

# TRTR NEWSLETTER



**QUARTER**  
**2020**  
**FOUR**

## LETTER FROM THE CHAIR

Dear TRTR Members,

I would like to express my enthusiasm for the opportunity to work with you to further the achievements, interests, and prosperity of our community.

I also would like to thank the outgoing TRTR chair Clive Townsend for all his contributions and for organizing a successful TRTR meeting during a tumultuous 2020. I especially appreciate his helpful feedback as I transitioned into the Chair position.

As 2020 winds down, I am sure that we are all looking forward to a new beginning in 2021. During the upcoming year, I would like to capitalize on past achievements and to develop further all issues that may impact the productive operation of our facilities. This includes continuing the constructive relationships and dialogue with our stakeholders such as our home institutions, the regulator, funding agencies, and of course, our users. In that regard, TRTR working groups continue to consider issues related to the implementation of 10 CFR 50.59 screening and operator licensing regulations. White papers that express TRTR's position are being developed for both issues.

As a significant fraction of our constituency are university reactors, I hope that we can leverage the TRTR/NSUF "University Research Reactor Fitness Study Report" to investigate future funding directions with various sponsors. Related to that is coordination with the Nuclear Engineering Department Heads Organization (NEDHO) to promote our joint mission. As you know, in 2020, university reactors were awarded nearly \$2.7 million in infrastructure funding through DOE's NEUP program. In 2021, similar levels of funding are anticipated. However, I aim to explore with NEDHO and NEUP the potential for future expansion of the levels and scope of this funding.

Furthermore, in 2021 the TRTR community stands to play an important role in supporting the national mission for the development and implementation of advanced nuclear power reactors. Various concepts of these reactors are envisioned that belong to the small and/or micro reactor classification. Consequently, they may share operational, safety, and licensing characteristics that are typical of research



**AYMAN I. HAWARI, PH.D.**  
**NORTH CAROLINA**  
**STATE UNIVERSITY**  
**TRTR CHAIR**



**AMBER JOHNSON**  
**UNIVERSITY OF MARYLAND**  
**EDITOR**



**LUKE GILDE**  
**UNIVERSITY OF MARYLAND**  
**CONTENT EDITOR**

**CHECKOUT THIS DELICIOUS HOLIDAY ACTIVITY ON  
THE BACKPAGE OF THIS EDITION!**



reactors. In fact, I feel that our research reactors can serve as test and validation facilities to support this development effort. Consequently, I propose that we examine this issue and consider a proactive TRTR role.

Finally, I would like to thank our members, the TRTR executive committee, our treasurer (Tom Newton), and our secretary and newsletter editor (Amber Johnson). I also would like to acknowledge our collaboration with the Nuclear Energy Institute (NEI) and our NEI liaison (Hilary Lane). As I begin my Chair's term, I am benefiting significantly from their feedback and experience.

I sincerely wish you and your families a healthy and happy 2021. Our preparations are under way for TRTR 2021, which is to be held in Raleigh, North Carolina, around the end of August. We are excited and look forward to seeing you there.

Ayman I. Hawari  
Distinguished Professor & Director  
Nuclear Reactor Program  
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## LETTER FROM THE EDITOR

Hello TRTR Community,

I hope this message finds you, your family and friends well! In this issue, we bring you some lessons learned during the public health emergency that might inspire some additions to training or outreach programs. Also, I am excited by our backpage shielding activity. My children enjoyed the hands-on activity while the rest of their schooling has been virtual. Mostly they enjoyed eating their results!

In our next issue, we would like to cover maintenance issues and upgrades. I will reach out sometime early next year to gather information about various detector, console, beamline, and infrastructure upgrades. If you have something to share, please send me an email!

Continue to stay safe and healthy. I look forward to seeing everyone next year in North Carolina!! As always, reach out with any comments or suggestions for the newsletter. Take care,

Amber Johnson  
Director  
Radiation Facilities  
University of Maryland

Luke Gilde  
Reactor Manager  
Radiation Facilities  
University of Maryland

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# UPCOMING EVENTS

## **FEBRUARY 9-11, 2021**

Conference on Nuclear Training and Education  
<https://www.ans.org/meetings/view-331/>  
Amelia Island, Florida (Virtual)

## **APRIL 8-10, 2021**

ANS Student Conference  
<http://studentconf.ans.org/>  
Raleigh, North Carolina

## **MAY 23-28, 2021**

International Symposium on Reactor Dosimetry  
<http://isrd17.reactordosimetry.org/>  
Lausanne, Switzerland

## **JUNE 13-17, 2021**

American Nuclear Society Annual Meeting  
[http://www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1)  
Providence, Rhode Island

## **JUNE 21-25, 2021**

International Conference on Advancements in Nuclear  
Instrumentation Measurement  
<https://indico.utef.cvut.cz/event/23/>  
Prague, Czech Republic

## **MAY 30 - JUNE 4, 2021**

International Group on Research Reactors  
<https://igorr2020.org>  
Kazan-Russian Federation

## **OCTOBER 31-NOVEMBER 4, 2021**

American Nuclear Society Winter Meeting  
[http://www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1)  
Washington D.C.

## **JUNE 12-16, 2022**

American Nuclear Society Annual Meeting  
[http://www.ans.org/meetings/c\\_1](http://www.ans.org/meetings/c_1)  
Anaheim, CA

# IN THE NEWS

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## WINNERS OF THE IAEA 2020 CROWDSOURCING CHALLENGE ANNOUNCED

The IAEA has announced the winners of its crowdsourcing challenge which sought solutions for nuclear facility decommissioning, and radiological remediation. Winners included a system for imaging radioactive contamination, a robot for mapping of contaminated areas, and new simulation techniques.

## ESTABLISHING BORON NEUTRON CAPTURE THERAPY AS A ROUTINE TREATMENT OPTION

Compact accelerator based neutron sources have been developed that can provide Boron Neutron Capture Therapy within a hospital rather than at a reactor facility.

## UNIVERSITY OF ILLINOIS SEEKS APPROVAL FOR NEW RESEARCH REACTOR

University of Illinois is seeking to build a new microreactor to provide power to the campus. The proposed reactor is a Micro Modular Reactor from Ultra Safe Nuclear Corporation.

## THORIUM FUEL BEING DEVELOPED AT TEXAS A&M

Researchers in the Nuclear Engineering and Science Center (NESC) at Texas A&M University and the U.S. Department of Energy's (DOE) Idaho National Laboratory (INL) have partnered with Clean Core Thorium Energy (CCTE), a Chicago-based company, to fabricate a proprietary thorium-based nuclear fuel called Advanced Nuclear Energy for Enriched Life (ANEEL). Fuel samples will be fabricated at the NESC and sent to INL for irradiation testing.

## DOE ADVISED TO PREPARE FOR HFIR PRESSURE VESSEL REPLACEMENT

The Basic Energy Sciences Advisory Committee (BESAC) completed a report for the Department of Energy recommending that DOE "immediately" begin preparing to overhaul the High Flux Isotope Reactor (HFIR) at Oak Ridge National Lab.

## COMPANIES EXPLORING BORON NEUTRON CAPTURE THERAPY

Several companies are working on new Boron Neutron Capture Therapy systems to increase its clinical use.

