Q3 2020

Register now for the virtual 2020 TRTR Conference September 28-October 1!

TRTR

NEWSLETTER

In This Edition

LETTER FROM THE CHAIR

Hi TRTR!

The 2020 Annual Meeting is drawing near! I am very excited to host the meeting on behalf of Purdue University and believe that, as virtual meetings go, we will be able to foster discussion among our community members and expose attendees to the broad swath of topics facing research reactors today! Please encourage all of your facility operations, training, and student personnel to attend and register today. We will have speakers across the spectrum of facilities including annual favorites and new faces.

I am excited to announce **NRC Commissioners Chris Hanson and Jeff Baran** will be speaking on Monday and Tuesday. As two of the five commissioners, it will be helpful for all to have an opportunity to hear from top officials in Rockville.

The Annual Meeting is, of course, online. I'm not sure what I will do with this extensive list of the best Pork Tenderloin sandwiches in the state of Indiana, the dining options near the hotel in downtown Chicago, or the directions to the ~~amazing~~ cancelled Lake Michigan dinner cruise. That being said, it will make the 2021 Meeting all the more special as we all head to NC State.

As we look forward to 2021, I encourage everyone to submit proposals to the NEUP Reactor Infrastructure Call. Last year saw $2.7m across nine separate awards. That is an average investment of $300,000 per winning facility.

If you have any questions regarding the meeting or TRTR in general, please don't hesitate to reach out to me at clive@purdue.edu.

Clive Townsend
Reactor Supervisor
Assistant Lab Director
Nuclear Engineering
Purdue University

UPCOMING EVENTS

September 28 - October 1, 2020
TRTR Annual Meeting
Virtual Meeting

October 11-15, 2020
European Research Reactor Conference
Helsinki, Finland

November 9-20, 2020
International Conference on Radiation Safety
Vienna, Austria

November 16-19, 2020
ANS Winter Meeting
Virtual Meeting
Hilary Lane from NEI will moderate a panel discussion on RTR Pandemic Response. Representatives from MURR, Purdue, MIT, and NIST will present.

December 2020
Nuclear & Space Radiation Effects Conference
Santa Fe, New Mexico

December 8-10, 2020
World Nuclear Exhibition
Paris, France

February 8-11, 2021
Conference on Nuclear Training and Education
Amelia Island, Florida

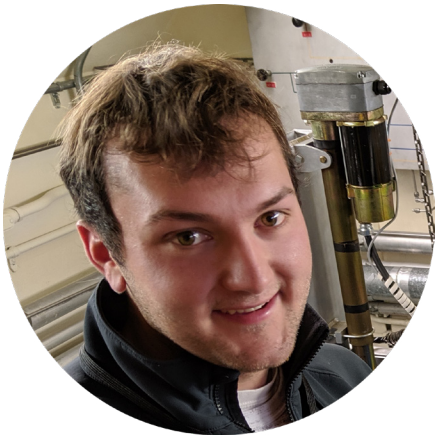
April 8-10, 2021
ANS Student Conference
Raleigh, North Carolina

May 23-28, 2021
International Symposium on Reactor Dosimetry
Lausanne, Switzerland

June 21-25, 2021
International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications
Prague, Czech Republic

May 30 - June 4, 2021
International Group on Research Reactors
Kazan, Russian Federation

LETTER FROM THE EDITOR



Hello TRTR Community,

I hope this newsletter finds you and your family safe and healthy. I would like to thank all the students who shared a brief summary of their research with us. I hope the remote summer at most facilities did not detract from the research experience. With undergraduate students receiving free registration to our annual conference, I am sure we will see some great posters.

I would like to thank Clive for all his work on behalf of the community during his term as Chair. Clive has shown great leadership throughout this pandemic. He has listened to the concerns of the community and worked with the NRC to address our challenges. I am disappointed to not visit the first all-digital nuclear reactor controls system but I am sure that PUR-1 would love visitors once travel is allowed.

While I am disheartened to not see everyone in person this year, I am looking forward to the virtual conference that Clive is organizing. I expect excellent presentations and stimulating discussions but I will miss the coffee breaks!

As always, please reach out with 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

News

NRC Accepts License Application for Oklo Advanced Reactor

The NRC has accepted Oklo Inc's application for the Aurora advanced reactor for review. The proposed reactor is a HALEU fueled fast reactor producing 1.5 MW of electricity.

More...

HFIR and SNS Used for COVID-19 Research

Neutron scattering at the High Flux Isotope Reactor and Spallation Neutron Source are being used to study how SARS-CoV-2, the virus that causes the disease COVID-19, reproduces, and the spike protein on the virus's surface.

More...

Nuclear Thermal Rocket Program from DARPA

The Defence Advanced Research Projects Agency intends to have a flyable nuclear thermal propulsion system by 2025 through its Demonstration Rocket for Agile Cislunar Operations, or DRACO program.

More...

Ulysse Reactor Decommissioned

The French Argonaut Reactor, Ulysse, which operated from 1961 to 2007 has been decommissioned.

More...

Neutron Generators for New Applications

The Madison, Wisconsin-based startup Phoenix is developing accelerator based neutron for new applications in the medical and imaging fields.

More...

