for its use was applied for in 2018 and received in 2020. In early 2021, the individual fuel elements were assembled into bundles to be added to the MUTR core; however, it was found that these new bundles could not be made to fit into the grid plate. Following an investigation, it was found that the original MUTR fuel bundles had been installed in the wrong orientation in 1974. The fuel bundles are therefore interfering with one another, preventing some from seating properly in the grid plate and blocking the addition of new bundles.

In order to rectify the fuel bundle orientation, and to add additional fuel to the core, tools to rotate all fuel bundles were purchased with the support of the DOE's Nuclear Engineering University Program (NEUP) in 2023. With these tools, the MUTR staff aims to complete the project by the end of 2023.

6. Reactor Cooling

With the anticipated ability to operate the reactor at 250 kW the lack of a secondary coolant system, which had to be removed from service in 2021 due to the inability to meet license requirements, will become a major problem. Without secondary cooling the reactor pool will increase in temperature by approximately 10 °C per hour while operating at 250 kW, and will cool only slowly. The entire MUTR coolant system outside of the pool, which has not received significant maintenance or upgrades in approximately 25 years, is being targeted for replacement with another NEUP grant request. The proposed upgrades include an air-cooled chiller to provide secondary cooling and enable continuous operations at full power if desired.

7. Instrumentation and Control Systems

From 2020 through 2022 significant upgrades to the MUTR Instrumentation and Control systems were completed including the replacement of 6 scram channels, the installation of digital recorders and displays, development of an improved control rod position indicator system, and a general cleanout and reorganization of the control console as shown in the before and after photos below.

Figure 5: The MUTR Console before (left) and after (right) upgrades.

These upgrades were completed without significant disruption to reactor operations, and were largely funded by NEUP grants. The I&C upgrades have enabled far more reliable operations, with the number of unscheduled shutdowns caused by instrument deficiencies dropping from 29 in the 9 months prior to project completion to 0 in the 9 months since.

8. Reactor Experiments

A goal of the current MUTR staff is to increase the experimental capabilities and usage of the MUTR. Following the graduation of the last Nuclear Engineering graduate students in 2015, the experimental usage of the reactor has fallen off. The MUTR is equipped with 5 experimental facilities: 2 beam ports, a through tube running adjacent to the core, a thermal column, and a pneumatic rabbit system for in-core irradiations.

Due to the low power of the MUTR, there is limited usage of the reactor for irradiation experiments, therefore efforts are being made to develop neutron instrumentation to increase the relevancy of the reactor to UMD's MSE Department. A neutron imaging system was donated by the National Institute of Standards and Technology in 2015, and installed to make use of a beam of thermal neutrons from the thermal column. While it has found use in several projects, the low flux, small image size, and limited resolution of this system make it more useful as an educational tool rather than an experimental facility. Currently, planning is underway to develop a neutron imaging system utilizing a beam port at the MUTR that should offer greatly improved capabilities.

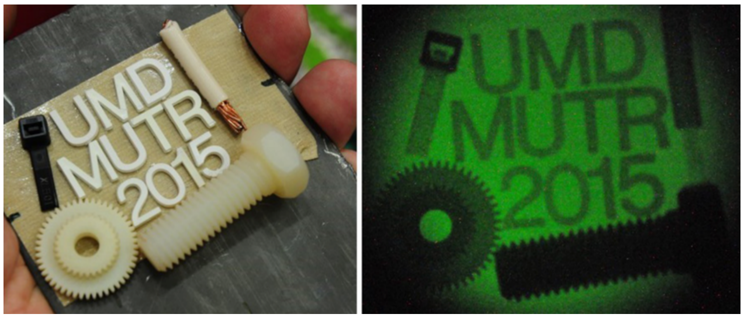

Figure 6: The first neutron image taken with at the MUTR in 2015.

Another facility soon to be under development is a neutron diffractometer utilizing another of the MUTR beam ports. A new graduate student in Materials Science starting this fall will design a diffractometer system with input from the MSE faculty to make it as relevant as possible to the department.

The MUTR staff has also worked to implement a neutron activation analysis (NAA) program utilizing the MUTR rabbit. This has come to fruition with commercial NAA work beginning in 2022. This capability also helped to support the mission of the NIST Center for Neutron Research in 2021 and 2022 while their reactor was shut down.

9. Operator Training

In 2014, a training program for undergraduate students to become licensed as Reactor Operators was restarted after a ~20 year hiatus, with the first students being licensed in 2015. The training program takes place over the course of 2 semesters, one for lectures on reactor theory, procedures, and regulations, and one for hands-on reactor operations. The year long program is open to students of all disciplines, and students completing the program have a roughly 50% placement rate in the nuclear industry. From 2015-2019 3-4 students were licensed per year, however, the COVID-19 pandemic caused significant disruptions, and only 2 students have been licensed since 2020. Efforts are underway to rebuild the operator population, and the goal is to license ~5 undergraduate students per year.

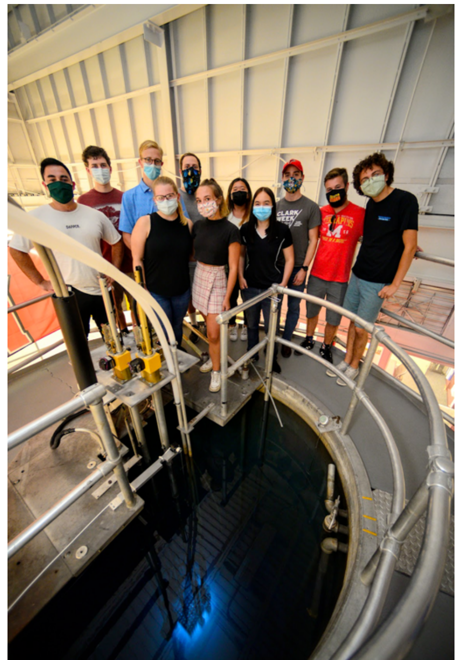

Figure 7: Reactor Operator trainees in 2021.

10. Outreach Efforts

Since 2014, the MUTR staff has also made significant efforts to increase local outreach. Approximately 1000 visitors each year now tour the reactor, many of these from local schools and universities, but also many from government agencies such as the Nuclear Regulatory Commission, Federal Emergency Management Agency, DOE, and Congress. The reactor staff also participates in many local science education events. Our "Master of Protons" guitar, made in 2022 with our particle accelerator facility has been key to attracting attention at these events! The guitar has also been recognized by Generation Atomic and the International Atomic Energy Agency. The reactor is also now used to support a Reactor and Radiation Measurements course in the UMD Mechanical Engineering department.

Figure 8: Master of Protons

11. Conclusion

Over the past 10 years, considerable upgrades have been made to the Maryland University Training Reactor, to improve the reliability and usability of the reactor, and to further its research and educational missions. This has been possible thanks to the support of the Department of Energy and the University of Maryland, and we strive to continue to improve utilization of the MUTR.