## MICRO REACTORS TO POWER TRUCKS

A team of engineers at Argonne National Laboratory is proposing to use micro reactors to provide power to recharge new electric trucks in remote locations.

## SM-3 REACTOR MODERNIZED

The Research Institute of Atomic Reactors in Russia has announced that it has completed a modernization of the core of the SM-3 research reactor. The SM-3 is the world's highest flux research reactor.

## LARGE COMPONENTS OF RA-10 REACTOR IN PLACE

The primary coolant pumps for the RA-10 reactor under construction in Argentina have been put in place. The pumps were the last large component to be installed.

## DOE CHOOSES REACTORS FOR ADVANCED REACTOR DEMONSTRATION PROGRAM

The DOE has announced that X-Energy and Terrapower will receive approximately \$80 million to build demonstration reactors.

## IDAHO STATE CUTS RIBBON ON NEW CONSOLE

Idaho State University held a ceremony during Nuclear Science Week to inaugurate the new console for their AGN-201 reactor.

## NEW REACTOR EXPECTED IN HANFORD

Energy Northwest has partnered with X-Energy and Terrapower to build 2 new reactors for the DOE's Advanced Reactor Demonstration Program. At least one of these reactors may be built near Energy Northwest's Columbia Nuclear Generating Station near Hanford Washington.

## NUSCALE LOSES INVESTORS

8 of the 36 public utilities that had signed onto the construction of the first NuScale power plant have pulled out of the project.

## NEW SPACE REACTOR COMPANY

Los Alamos National Laboratory has signed an



## Mark Korol

### Tawfik M. Raby Scholarship Winner

Degree program: B.S. Mechanical Engineering

Degree date: May 2021

Reactor Operator License level: n/a

**What interested you in working at a reactor?** When I entered Mizzou's engineering program, I was interested in energy systems and the future of our energy grid, but like most freshman, I didn't know what path to take. I was presented with an opportunity during my sophomore year at university to work at the Missouri University Research Reactor (MURR) as a student technical assistant and during my interview process for the position, I also learned about MURR's summer RO internship. During the RO internship, I gained hands on experience in various disciplines of science and engineering and was challenged beyond my comfort zone, which has made me a better student and future

agreement to license the "Kilopower" space reactor technology to Space Nuclear Power Corporation (SpaceNukes). The Kilopower reactor is designed for use with a stirling generator in space.

### NEW IAEA COURSE ON NEUTRON IMAGING

The IAEA has launched a new neutron imaging E-learning course to aimed at young specialists, technicians and analysts.

### IDAHO NATIONAL LAB TO WORK ON HYDROGEN GENERATION PROJECT

Idaho National Laboratory will work with Xcel Energy on devising and building a hydrogen-energy production facility most likely at the Prairie Island Nuclear Generating Station in Red Wing, Minnesota. The DOE has awarded just under \$14 million for the project.

engineer.

**What reactor related projects are you involved with?** As a student technical assistant, I have worked on solid modeling, mechanical design, and drafting for various components involved in the various radiochemical processes that go on at MURR. I also am working with another undergraduate student on a flow characterization project for model validation of the MURR Graphite Reflector.

**Future plans, either with the reactor, outreach, or after graduation?** I plan on pursuing a PhD in Mechanical Engineering at MU. I hope to expand the work on the flow characterization project into my graduate research and I hope to be closely involved with MURR throughout the PhD. If this isn't too ambitious, I also hope to work towards and gain my RO license at MURR during my graduate studies. As I have done during undergrad, I look forward to any and all opportunities of outreach that MURR provides to Missouri, especially when we navigated beyond the current pandemic.

**Anything else you would like to add?** I'd like to thank all the staff at MURR for helping me find a clear path during my studies and for encouraging and challenging my academic and technical abilities. I'd also like to thank those at TRTR for awarding the Tawfik M. Raby memorial scholarship, which has been a blessing to me and my family during a time when everything else in the world had seemed uncertain.

### NUSCALE SIMULATOR FOR OREGON STATE

A new simulator facility of a Nuscale small modular reactor opened at Oregon State University. The simulator facility was paid for with a \$252,000 grant from the DOE. Similar simulator facilities are planned for Texas A&M University and University of Idaho.

### IDAHO PREFERRED LOCATION FOR VTR

The U.S. Department of Energy has stated that that Idaho National Laboratory will be listed as its preferred site for the new Versatile Test Reactor.

### NUCLEAR ENERGY IS THE SAFEST INDUSTRY

The nuclear industry is the safest job in America with less than 1 fatality per million worker-years. It is safer than jobs including accountant, actuary, computer systems analysts, dietitian, interpreter, and mathematician.

# PUBLIC HEALTH EMERGENCY

## LESSONS TO SHARE

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We are pleased to share some adaptations made by our member facilities in response to the public health emergency.

### WASHINGTON STATE UNIVERSITY NUCLEAR SCIENCE CENTER

**Maddison Heine**  
Research Operations Engineer

1. Virtual training – Washington State University started the school year and will continue practicing distance-based learning at least through the end of spring semester. To continue the growth of our training program we transitioned all training sessions from classroom/facility based to live virtual sessions. Students will begin training one at a time at the facility during spring semester to obtain the required operational hours and knowledge. To supplement the in and outs they may not observe with reduced facility time, the staff has implemented weekly quizzes, virtual office hours, and encourages virtual study groups. We are also working towards video SOPs, virtual operations – including pulsing, and system walkthroughs to offer students all resources necessary to prepare them for the exam. The changes ultimately take more time and effort from the staff to accomplish and require plasticity from both parties to adapt when our methods are unsuccessful. Our greatest tells of success are the routine quizzes and check-ins with the virtual trainees.

2. Virtual tours – To continue our mission of educating the public in nuclear science and of our facility operations, we have started offering live virtual tours. The tour guide is filmed as if the camera is the audience and speaks to the virtual visitors about the history of the facility, reactor physics, radiation basics, and reactor experiments. The use of Zoom allows for live Q&A during the tour to help navigate what the participants are interested in. We use a second camera, on a muted account from the pool room to show the virtual visitors

the operating reactor core – this has been the high point of the tour. Since the second camera is mute, there is no interference from the continuous air monitor or ventilation system. The tour guide can continue the tour from the quiet control room while the second camera stays focused on the reactor core.

### UNIVERSITY OF NEW MEXICO

**Carl Willis**  
Chief Reactor Supervisor

The pandemic has created many challenges for in-person lab course delivery at the University of New Mexico reactor. One result has been a new emphasis on generating video content to supplement introductory reactor operator training and our senior reactor laboratory. The hands-on experience is still vital, but having some supplementary material on video frees up time on the reactor itself for operations under limited occupancy. I made a public-facing introduction to our little AGN-201M reactor and posted it [here](#).