New Reactor Movie

Bruce Willis will star in the action thriller "Reactor" where a nuclear power plant is taken hostage.

More...

New Nuclear Partnership in Canada

Global First Power, Ultra Safe Nuclear Corporation, and Ontario Power have formed a joint venture to develop the Micro Modular Reactor, a 15 MW small modular reactor that is designed to provide power and heat to industry and remote communities.

More..

New Nuclear Energy Secretary in Canada

Saskatchewan has announced plans for a new nuclear secretariat mandated to develop and execute a strategic plan for the deployment of "clean-energy small modular reactors" in the province.

More...

Fission Product Release in Northern Europe

Fission products have been detected over northern europe; they are believed to be the result of a Russian nuclear reactor failure or nuclear weapons test.

More...

Fermi 2 Shut Down by Flies

The Fermi 2 nuclear power plant was shut down due to a loss of offsite power caused by "Mayfly accumulation in and around the facility's switchyard".

More...

Faults in Netflix's History 101 Nuclear Power Episode

The DOE points out some faults in Netflix's History 101 episode on nuclear power.

More...

France's Oldest Nuclear Power Plant Shuts Down

France's Fessenheim Nuclear Power Plant has shut down after 43 years in operation.

More...

Britain to Invest in Small Modular Reactors

The British government has pledged to invest approximately $50 million in small modular reactor projects.

More...

Efforts Underway to Replace HEU Fuel

The American Nuclear Society reports on the ongoing effort to replace all highly enriched uranium reactor fuels with low enriched uranium.

More...

Legacy of the Manhattan Project

On the 75th anniversary of the Trinity Test, the peaceful uses of radioisotopes are examined.

More...

65th Anniversary of First Public Use of Nuclear Power

July 17th marked the 65th anniversary of Arco, Idaho becoming the first town to be powered entirely by nuclear energy.

More...

75th Anniversary of the Trinity Test

The New York Times examines the legacy of the Trinity Test.

More...

Southern Nuclear Wins NEI Award

A team at Southern Nuclear was awarded a Top Innovative Practice (TIP) Award from the Nuclear Energy Institute (NEI) for the development and use of continuous online monitoring of digital components.

More...

Fuel to be Developed for PIK Reactor

A contract has been announced for the development of fuel for Russia's PIK reactor. Construction on the reactor began in 1978 and it is expected to begin operations soon.

More...

New Advocacy Group

Good Energy Collective is a new, women lead, nuclear energy advocacy group.

More...

Art Stored With Nuclear Waste

CORVA, the Dutch radioactive waste storage company, stores art and antiques alongside radioactive waste in its long term storage facility.

More...

Radiation Resistant Bacteria may be Used to Make Vaccines

Researchers at the Uniformed Services University in Bethesda are working to develop vaccines using extremophile bacteria.

More...

Transformational Challenge Reactor

Oak Ridge National Laboratory's Transformational Challenge Reactor is attempting to bring 3D printing and Artificial Intelligence technology to nuclear reactors.

More...

History of the NRX Reactor

In 1947, Canada's first large research reactor, NRX began operations.

More...

Radiation on Flights Over the North Pole

Commercial flights over the north pole can result radiation doses as high as 24 mRem.

More...

US Intends to Build Nuclear Reactors on the Moon

The Department of Energy put out the formal request for designs for nuclear reactors that can provide power on the moon.

More...

Radiotrophic Fungus Used for Space Radiation Shielding

A radiotrophic fungus found in Chernobyl is being explored as a potential, self-healing, radiation shield.

More...

New Book About the Hanford Site

Steve Olson has written a new book, "The Apocalypse Factory" about the Hanford Site.

More...

Belgium's Myrrha Reactor Begins Testing

The Myrrha (Multipurpose Hybrid Research Reactor for High-tech Applications) accelerator driven reactor's accelerator system has begun testing.

More...

Drones Fly Over Nuclear Power Plant

Last September, a swarm of drones flew over the Palo Verde Nuclear Power Plant on two separate nights. The source and purpose of the drones remain unknown.

More...

Funding for Molten Salt Research Reactor

Abilene Christian University, working with a consortium of Texas A&M University, University of Texas - Austin, and Georgia Tech, has received $30.5 million in funding to develop a molten salt research reactor.

More...

Reactor Neutrino Detection

An experiment to detect the neutrinos produced by nuclear reactors is underway in Brazil.

More...

First Reactor in the UAE

The UAE's first nuclear power plant began operation on August 1st.

More...

Radioactive Materials to be Recovered From Arctic Ocean

The Rosatom State Corporation plans to recover six radioactive items from the Arctic Ocean. These are mostly spent nuclear fuel and are believed to represent approximately 90% of the radioactivity being released into the ocean.

More...

Power Plant in Belarus Begins Fueling

The new, Russian built, Astravets nuclear power plant has begun loading fuel and is expected to begin operations by the end of the year.

More...

New Neutron Camera Developed

Micah Folsom a recent doctoral graduate in the Tickle College of Engineering at the University of Kentucky has developed a new kind of neutron camera that uses coded-aperture imaging.

More...

University of New Mexico and Los Alamos National Laboratory to Study Radioisotopes in Tortoise Shells

A $987,000 grant will allow research into the radioisotopes deposited in tortoise shells.