### UNIVERSITY OF MARYLAND RADIATION FACILITIES

**Luke Gilde**  
Reactor Operations Manager

University of Maryland's Radiation Facilities teaches a Reactor and Radiation measurements lab course for students in the Nuclear Engineering minor program each year. The course typically features hands-on experiments for gas filled radiation detectors, gamma ray and alpha particle spectroscopy, and neutron activation, as well as demonstrations with the Maryland University Training Reactor (MUTR). This year, the course was taught remotely which required significant changes. Several kits were developed to allow students to perform the experiments at home. These experiments included: performance characteristics of a Geiger-Müller tube,

radiation shielding, 1/R2 law, and scintillator gamma ray spectroscopy. Online simulations were used where it was impractical to give students the necessary materials to complete experiments at home such as short half-life sources to measure. To replace experiments typically performed with the MUTR, a [free TRIGA reactor simulator](#) from the Jožef Stefan Institute was used to perform a 1/M approach to criticality, control rod worth curves, and thermal power calibrations. These take home experiments and simulations helped to provide a more realistic lab experience for the students.

## **REED RESEARCH REACTOR**

**Patrick Park  
(RO, Physics '22)**

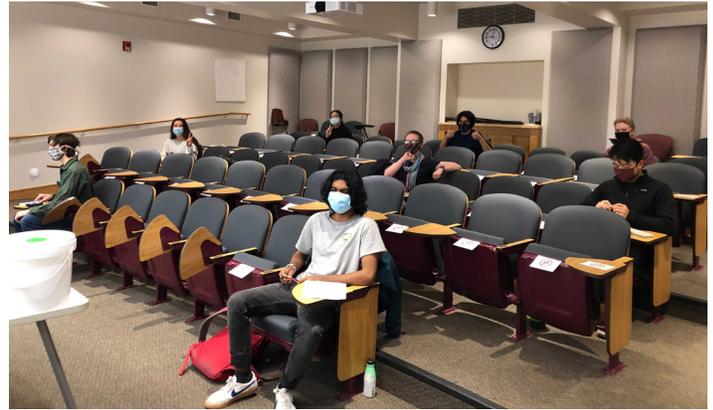
### **OPERATIONS**

Facility COVID-19 and remote work guidelines have been formulated by our Reactor Operations Manager, Toria Ellis (Physics '19).

Prior to coming into work, staff members must pass Reed's daily health check, which is an online questionnaire checking each participant's potential symptoms of the day. Additionally, Reed requires on-campus student workers to pass a COVID-19 saliva test twice a week. All events that require personnel in the facility must be pre-arranged on a shared staff Google calendar, such as reactor operations, surveillance checklists, and operator training. This is a more detailed addition to our normal scheduling system.

A shared calendar has had positive reviews from staff members. "I liked the use of the Google calendar," says supertrainee Orion Lee (Physics '23). "It made it very easy to know when I could go into the facility and when I could schedule things. But occupancy guidelines made it much more difficult to do biweekly [checklists] with a new trainee."

Inside the facility, ALARA principles of time, distance, and shielding are applied to COVID-19 prevention. While our facility classroom used to be a hub of socialization for our 40-student staff, we must now leave right after our job is complete. Stringent occupancy guidelines have been posted. For instance, up to 2 people are allowed in the Control Room, and up to 3 in our Reactor Bay. Preferably, less than 6 people should be in



**SUPERTRAINEES READY FOR THE NRC WRITTEN EXAM IN OCTOBER 2020. A FEW SUPERTRAINEES ELECTED TO TAKE THE YEAR OFF OR TAKE THE EXAM WITH THE NEXT TRAINEE CLASS.**

the facility in total. A face covering is always required.

Unfortunately, occupancy guidelines have limited the number of staff members that can work on a given task, which may limit sharing of facility knowledge. An anonymous staff member said, "In terms of myself, I am always hesitant to sign up for the job that the new trainees can do. I simply want them to take the chance to explore around reactor." Trainee Leandra Bruggink '24 added on: "Once when I was in the facility with some others to clean, the limitations for people in a room made it particularly difficult for operators and supervisors to point out things about the facility to me and other trainees."

Nevertheless, the Reed reactor has been able to continue operating, complete routine surveillance checklists, conduct maintenance, and accommodate student research. Since June 1, 2020, Reed College reports a total of 21 cases among 1,000 faculty, staff, and students currently on-campus. Training supervisor M Benesch (Linguistics '22) says, "Reed had a pretty good system in place with surveillance testing and contact tracing that I feel like we really benefited from."

### **TRAINING**

Reed operator training takes about 30 weeks, equally divided in the fall and spring semesters. It is open for all majors, although applicants must be first or second year students. Candidates must attend and pass a weekly battery of lectures, lecture quizzes, labs, and checkoffs. Trainees are neither paid nor given academic credit for training requirements.

Generally, around 50 students apply in the first week,

although many quit or fail the training requirements. 15 trainees are selected at the end of about two months of training. NRC exams traditionally occur in March during Week 24 of training, with the remaining 6 weeks dedicated to a short research project. For the 2019-20 training class, dubbed “supertrainees,” NRC exams were delayed to October 2020 because of COVID shutdowns in the spring.

During COVID-19, training supervisors Nemo Shen (Linguistics '21) and M Benesch needed to adjust the curriculum accordingly. “I think [we] did the best [we] could in the transition online,” says M, “I hope that we continue measures we have taken to increase the accessibility of the training program— recording and posting [online] lectures, not making synchronous lecture attendance mandatory, and not requiring physical presence at any events, at least this first semester.”

As of December 7, 2020, we are currently in Week 14 of training. Many trainees have only briefly been in the facility. Very few trainees have been able to participate in facility maintenance and checklists. No trainees have operated under direction yet.

“I'd say overall most online materials were pretty accessible,” says Leandra, “although anything related to the physical facility felt very abstract and difficult to conceptualize. Once I was able to visit the facility it felt like I had to relearn much of the stuff.”

Another trainee, Valerie Wu (Physics '24) says, “Overall I'm having a great online learning experience. I'm almost always able to get help when needed because everyone is so happy to help. That being said, I do think it would be helpful to have more videos that are filmed inside the facility because we don't get a lot of hands-on experiences.”

Staff members on the other side of training— giving lectures and checkoffs— also reflect:

Supertrainee Hart Monyatovsky (Biology '23) says, “I think that doing walkthroughs and checkoffs online was frankly exhausting, but it's also a decent system and keeps everyone safe from each other. At the same time, though, I think we're learning that so much more can be digitized than we wanted to admit. After all, there's no real reason that checkoffs have to be in-person.”

Supertrainee Amelia Schaeffer (Physics-Chemistry '23) also says, “I think finding ways to emphasize visual and spatial learning more would help the training program succeed. I helped with one lab where the trainees described it as a ‘first-person video game’ as they told the staff member who was live-streaming from the facility where to go and what to do to complete the lab. It was the most engaged I've seen the trainees, and many said afterwards how much more they felt they understood.”

## CONCLUSIONS

There are still some staff concerns about the facility. M says, “The problems of the Reed Research Reactor remain: a lack of continuation of projects and loss of institutional memory because by the time [trained staff] get around to making change, they're halfway out the door.”

“With COVID, I've been thinking a decent amount about the future of the facility,” says Amelia. “It's hard, because I do believe with the loss of time in the facility, our staff retention rate will drop off. I find myself thinking about [...] how we're going to maintain the coherence we had before the pandemic. I don't feel like I have any answers to the issue, aside from trying to stay involved and bond with trainees, but it's something I see and think about nonetheless.”