More...

Push to Make Santa Susana Laboratory a Historic Landmark

NASA has nominated the Santa Susana Field Laboratory for official listing as a historic landmark.

More...

New Method of Evaluation Shows Lower Risks than Previously Believed for Nuclear Accidents

Professor Philip Thomas of Bristol University started the NREFS project (Management of Nuclear Risk Issues: Environmental, Financial and Safety) in 2012 to study the risks of nuclear accidents. A tool called the Judgement, or J-value was developed shows that many of the responses to nuclear accidents have worse consequences than the accidents themselves.

More...

Work Continues at WIPP

Work is continuing at the Waste Isolation Pilot Plant despite at least 14 COVID-19 cases among employees and subcontractors.

More...

Dead Horse Bay Closed due to Radioactive Contamination

National Park Service has closed a portion of Dead Horse Bay, a park in New York, due to the discovery of several radium artifacts.

More...

Fast reactor completes trial operating cycle

The China Experimental Fast Reactor (CEFR) completed a trial operation and has laid "a solid foundation for the subsequent commissioning phase to be transferred to the operations phase". The reactor is a 65 MW sodium-cooled, pool-type fast reactor that can produce 20 MW in electrical power.

More...

NRC Considers Shrinking Emergency Planning Zones for Small Reactors

The NRC is considering whether to shrink emergency planning and evacuation zones around Small Modular Reactors and Microreactors.

More...

TerraPower Hopes to Extract Actinium-225 from Nuclear Waste

TerraPower hopes to harvest Actinium 225 from nuclear waste for medical treatments. The company believes that it can extract between 200,000 and 600,000 doses of ^{225}Ac per year, 100 times the number of doses currently available globally.

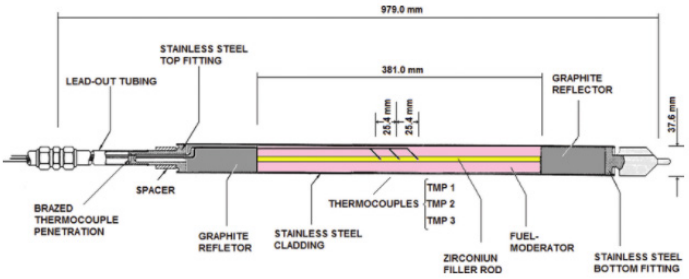
More...

Physicists Control Gamma Rays with Acoustics

Researchers from Kazan Federal University, Texas A&M University and Institute of Applied Physics (Russian Academy of Sciences) have found a way to control gamma quanta with an acoustic field.

More...

Oregon State University Instrumented Fuel Element LAR



As covered in the Q1 2019 newsletter, Oregon State University's reactor developed a problem with its instrumented fuel element (IFE) following a pulse in May of 2018; the IFE began reading higher and higher temperatures each day and threatened to shut the reactor down when it reached 510 C. In January 2019, OSU submitted an LAR to allow for the reactor to be operated without an IFE as long as it was not pulsed. OSU presented at a public meeting in February 2019. This LAR was granted in June 2019. The Basis and Safety Evaluation Report for this license amendment are available on ADAMS. In June 2020, OSU submitted a second LAR to allow the reactor to be operated and pulsed without an IFE. OSU has stated that they believe the basis for this LAR will be generally applicable to most TRIGA reactors, paving the way for other reactors to get rid of their IFE requirements.

NRC Inspections

WASHINGTON STATE UNIVERSITY NUCLEAR SCIENCE CENTER

JULY 7 – 9, 2020

The inspection included a review of organization and staffing, procedures, health physics, design changes, committees, audits and reviews, and transportation. No violations were identified. The complete inspection report is ML20230A164.

IDAHO STATE UNIVERSITY AGN-201

JUNE 29–JULY 1, 2020

The inspection included a review of organization and staffing, procedures, health physics, design changes, committees, audits and reviews, and transportation. A Severity Level IV violation was issued for a failure to perform the TS required annual determination of control rod worths. The complete inspection report is ML20196L821.

NORTH CAROLINA STATE UNIVERSITY PULSTAR REACTOR

JUNE 15-25, 2020

The inspection included a review of organization and staffing, operating logs and records, procedures, requalification training, surveillance and limiting conditions for operation (LCO), experiments, health physics (HP), design changes, committees, audits and review, emergency planning, maintenance logs and records, fuel handling logs and records, and transportation of radioactive materials procedures. A Severity Level IV violation was issued for failure to account for a leak from the pool in the annual effluent reports. The complete inspection report is ML20191A277.

NRC Quarterly Call Summary

August 28, 2020

NUREG 1478 rev 3 "Operator Licensing Examiner Standards for Research and Test Reactors" is expected to be available for a 60 day public comment period by end of the calendar year.

NUREG 1537 "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors" is expected to be available for a 60 day public comment period by the end of the calendar year.

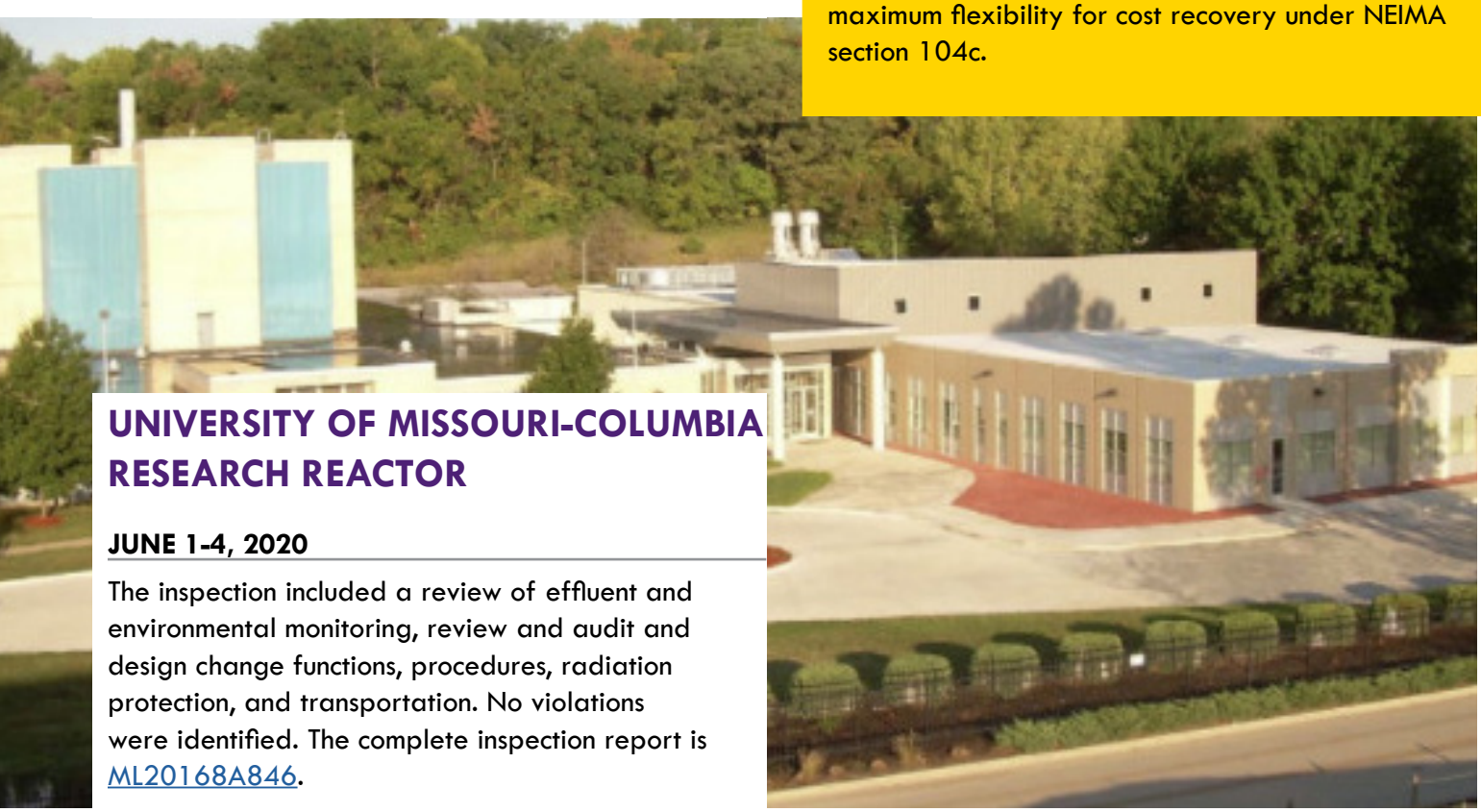
NRC is convening an internal working group for the review of the 50.59 white paper as part of the formal process for endorsement. Tom Newton is the lead for the TRTR community.

Rulemaking submitted to the Commission to allow maximum flexibility for cost recovery under NEIMA section 104c.

UNIVERSITY OF CALIFORNIA-DAVIS MCCLELLAN NUCLEAR RESEARCH CENTER

JUNE 15 – 18, 2020

The inspection included a review of operator licenses, requalification, and medical examinations, experiments, organization and operations and maintenance activities, review and audit and design change functions, procedures, fuel movement, surveillance, and emergency preparedness. No violations were identified. The complete inspection report is ML20183A312.



UNIVERSITY OF MISSOURI-COLUMBIA RESEARCH REACTOR

JUNE 1-4, 2020

The inspection included a review of effluent and environmental monitoring, review and audit and design change functions, procedures, radiation protection, and transportation. No violations were identified. The complete inspection report is ML20168A846.

2020 NEUP GRANT AWARDS

Idaho State University
$59,262

Construction of a new control rod drive mechanism to replace the original mechanism that now jams frequently.

[More]

MIT
$537,818

Replacement of aging Emergency Battery Banks and Motor Control Centers.

[More]

Oregon State University
$118,020

Purchase of a Hot Cell, Digital Neutron Imaging System, and a Liquid Scintillation Counter.

[More]

Penn State University
$306,744

Removal and replacement of antiquated tank farm.

[More]

Purdue University
$36,000

New Heat Exchanger for 10 kW operations.

[More]

Rhode Island Nuclear Science Center
$477,000

Removal and replacement of last remaining vacuum tube components of the Reactor Safety Systems.