## A BUSY WEEK FOR THE FACILITY IN THE SHARED STAFF GOOGLE CALENDAR.



# NRC INSPECTIONS

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## Reed Research Reactor

July 20-24, 2020

The inspection included a review of organization and staffing, procedures, health physics, design changes, committees, audits and reviews, transportation, and confirmatory order follow-up. One Severity Level IV violation was found for an improperly performed 50.59 review of a ventilation system failure. The complete inspection report is [ML20237F406](#).



## University of Florida Training Reactor

July 27-29, 2020

The inspection included a review of activities related to security. No violations were identified. The notification of the inspection is [ML20219A719](#).



## Texas A&M Nuclear Science Center

July 27-30, 2020

The inspection included a review of activities related to security. Two Severity Level IV violations were identified. The notification of the inspection is [ML20220A483](#).



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## Penn State University Breazeale Reactor

July 27-30, 2020

The inspection included a review of organization and staffing, operations logs and records, requalification training, surveillance and limiting conditions for operation (LCO), emergency planning, maintenance logs and records, and fuel handling logs and records. No violations were identified. The complete inspection report is [ML20223A009](#).



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## Missouri University of Science and Technology Research Reactor

August 10-12, 2020

The inspection included a review of organization and staffing, operations logs and records, procedures, requalification training, surveillance and limiting conditions for operation (LCO), experiments, design changes, committees, audits and reviews, emergency planning, maintenance logs and records, and fuel handling logs and records. No violations were identified. The complete inspection report is [ML20248J267](#).



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## Massachusetts Institute of Technology Reactor

August 3-6, 2020

The inspection included a review of operator licenses, requalification, and medical examinations, experiments, organization and operations and maintenance activities, procedures, fuel movement, surveillance, and emergency preparedness. One finding of non-compliance was identified; however, enforcement discretion was exercised and no violation was issued. The complete inspection report is [ML20248H568](#).



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## Kansas State University Research Reactor

August 17-20, 2020

The inspection included a review of organization and staffing, operations logs and records, requalification training, surveillance and limiting conditions for operation (LCOs), experiments, design changes, committees, audits and reviews, emergency planning, maintenance logs and records, and fuel handling logs and records. No violations were identified. The complete inspection report is [ML20240A199](#).



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## Aerotest Research Reactor

August 10-12, 2020

The inspection included a review of staffing and audits, operator requalification and active license status, radiological surveys, surveillance, and emergency preparedness. One Severity Level IV violation was found for an RSO who did not meet the qualifications described in the Technical Specifications. Aerotest is [contesting](#) the ruling. The complete inspection report is [ML20240A252](#).



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## University of Wisconsin Nuclear Reactor

August 31 – September 2, 2020

The inspection included a review of organization and staffing, procedures, health physics, design changes, committees, audits and reviews; and, transportation activities. No violations were identified. The complete inspection report is [ML20260H076](#).



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## Walthausen Reactor Critical Facility

August 25-27, 2020

The inspection included a review of organization and staffing, operations logs and records, requalification training, surveillance and limiting conditions for operation (LCO), emergency planning, maintenance logs and records, and fuel handling logs and records. No violations were identified. The complete inspection report is [ML20261H594](#).



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## NIST Center for Neutron Research

August 3-7 and August 12, 2020

The inspection included a review of organization and staffing, review and audit and design change functions, procedures, radiation protection, effluent and environmental monitoring, and transportation activities. No violations were identified. The complete inspection report is [ML20232A844](#).



# AFRRI: SAFETY CONSCIOUS WORK ENVIRONMENT

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On November 19, 2020, the Armed Forces Radiobiology Research Institute (AFRRI) was issued a confirmatory order for a violation of 10 CFR 50.7 “Employee Protection”. The violation was given for the suspension of an AFRRI employee without pay for 2 days for engaging in protected activity in May 2018.

Following an NRC investigation, AFRRI participated in an Alternative Dispute Resolution (ADR) mediation session mediated by a professional mediator from Cornell University’s Scheinman Institute on Conflict Resolution.

The NRC recognized the corrective actions that AFRRI had already taken including:

- Industry-led AFRRI leadership Safety Conscious Work Environment (SCWE) training
- Industry-led AFRRI employee SCWE training sessions
- Establishment of a SCWE Working Group to ensure employee involvement in the AFRRI SCWE program
- Appointment of a Safety Culture Program Officer
- Email communication from the AFRRI Director to all AFRRI staff encouraging participation in the SCWE training
- Issued a message from the Safety Culture Program Officer to all AFRRI staff emphasizing leadership’s focus on safety and mechanisms for reporting concerns
- Participated in National Organization of Test, Research, and Training Reactors calls and conferences
- Solicited feedback from AFRRI staff regarding the ongoing command climate survey to serve as a baseline for future safety improvement metrics

AFRRI agreed to take the following corrective actions regarding the violation:

- The Uniformed Services University (USU) President shall issue a written statement communicating the

specific strategy to improve AFRRI’s nuclear safety culture

- AFRRI shall hold an all hands meeting for management to discuss the importance of the above communication with AFRRI employees
- AFRRI shall ensure its nuclear safety culture policy, guidance and related materials are in place and updated
- AFRRI shall establish a nuclear SCWE program
- AFRRI shall develop and/or revise its employee protection, nuclear safety culture and safety conscious work environment training for all AFRRI employees
- AFRRI shall develop supervisor training to include expectations specific to the role of management and include specific discussion on how to (1) effectively manage safety concerns and (2) ensure employees feel comfortable raising concerns
- AFRRI shall provide SCWE training to all employees engaged in work associated with NRC regulated activities with annual refresher training given annually
- AFRRI shall provide all training materials to the NRC for review at least 60 calendar days prior to conducting training
- AFRRI shall hire a third party independent organization and complete a tailored comprehensive nuclear safety culture assessment to ensure the effectiveness of the nuclear safety culture and SCWE programs
- A follow-up assessment shall be conducted within 2 years after the initial assessment.
- AFRRI shall make available to the NRC, upon request, the results of the assessments, surveys, AFRRI’s analysis of the trends, results and proposed corrective actions
- AFRRI will hire a third-party, independent organization to assist AFRRI with updates to its nuclear safety culture policy and the establishment of its safety conscious work environment program and associated tasks
- AFRRI will develop a program for AFRRI employees to raise concerns

Due to the issuance of the Confirmatory Order, the NRC:

- Will consider enforcement discretion for violations of the NRC Employee Protection Rules that occurred prior to or during implementation of the corrective actions aimed at correcting that specific condition as specified in the CO
- Will not cite a violation or issue a civil penalty in connection with the NRC's June 8, 2020, letter to AFRRRI
- Will not count the CO as escalated enforcement in the civil penalty assessment process for future cases, as long as the future action is not related to the NRC Employee Protection Rule
- May, in writing, relax or rescind any of the above conditions upon demonstration by AFRRRI of good cause
- Agrees not to pursue any further enforcement action in connection with the NRC's June 8, 2020, letter to AFRRRI

The complete Confirmatory Order is [ML20303A211](#).