[More]

UMass Lowell
$129,788

Reactor Safety Systems and Nuclear Instrumentation upgrades, high-resolution Spectroscopy system, and Scintillation Detector Array.

[More]

Missouri University Research Reactor
$585,013

Replacement Beryllium Reflector.

[More]

University of Utah
$487,387

Upgrade of the Reactor Cooling System to allow for 1 MW operations.

[More]

Duane Hardesty of the NRC shared several reports from the Incident Reporting System for Research Reactors (IRSRR) regarding aging issues experienced at non-U.S. reactors.

IRSRR REPORTS

Beam Tube Ventilation Leak at the Vienna University of Technology Atominstitut TRIGA Reactor

A pipe used in the beam tube ventilation system was found to have split along a seam during an annual inspection. The tubing was original to the installation of the reactor and was over 50 years old. Following the discovery of the break, the piping was sealed with sealing tape and was replaced within 2 months.

Broken Regulating Rod Cable at the Dalat Research Reactor

During an operation the reactor was observed to not be responding properly to the movements of the regulating rod. An investigation found that the actuator cable of the regulating rod was broken and the regulating rod had not withdrawn from the core. The cable had been in use for over 30 years and is believed to have become fatigued. The cable was replaced.

Rabbit System Failure at the RECH-1 Reactor

During an attempt to recommission a rabbit system a plastic pipe cracked and released activated copper and zinc dust into a laboratory causing several individuals to become contaminated. The broken piping was replaced.

Fueling Error at the McMaster University Reactor

While shuffling the reactor fuel, a bundle was inadvertently placed in a non-cooled grid plate location. The reactor was operated for several minutes with the fuel in this location. Bubbles were observed coming from the fuel element, but no elevated radiation levels or power oscillations were observed. The fuel element was removed and the Canadian nuclear regulator was notified. The incident was found to be within the bounds of accidents analyzed in the SAR. Permission to restart the reactor was granted 2 days later.

Pool Level Increase at the Romanian Dual-core TRIGA Reactor

A pool level rise was observed while the reactor was shut down. The increase was not due to an internal heat exchanger leak, or leakage from the makeup water system. Investigation found that compressed air was leaking into the demineralizer beds. The air dissolved in the pool and caused its volume to increase. The leaking air valve was replaced and the situation was resolved.

Mo-99 Production Incident at OPAL Reactor

A mistake with assembling a target holder resulted in the inability to close the transfer valve on a hot cell used for Mo-99 production. No radiation was released as a result.

More information on the findings of the events documented in the IRSRR can be found in the IAEA Techdoc: Operating Experience from Events Reported to the IAEA Incident Reporting System for Research Reactors.

A U.S. OPERATOR'S EXPLORATION OF THE KOREAN NUCLEAR INDUSTRY, AND HOW WE AFFECT EACH OTHER

Patrick Park

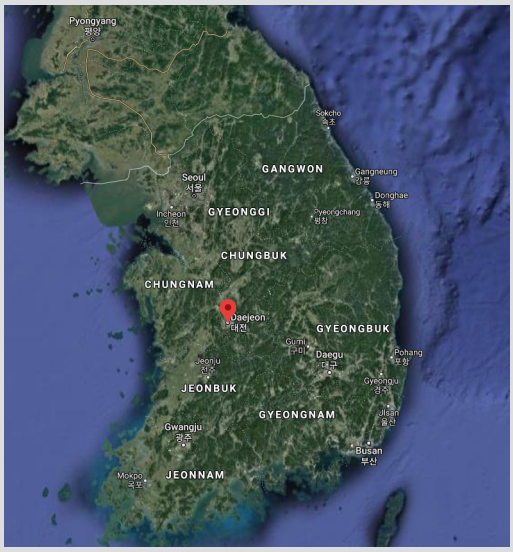
Current Reactor Operator at the Reed Research Reactor, he shares his experiences at the Kyung Hee University Reactor Research and Education Center and the 30 MW(Th) High-Flux Advanced Neutron Application Reactor (HANARO) in Daejon.

While working at UC Irvine's facility last year, I had the honor of attending Dr. Ed Jenner's thesis defense. While his work discussed the characterization of lanthanides for nuclear materials tracing, Dr. Jenner also analyzed the comparative geopolitical contexts and research capabilities of other countries' nuclear industries. For a young undergraduate, this "research into research methods" was a middle ground of my personal interests in world affairs and nuclear science.

Soon after the announcement of the NRC's approval of the new Korean APR-1400 PWR for U.S. construction, I looked into Korea's nuclear industry. How could a country with only two research reactors and an anti-nuclear president continue to produce advanced power reactors? The Korean nuclear legislations and "how they do things" was a mystery I wanted to learn more about. So, in the pre-quarantine days of January 2020, I was able to secure a grant to visit both research reactors and learn from Korean operators, researchers, and professors across three institutions.

Academic Curriculum and Operator Training

The Kyung Hee University Reactor Research and Education Center (KHU RREC) is one of two research reactors available in South Korea. Donated by Colorado State Univ. in 1976, the 10 W-th dry core is completely above ground, moderated by solid polyethylene, and completely cooled by a commercial air conditioner installed 2 feet above the core. Two SROs and two ROs maintain the facility, and both undergraduate and graduate students use the facility for about 8 hours per week.



Above: the HANARO Reactor is located in Daejon, South Koreak
Left: The control room of the Kyung Hee University AGN-201K Reactor.

This work was possible thanks to my Korean hosts, Prof. Lucas Illing, and Dr. Melinda Krahenbuhl, alongside support by the Center for Life Beyond Reed's Winter International Travel Fellowship. Excerpts shared in this article were also presented to former Secretary of the Navy Richard Danzig and the Reed College Board of Trustees.

Professor Myung-Hyun Kim, an SRO and the director of the facility, hosted my visit and shared some additional insights into the KHU RREC, like its unique dual console and Internet Reactor Laboratory.

The KHU RREC sports two consoles-- an operator's analog console and a student's digital console for operating under direction. Prof. Kim designed and installed this digital console in 2004, which allows students to independently control and scram the regulating and shim rods with digital readouts of reactor parameters. The licensed operator, on the analog master console, can override student inputs.

The KHU RREC is also the East Asia host for the IAEA's Internet Reactor Laboratory, which allows students without a nearby reactor to remotely experience reactor experiments and share lectures between various professors' specialties. With the reactor, KHU RREC shares weekly labs through IRL while Seoul and Busan National Universities stream lectures. Prof. Kim says he was inspired by NC State's PULSTAR facility, which also maintains an IRL and remotely shares its resources with partners like Georgia Tech. This type of education may be all the more prevalent in a post-COVID future with increased teleworking.

This AGN-201K is now a cornerstone of East Asian nuclear education. Local nuclear engineering seniors are required to take a semester-long reactor operations course here, and foreign students frequently train at the facility. I was lucky to be at KHU coincidentally with Japanese exchange students, so I participated in a series of labs with Korean and Japanese professors and students. I'm not sure if there had ever been a control room with Korean, Japanese, and American operators together! These labs were similar to my Reed operator training, such as NAA, rod calibrations, and the 1/M criticality calculation. I noticed the Korean and Japanese students easily overcame language barriers with English proficiency, as both countries' nuclear engineering courses are in English, derive from American curriculum, and even use Lamarsh and Knoll's venerable books.

Korean operators' regulations and terms should also be familiar to U.S. operators. The Korean Atomic Security Act defines ALARA, OUD, dose limits, and the like, although these are passed by Parliament unlike our 10 CFR managed by the DOE. The Korean Nuclear Safety and Security Commission (NSSC), the counterpart to the U.S. NRC, borrows from American hierarchy of RO and SRO licenses. Korean research reactors must maintain NSSC-approved facility License, Tech Specs, SAR, and a Requal Plan.

However, the concept of student operators (let alone Reed's 40 operators!) was completely foreign to the Korean and Japanese staff. According to Prof. Kim, a baccalaureate science degree is required to qualify for the NSSC's RO exam, which is a theory-only written exam resulting in a transferable operating license

Top: The KHU RREC Digital Student's Console
Bottom: Analog Operator's Consolet

Students working in the IAEA's Internet Reactor Laboratory

Effects of U.S. NRC policies in Korea

I also met with Professor Youho Lee, currently an assistant professor of Nuclear Engineering focusing on nuclear fuel and safety at Seoul National University (SNU). Having obtained a M.S. and Ph.D. at MIT and taught at Univ. of New Mexico, Prof. Lee had unique perspectives regarding the inner workings of both the Korean and American nuclear industries.

Prof. Lee explained that, like many U.S. universities, his undergraduates may take classes on MCCARD (pronounced "McCard"), Korea's native neutronics code written in-house at SNU. Korea has also developed its own thermal hydraulics code called MARS, based on RELAP5. "We develop all sorts of our own computer codes needed for nuclear engineering," says Prof. Lee. "So that's where we really see the technical competency of this country."

However, Prof. Lee also elucidated how the U.S. NRC's domestic policies actually have global effects on nuclear research.

"[The] U.S. has been able to maintain its technical leadership because many countries follow U.S. NRC regulation… When it comes to technical stuff still, we are relying on many numbers from the U.S. For instance, there are some numbers that the U.S. NRC impose, like don't go above 1200 degrees and 17% oxidation—these are also [used] in Korea… That's really the strength of the U.S., creating and enforcing the numbers.

"I'm making some analogy here. Korea now has become a country that can build [our own] highways [and] bridges… But at the end of the day, the U.S. Constitution has affected our laws, mentality, and almost every corner of our society. It's like that. So, Korea uses U.S. rules, that matters a lot. But there is room for improvement. So, [my] research is to improve Korean safety regulations beyond the levels that the U.S. NRC assures."

While conducting research both in the U.S. and in Korea, Prof. Lee then drew some differences he noticed in funding.

"U.S. funding from… DOE, NRC, NNSA, [is] from taxpayers' money of the U.S. [and] cannot 'cross the border' [i.e. include overseas PIs]. But most of the Korean funded projects have a little bit of more room for our money to cross the border. There are some Korean government supported programs that allow [us] to [financially] endorse U.S. partners… for some specific work or calculations that they conduct for our project."