## LICENSING GUIDANCE FOR MOLTEN SALT REACTORS

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The NRC has reviewed and endorsed the guidelines for licensing applications for Non-Power Molten Salt Reactors (MSR) prepared by Oak Ridge National Laboratory (ORNL). Specifically, the NRC endorses Appendix A, "Part 1, Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power MSRs: Format and Content," of the report titled, "Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application" ([ML20219A771](#)) provided that:

- The description of "Changes, Tests, and Experiments" to be made under 10 CFR 50.59 is updated to match the current 10 CFR 50.59 criteria.
- The section on conditions of licenses be updated to include that 10 CFR 55.53(f)(2) requires certification that the licensee completed a minimum of 6 hours of licensed activities prior to license reactivation.

- It should be noted that "non-power production and utilization facilities" or "NPUFs" is not the terminology currently used in NRC regulations, but the final ruling on the NPUF rule is currently under consideration by the Commission.

The guidance prepared by ORNL can be used in conjunction with NUREG-1537 and associated guidance for preparing MSR license applications.

The NRC does not endorse Appendix B of the report which provides guidance for the NRC to review MSR applications, but instead plans to incorporate parts of it into upcoming revisions of NUREG-1537.

## REED REACTOR LESSONS LEARNED

MELINDA KRAHENBUHL, PH.D.

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### INTRODUCTION

In April 2016, the U.S. Nuclear Regulatory Commission (U.S. NRC) initiated an investigation that led to enforcement proceedings regarding my actions while employed as the research reactor director at Reed College. In the course of those proceedings, the NRC Director of the Office of Enforcement made a finding that I had submitted incomplete or inaccurate information to the NRC in 2015. As part of the resolution we reached, I agreed to outline those events so that others of you can learn from my experience. I also offered to propose the redraft of ANSI/ANS 15.4 so that the challenges I encountered are unlikely to recur for other Directors.

During the problematic spring of 2015, I was running the Reed Research Reactor without a Reactor Operations Manager (ROM). (During this same time period, I also was attempting to care for an ailing parent out of state.) My very capable ROM had been hired by another program and no qualified replacements who applied were willing to accept the salary offered.

As the Level 2 and the designated reviewing official, I was responsible for both granting unescorted access to the reactor facility and certifying the medical fitness of

operator license applicants. However, it became clear during the course of the proceedings that the U.S. NRC identified issues with information provided concerning determinations of fitness for certain applicants.

The mental health of the candidates I advanced for licensure was the common thread in these investigations. ANSI/ANS 15.4 is the standard that governs the relevant determinations. Based on my experience attempting to reconcile the standard with the language of the medical professionals we retained to assist with these determinations, I have now proposed a revision of ANSI/ANS 15.4 that should make it easier for Directors to communicate with the NRC about candidates who present potential issues in three categories:

- prescription medication for anxiety and/or depression;
- suicidal thoughts versus suicidal ideation and planning versus suicidal actions, and;
- gender identity.

## BACKGROUND

A Level 2 is responsible for certifying the medical fitness of an examinee, reactor operator (RO) or senior reactor operator (SRO). To inform the Level 2's decision, the examinee, RO or SRO is required to have a physical completed by a physician. The physician uses the definitions in ANSI/ANS 15.4 section 7 and a self-reported medical history provided by the candidate, RO or SRO to complete their evaluation. The physician returns a signed certification that the individual is capable of operating a reactor. The process seems straightforward: a physician certifies and the Level 2 follows the recommendation.

However, as society and medicine evolve, the standard has been interpreted differently by practicing physicians and the U.S NRC medical review officer. I presented a possible underlying cause of these diverging opinions at the 2015 TRTR annual meeting. In the presentation "Are you fit for duty?" M. Krahenbuhl, and D. Corey, we summarized the findings of the MMPI results for power plant operators and Reed College operators.

One of the findings is significant with respect to self reporting mental health diagnosis and treatment: the data in the study indicated that the students at Reed are unusually forthcoming in comparison to power plant

operators. For Dr. Corey and for me, as the Director, this could be challenging because the students report potential ANSI/ANS 15.4 issues at a far higher rate than their counterparts at a nuclear power plant.

*Editor's note: Text of the proposed redraft of ANSI/ANS 15.4 submitted to the TRTR Working Group is reprinted on pages 17-19.*

## RECOMMENDATIONS

Have a succession plan and well trained staff with enough redundancy that the departure of a single individual will not lead to problems if the position remains unfilled for nine months or a year.

Retain an external, well-informed auditor annually, to help you avoid tunnel vision and isolation.

Talk with NRC staff if you encounter, as I did, differing interpretations of the ANSI/ANS 15.4 medical fitness standards. Document those conversations in writing so there is no doubt that you initiated such exchanges with the agency. Work to develop and maintain a strong working relationship with your inspectors and examiners, and do not assume that a long, productive history with their predecessors will carry forward until you establish a strong relationship anew.

Adopt the revision to ANSI/ANS 15.4 I have put forward to the TRTR 15.4 Work Group, which was drafted with the participation of a forensic psychologist, a forensic neuropsychologist and an M.D. who is Ethics Director for a major medical institution.

- It will update the medical terminology used in the standard so that all involved in the process speak a common language. The changes in terminology are drawn from the standard texts those professions rely on in making such determinations, the current editions of the International Classification of Disease (ICD) and the Diagnostic and Statistical Manual of Mental Disorders (DSM).

- It will give the medical professional advising you the discretion to determine which subtypes of the diagnostic categories noted might impair functioning and which would not be expected to impair functioning. These determinations are best left to medical professionals - specifically, physicians and doctoral psychologists - who have the requisite training and experience to understand the nuance of each subtype.

- With the benefit of that professional determination, each Level 2 should recognize that they are responsible for interfacing with the NRC. The Level 2 must be in good communication with both the medical professionals and the regulatory staff about the conditions of concern so that the agency is adequately apprised of the potential risk and the mitigating measures that provide reasonable assurance of continual professional performance and reliable public safety. We need both the agency and the public to have confidence in what we do.

## CONCLUSIONS

At TRTR 2019, the U.S. NRC stated that the 5% of the NRC is under the age of 30 and 45% are able to retire today. Most of us and most of the U.S. NRC staff grew up in a society in which even an admission of depression or anxiety could be considered shameful and a sign of weakness. Our new operators have grown up during a time when the discussion and treatment of mental health is accepted, and openness is encouraged as a healthy way to develop and thrive.

Over my 27 years in the TRTR community, I have been outspoken, active and optimistic. I have served our country in many capacities, not the least of which involved Joint Coordinating Council for Radiation Effects Research inspections in Russia (for which I was arrested by the Russian government) and providing security at the nuclear facility during the 2012 Winter Olympics. I love this industry and am committed to its growth. We need to engage the next generations of students to ensure the future of nuclear research and nuclear energy. Interest at your facilities should be growing, new technology emerging, and new engineers and scientists graduating - ready to take this industry to a new and exciting level. To accomplish that, we need to meet the new generations where they stand, rather than expecting their mental health to mirror that of our parents.