Prof. Lee concluded, "With experience in both countries, [I can say] the U.S. has its own strengths and Korea has also its own strengths. In my [specialty] of nuclear fuels, the U.S. has huge accumulated experience... They have exclusive experience in a lot of [materials] research not open to the public. But when it comes to commercial reactors [like the APR-1400], I think Korea is as competent as the U.S. or even more competent in some areas."

As an American operator, it was incredibly eye-opening to learn

Professor Youho Lee

Bottom: The Advanced Thermal-Hydraulic Test Loop for Accident Simulation (ATLAS) at KAERI.
Next page: The HANARO Reactor

how the NRC and other U.S. laws have international implications on nuclear research. Learning more about this has motivated me to think about any future American regulations with a global lens and to better appreciate Korea's rising research capabilities.

Fostering Research Independence

After their nuclear science education at universities like Kyung Hee or Seoul National Universities, Korean graduates might find employment at the Korean Atomic Energy Research Institute (KAERI), which is an equivalent of our NIST Center for Neutron Research (NCNR). KAERI boasts the 30 MW-th open-pool HANARO reactor with an installed cold neutron source, which serves as East Asia's premier facility for isotope production, materials testing, and neutron beam research. Unfortunately, the HANARO was shut down during my visit, so Dr. Nam Hyun Choi and Na Jeong Park of KAERI's Science Communications Team instead showed me the new Advanced Thermal-hydraulic Test Loop for Accident Simulation (ATLAS).

Ms. Park and Dr. Choi explained that ATLAS is an international resource designed to develop Korean independence in thermal hydraulic data, much of which is obtained from Oak Ridge National Laboratory's hydraulic test loop facilities. "Fluid dynamics is as crucial as neutrons in commercial reactors," said Ms. Park in Korean. "The data obtained from ATLAS is a way to establish our own framework of cooperation between international nuclear research communities."

The need for ATLAS was highlighted after the Fukushima incident in 2011. Dr. Choi explained: "ATLAS is one of the largest post-Fukushima international cooperative projects in nuclear safety research, supported by several OECD Nuclear Energy Agency members, like Germany, India, and Japan... Completed in 2014, ATLAS is a 1/2-scaled test facility physically modelling the APR-1400, which is one of the world's newest reactors."

Dr. Choi explained more about how Fukushima motivated a new wave of international research: "Fukushima highlighted what works and what doesn't with our current systems. Back then, a lot of hydraulic and neutronics data for making reactors was unavailable to Asians because only America had the testing facilities. If Korea wanted to continue producing reactors, it became imperative we develop our own such facilities."

Beyond international collaboration, KAERI also fosters domestic interest in nuclear energy. They invest significant resources in encouraging frequent public tours with its dedicated Science Communications Team and maintain a very well-furnished Visitor's and Education Centers. While I was there, several high school students were on a self-planned field trip to KAERI, with Ms. Park also acting as their guide and steadily answering their numerous questions. It was pretty heartwarming to see high school students interested in KAERI's HANARO reactor and test facilities. Who knows? Maybe one day we'll be international co-investigators.

Conclusions

My experience in Korea helped frame my own education, training, and experiences on a global playing field. It was incredibly impressive to see Korean students' familiarity with American curriculum, as well as similarities and differences in operator training. Although the U.S. maintains a lead in nuclear capabilities, Korea is clearly improving its competitiveness. Nevertheless, I am incredibly fortunate to work in our nuclear field with more than 20 research reactors and mentors with decades of various nuclear skills—ranging from Navy nukes to professors to national lab researchers. I look forward to a future with greater cooperation with countries like Korea-- one of America's closest East Asian economic, political, and military allies.

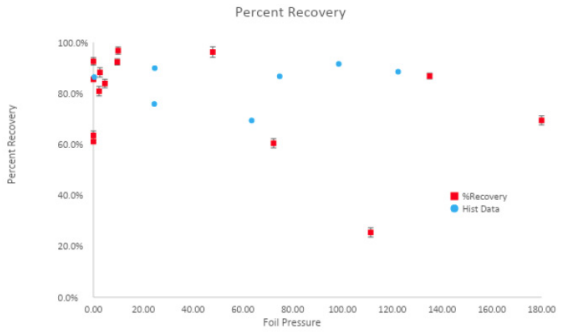
STUDENT RESEARCH

MIT RESEARCH REACTOR SIMULATOR

In conjunction with engineers at Western Services Corporation (WSC), recent graduate Sara Hauptman (B.S. '19) worked with Dr. Lin-wen Hu of the NRL research staff to develop and validate software for a glasstop simulator of the MITR. The simulator will feature RELAP modelling of major process systems, a point-kinetic core model, and realistic instrumentation and reactor control functionality. After completing acceptance testing, the MITR Simulator will be available to be utilized for public outreach demonstrations, undergraduate labs with MIT's Nuclear Science and Engineering Department, and supplementary training opportunities for future MITR Operators.