# PROPOSED REVISION OF THE AMERICAN NATIONAL STANDARD FOR THE SELECTION AND TRAINING OF PERSONNEL FOR RESEARCH REACTORS

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## 7.1.1 GENERAL ASPECTS

The primary responsibility for assuring that qualified personnel are on-duty rests with Level 2. The health requirements set forth herein shall be considered to determine the physical condition and general health of the individual in order to perform certain assigned duties as determined by Level 2. Each requirement should be considered in the context of the certain assigned duties of the individual at the particular facility as related to the consequences of health induced operational errors endangering public health and safety. *The licensee shall retain a licensed physician or doctoral psychologist, or both, to conduct such medical examinations as are necessary to evaluate whether operators and candidates for operator licensure are medically qualified for the duties of operator. The licensee shall provide this standard to each medical examiner conducting such an evaluation on its behalf and also shall provide each medical examiner with the job description and duties of the operator position for which the evaluation is being conducted. It is the responsibility of the Level 2 to assure that the designated medical examiner shall be conversant with this standard.*

## 7.2.1 BASIS OF REQUIREMENTS

The physical condition and the general health of research reactor operators shall be such that they are capable of properly carrying out licensed activities under normal, abnormal, and emergency conditions and are able to perform the associated tasks. Conditions that can cause ~~sudden~~ incapacitation include and are not limited to conditions such as ~~coronary~~ heart disease<sup>1</sup>, brain injury, neurological disease, mental disorder, diabetes, fainting spells, impaired hearing or vision, and effects of medication ~~are most serious in solo operation but shall be considered at any research reactor.~~

Many of the conditions indicated above may be accommodated by restricting the activities of the individual, requiring close surveillance of the condition, imposing a medical regimen, or requiring a second

individual without such restrictions to be present when the individual in question is performing certain assigned duties. As a minimum, the second individual shall be able to shut down the reactor and summon competent help.

7.2.2 (1) (a) Mental alertness, with behavioral and emotional regulation and stability,

7.2.2 (2) Freedom from incapacity. The examinee shall be free of any of the following conditions that are considered by the designated medical examiner and Level 2 as predisposing to from a predisposition for incapacity for duty, as determined by a designated medical examiner who shall be a licensed physician or doctoral psychologist acting in consultation with the Level 2, arising from any of the following:

- (a) Mental or physical impairments,
- (b) Any medical, surgical, or other professional treatment; Neurological impairment, or
- (c) Any condition, habit or practice that might result in sudden<sup>ii</sup> or unexpected incapacitation.

7.2.3 (5) Mental condition. An established history or clinical diagnosis as described in the current edition of the International Classifications of Disease - XX F Mental, Behavioral, and Neurodevelopment disorders. (ICD -11 F01-99)iii and/or the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5) shall be evaluated to determine whether it clearly and directly negatively impacts or limits those mental, emotional, behavioral, and cognitive abilities, behaviors, and skills necessary for the continuous safe and competent discharge of duties and responsibilities. Specific diagnostic codes are listed when appropriate; however, the designated medical examiners, who shall be licensed physicians or doctoral psychologists in consultation with the Level 2, shall use their professional judgement when making determinations of mental health conditions of operators and shall identify the extent to which essential job functions may be negatively impacted.<sup>iv</sup> The ~~Of any of the~~ following conditions should be so evaluated:

- (a) Any psychological or mental condition that could cause impaired alertness, impulse control, judgment, sensory or motor ability. Clinically Significant emotional or behavioral problems that have been

identified and that impact essential job functions shall require thorough clinical evaluation that may include psychological testing and psychiatric evaluation. Operators that have established ongoing care for a clinical diagnosis shall provide written confirmation from a licensed mental health professional detailing treatment including rehabilitation, psychotherapy and prescription medication used to treat the symptoms of the psychological or mental condition,

(b) A personality disorder that is severe enough to have repeatedly manifested itself by overt bizarre disruptive or similar acts, unless the condition has been relieved and certified as stable and resolved. Personality disorders that qualify are ICD -11 F60-63 and F65-F69. Operators that have established ongoing care for a clinical condition shall provide written confirmation from a licensed physician or doctoral psychologist detailing treatment, including rehabilitation, psychotherapy and/or prescription medication. Otherwise, the disorder shall be disqualifying for all operations,

(c) History or threat of suicidal plans, gestures, or attempts, ICD-11 R 45.851, shall be disqualifying for all operations,

(d) History of a psychotic disorders, ICD-11 F20 through F29, Schizophrenia, schizotypal, delusional, and other mental disorders that clearly impact mental, emotional, behavioral, and cognitive abilities, behaviors, and skills necessary for the continuous safe and competent discharge of duties and responsibilities shall be disqualifying for all operations,

(e) Alcohol abuse of dependence Use Disorder unless treated and corrected, shall be disqualifying for all operations,

(f) Abuse Substance Use Disorder of drugs other than alcohol, tobacco, or ordinary caffeine containing beverages, as evidenced by nonprescribed habitual use of the drug, unless the condition is treated and corrected. Otherwise, abuse shall be disqualifying for all operations;

7.2.3 (6) Medication. Any medication taken in such a manner or dosage that the taking or temporary delay of taking might would be expected to result in high probability likelihood of sudden<sup>v</sup> incapacitation.

APPENDIX: The following DSM-5 Diagnoses include subtypes of disorder that reasonably could or would impair the essential mental, emotional, behavioral and cognitive capacities required to safely and effectively dispatch relevant job duties. Each category of disorder listed here contains subtypes which might or might not reasonably impair functioning, depending on type and severity; this determination is best left to the examining clinician(s).

- 1) Neurodevelopmental Disorders
- 2) Schizophrenia Spectrum and Other Psychotic Disorders
- 3) Bipolar and Related Disorders
- 4) Depressive Disorders
- 5) Anxiety Disorders
- 6) Obsessive-Compulsive and related Disorders
- 7) Trauma and Stressor-related Disorders
- 8) Dissociative Disorders
- 9) Sleep-Wake disorders
- 10) Disruptive, Impulse-Control and Conduct Disorders
- 11) Neurocognitive Disorders
- 12) Substance-Related and Addictive Disorders
- 13) Paraphilic Disorders
- 14) Medication-Induced Movement Disorders
- 15) Personality Disorders

<sup>i</sup>‘Heart disease’ is more comprehensive, in that it includes Coronary Artery Disease and also heart failure and rhythm problems that can cause incapacitation.

<sup>ii</sup>The Committee should determine whether the qualification ‘sudden’ is necessary. There is a subjectivity element to this which can be argued – similar to “urgent” vs “emergent”.

<sup>iii</sup>ICD-11 will not be implemented until 2022.

<sup>iv</sup>This recommended change places the burden for determining licensed operator medical qualification on the designated medical examiner (a licensed physician or doctoral psychologist) “acting in consultation with the Level 2.” The responsibility for ensuring that the medical examiner is “conversant with [the ANSI/ANS] standard” continues to rest with the licensee (typically via the Level 2), as provided in Section 7.1.1, “General aspects.” If this approach is considered and adopted by the standards committee, Section 7.1.1 should clarify that it is the sole responsibility of the licensee to ensure

that the medical examiner fully understands (1) the requirements of the ANSI/ANS standard, and (2) the nature and assigned duties of the licensed operator, as determined by the Level 2. The proposed change to 7.1.1 is intended to provide that clarity.

<sup>v</sup>See endnote ii, above, addressing the necessity of the qualification ‘sudden’.

# TRTR 2020

## TRTR ELECTION RESULTS

Chair	Ayman Hawari North Carolina State University
Past Chair	Clive Townsend Purdue University
Treasurer	Tom Newton National Institute of Standards and Technology
Secretary	Amber Johnson University of Maryland
Chair Elect	Jeff Geuther Pennsylvania State University
Committee	Leo Bobeck University of Massachusetts Lowell
Chair Elect	
Meeting	

## TRTR BOARD MEMBERS

Cameron Goodwin  
Rhode Island Nuclear Science Center  
Sean O'Kelly  
Advanced Test Reactor Complex  
Idaho National Laboratory  
Alexander Adams  
U.S. Nuclear Regulatory Commission (retired)

## APPROVED

Establish a financial relationship with NEI for \$4133 / year to retain staff assistance in quarterly calls, support for generic regulatory issues, and governmental affairs.



TRTR 2020 WAS HOSTED BY PURDUE UNIVERSITY

The 2020 TRTR Annual Meeting was hosted virtually by Purdue University from September 28th through October 1st on Hublio. The meeting included the TRTR Executive Committee Meeting, Doug Morrell's annual presentation on the DOE's support of university research reactors, presentations from members of 12 TRTR facilities, the FBI, and the NRC.

Some highlights of the meeting were talks by NRC Commissioners Hanson and Baran, and Alice Caponiti, the DOE's Deputy Assistant Secretary for Reactor Fleet and Advanced Reactor Deployment. Also of particular interest were the discussions on the proposed new research reactors at the University of Illinois and Abilene Christian University.

Presentations from the NRC included:

## NON-POWER PRODUCTION OR UTILIZATION FACILITY (NPUF) LICENSING AND OVERSIGHT

Status update on research reactor licensing and regulatory activities from the Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)

## NEW FACILITIES AND NPUF LICENSING: WHAT IS ON THE HORIZON?

Update from DANU on the licensing pathways for new reactors and SNM utilization facilities, as well as the status of revisions to NUREG 1537

## Leaderboard 10 players

 Jeff Geuther	1,236p +0
 Patrick	1,137p +0
 George Miller	975p +0
 Enrico Fermi	967p +0
 David	903p +0
 tom newton	840p +0
 Clayton Manning	827p +0
 Chris Farwell	734p

CONGRATULATIONS TO OUR TRIVIA NIGHT FINALISTS!

## ONLINE LICENSING SUBMISSIONS FOR NONPOWER PRODUCTION AND UTILIZATION FACILITIES

Development of an online submission process for NPUFs

## NRC INTERNSHIPS BY THE NUMBERS

From [slides](#) presented by Greg Casto at the annual meeting.

60+ teleworking summer interns

Approximately 15 from TRTR Universities

Many with OLs or in OL license class

Four (4) interns in Division of Advanced and Non-power Reactors (DANU)

Three (3) DANU licensing interns accepted for 2021 internship

## OVERVIEW OF THE NUCLEAR REGULATORY COMMISSION'S ENFORCEMENT PROGRAM

Description of the NRC's enforcement process and statistics on enforcement actions

## SECURITY

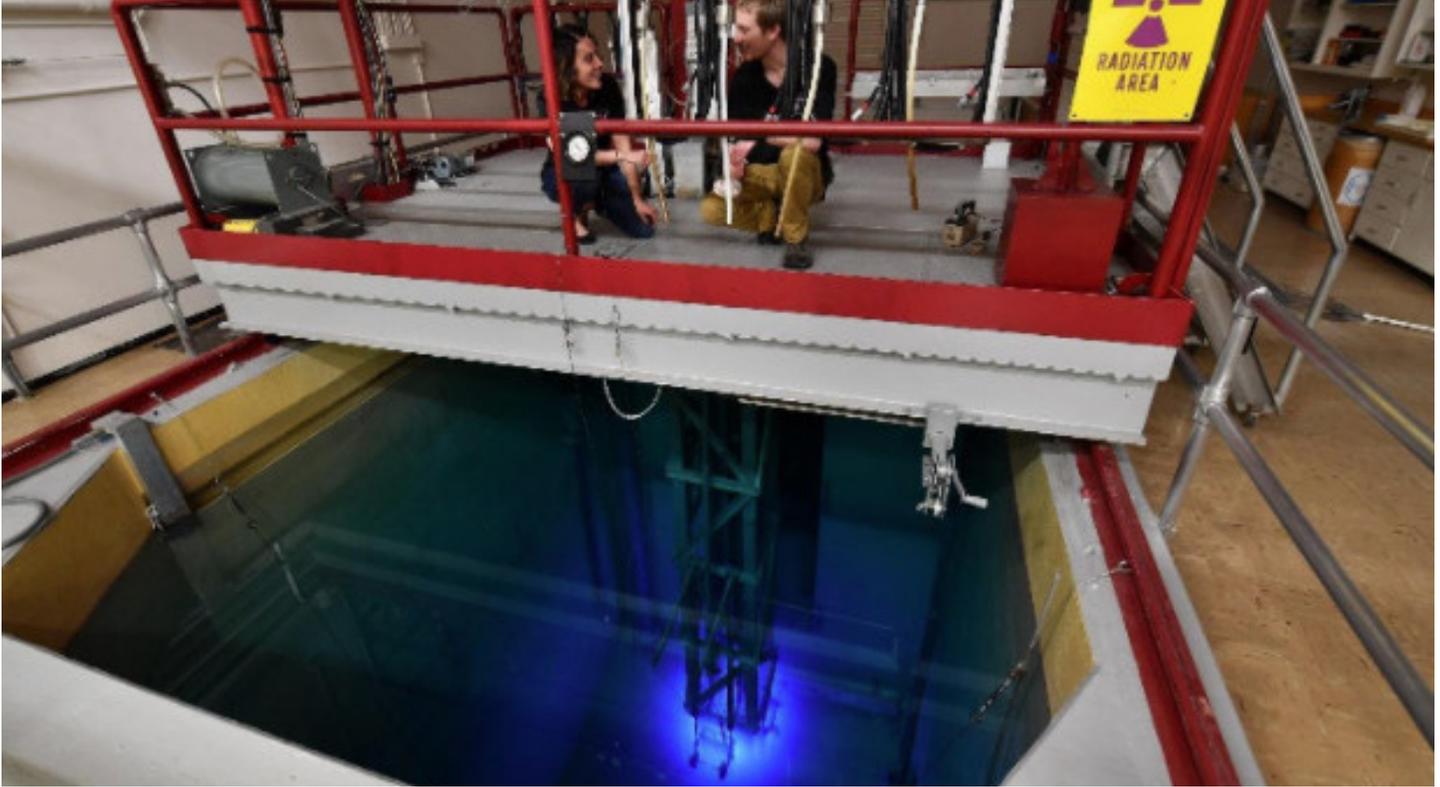
A comparison of 10 CFR Part 37 and 73, information about the access authorization program, and material control and accounting.

The traditional banquet was replaced with a virtual trivia night hosted by the TRTR Newsletter and the Tawfik M. Raby Scholarship was awarded to Mark Korol of the University of Missouri.

The 2021 TRTR Annual Meeting is scheduled to be hosted by NC State University and the new TRTR Chair, Ayman Hawari. We hope to see you there in person!

This past summer, Caleb Darr (2021 Purdue University Nuclear Engineering), participated in an internship in the Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU). Excited by the opportunity to learn and participate right beside NRC staff, Caleb worked on a license amendment request (ML20161A127) from the U.S. Geological Survey to allow for low power operation with a smaller core to perform I/M measurements. Caleb was "excited that the NRC just threw (him) in and helped (him) run right beside them in their work."

Applications for the Temporary Summer Student program are accepted between September and October.



## KNOW MORE NUKES

**Washington State University  
Nuclear Science Center**

**Maddison Heine, Research Operations Engineer**

What year did your reactor first go critical?

March 7th 1961, we are excited to celebrate the 60th anniversary next year even if it's virtually.

What is the reactor license number? Power level?

R-76, 1.0 MW

What is your position at the reactor? How long have you held that position?

I am the Research Operations Engineer and an SRO. I have held this position for two years.

Have any major changes/modifications, such as conversion, power upgrade, etc..., been done?

1961 – MTR Plate Type Reactor 100kW

1967 – TRIGA FLIP HEU fuel 1.0 MW

2008 – 30/20 LEU fuel 1.0 MW

(PREVIOUS PAGE) TOP: CARLIE JACKSON AND STUDENT OPERATOR, CANON HIX (2018-2019) TAKE A LOOK AT ROTATOR HOSES FOR MOVABLE EXPERIMENTS. LEFT: MADDISON HEINE LEADING THE STUDENT RO TRAINING PROGRAM CLASS (2019), RIGHT: MADDISON HEINE AND STUDENT OPERATOR, ALEX GOMEZ (2017-2019) REVIEWING NSC STANDARD OPERATING PROCEDURES AT THE CONTROL CONSOLE.

BELOW (FROM LEFT): DIRECTOR COREY HINES, REACTOR SUPERVISOR HILLARY BENNETT, RESEARCH OPERATIONS ENGINEER MADDISON HEINE, REACTOR OPERATOR BRYANT TANNER, RESEARCH PROJECTS ENGINEER TYLTER LAVOIE

### What is a unique feature of your reactor?

We have a pool type reactor with a view of the operational core at power and a Boron Neutron Capture thermal column.

### What is a fun fact about your reactor?

The core sits on railroad tracks allowing it to be moved back and forth in the pool. This allows for more versatility in the irradiation facilities.

### What is the biggest challenge facing your reactor?

Like most facilities, we have old systems and out of date diagrams. The console was built and wired in-house 40+ years ago. When components fail, replacements can be hard if not impossible to find. Over time systems have been updated and rewired but documentation of those changes is minimal. We are working on updating all systems and wiring the console to today's standards.

### What is the most unusual request someone has had to use your reactor?

I think we irradiated fingernails way back but I'm not 100% sure if that's true or why.

### What drew you to your current position?

As an undergraduate, I held an internship on the Hanford Site that led me to the training program at the Nuclear Science Center

### What has been your favorite project?

As the training coordinator, I have really enjoyed the process of revamping the program to best serve our students. It is part of our core mission to develop the nuclear workforce and I am happy to have a part in that process.

### Before working at your reactor, what was the most unusual or interesting job you've ever had?

I was a pastry chef the summer of 2017 at the local

Co-op. I went to work at 4:30 am and baked endless amounts of cookies, scones, buns and rolls. I loved it!

### What do you find the most challenging at reactor?

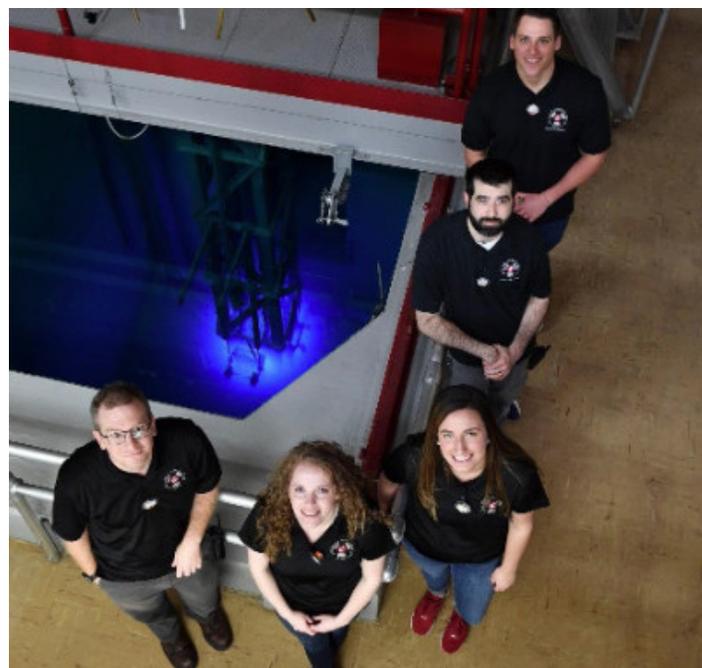
Balancing my "fun" projects with the operation of the reactor. My job is a step removed from the operations, but I still need to be available to help with operating hours, experiments, and maintenance.

### What advice would you give to new reactor operators?

Find a morning routine that works for you, this has been a game changer for my day-to-day performance. By waking up the same way and giving myself enough time to enjoy my morning, I don't feel rushed or under caffeinated. Also, always ask the questions you're afraid will make you look dumb. If you cannot convince yourself of an answer, find someone who can help you to understand. This helps staff identify weakness in training material and keep licensees sharp.

### What are three career lessons you've learned thus far?

Stand up for what's important to you, but be able to back it up with thoughtful plans and action items. Overcome perfectionism and meet deadlines with the 80/20 rule (don't be afraid to make mistakes). Connecting with others/ networking. This is something I am still working towards, but I find it makes the job feel more meaningful and keeps me excited about my career path.



# TRTR

## Newsletter

### Gingerbread

### Shielding Kit

A beam experiment is taking place at the North Pole's new FROSTI (Fast Reactor Or SomeThing Interesting) reactor. A collimated beam of 108 neutrons per second with a fission spectrum emerges from the reactor and hits a sample. The sample then produces a gamma dose rate of 14 R/hr at 30 cm. Additionally, the gamma dose rate in the neutron beam is 252 R/hr. The Abominable Snowmonster has chosen to live right next to the reactor so you have to design a low cost shield to reduce the dose rate to less than 2 mR/hr at the surface. In order to do this, you need to achieve a neutron shielding score of at least 30 in the forward direction, and 5 all around, plus a gamma shielding score of at least 20 in the forward direction and 10 all around. You have the following materials and the goal is to minimize the total cost.



Send pictures of your creation to [trtr-art@isotopictopics.com](mailto:trtr-art@isotopictopics.com)!

Food	Equivalent Material	Gamma Effectiveness	Neutron Effectiveness	Cost
Gingerbread	Concrete	3	2	\$2
Marshmallow Fluff	Depleted Uranium	5	0.5	\$3
Spice Drops	Lead	4	1	\$4
Peppermints	Borated Polyethylene	1	5	\$5
Graham crackers	Wood	1	4	\$1
Frosting	Water	2	3	\$1
Candy Cane	Steel Support	NA	NA	\$3

Gamma shielding score = (Gamma Effectiveness of layer 1)\*(Gamma Effectiveness of layer 2)\*(Gamma Effectiveness of layer 3)\*.....  
 Neutron shielding score = (Neutron Effectiveness of layer 1)\*(Neutron Effectiveness of layer 2)\*(Neutron Effectiveness of layer 3)\*.....