MIT NUCLEAR REACTOR LABORATORY
Sara Hauptman (B.S. 2019), Dr. Lin-wen Hu (Advisor)

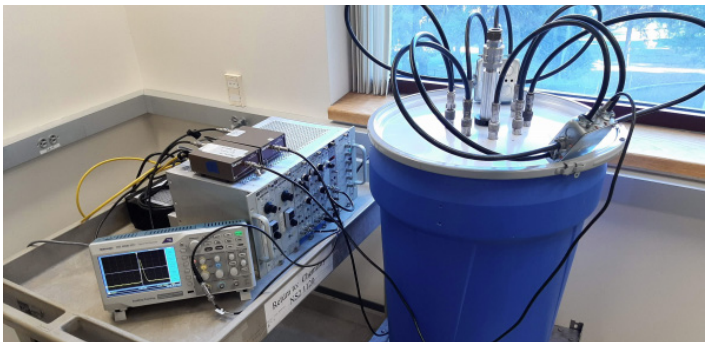
RADIOXENON NOBLE GAS STANDARDS



As a student in the Nuclear Science Center at Washington State University, Rachael Bergman worked as an intern at Idaho National Laboratory with the Noble Gas Lab assisting in research pertaining to gas standards production and radioisotope analysis. Gas standards containing radioisotopes of xenon are used by laboratories in conjunction with International Monitoring Stations to monitor the atmosphere for above normal levels of numerous radioisotopes. These standards require the use of carrier gases such as CO_2 to move small volumes of radioxenon during the production process. CO_2 as a sole carrier gas can lead to unstable and unpredictable final concentrations of radioisotopes in said standards, however, the addition of stable xenon to the CO_2 carrier gas was found to increase stability of radioxenon concentration in the standards. The project worked to find a ratio of stable xenon and CO_2 carrier gases to establish consistent and predictable radioxenon concentrations during standards production.

WASHINGTON STATE UNIVERSITY NUCLEAR SCIENCE CENTER / INL
Rachel Bergman - Technical Assistant (WSU) / Intern (INL), Mr. Troy Robinson (Advisor)

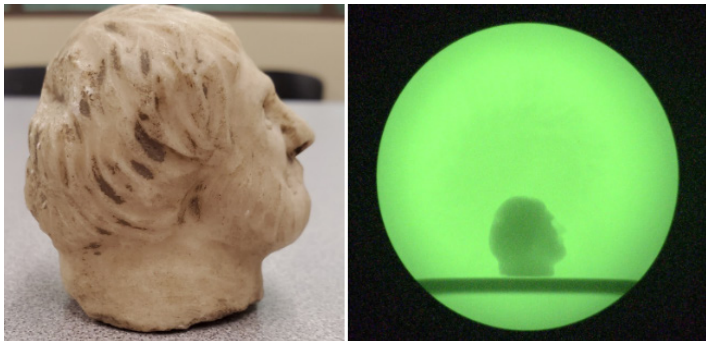
RESOLVING MIXED SAMPLES OF URANIUM-235 AND PLUTONIUM-239



As an undergraduate, I had the fantastic opportunity of being able to participate in research at UC Irvine's TRIGA reactor. From the summer of 2017 until my graduation in June 2020, I worked under Professor A. J. Shaka with the main goal of my research being to investigate a new method of delayed neutron activation analysis (DNAA). DNAA is an analytical procedure in which samples of fissile and/or fissionable material are irradiated with neutrons, followed by a quick pneumatic transfer to a neutron counter, in order to count the delayed neutrons emitted from the sample. The new method of DNAA which I investigated was geared towards simultaneously resolving unknown mixtures of $^{235}U/^{239}Pu$—a difficult task that relies on a differential effect on ^{239}Pu fission rate vs. ^{235}U fission rate when the mixture is irradiated in a cadmium-lined terminus. A significant part of the project involved designing and building a new neutron detector assembly, composed of nine individual 3He proportional counter tubes that were all electrically connected and fed into one counting system. I would like to acknowledge Professor A. J. Shaka, Professor George E. Miller, and the UCI TRIGA reactor staff for their help during my time as an undergraduate. A picture of the detector barrel (with a natural background neutron pulse observable on the oscilloscope) is shown above.

UC IRVINE TRIGA REACTOR
Tiziano Bassi (Undergraduate Student), Dr. A.J. Shaka (Advisor)

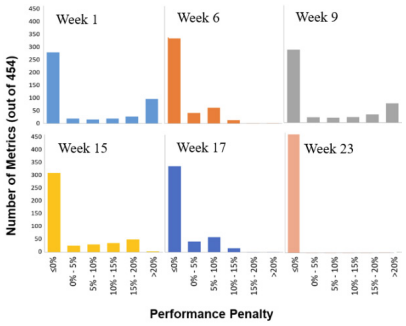
NEUTRON RADIOGRAPHY OF HISTORICAL ARTIFACTS



This experiment utilized neutron radiography to obtain images of four potential historical artifacts in an effort to determine if NR can be used as a non-destructive technique for authentication. The artifacts imaged were a small marble bust, a clay vase, a terracotta figurine, and a large clay bead with possible cuneiform writing. All objects are believed to be more than 1500 years old with the oldest potentially being 4000 years old. The images produced using neutron radiography are quite clear and show the differences in clay/marble thickness throughout each object. The marble bust is especially interesting from the side view because it clearly shows the nose and gash on the back of the bust. Further analysis can be done to try and determine if there are any minute aspects of each piece that would prove whether or not they are forgeries.

OREGON STATE UNIVERSITY RADIATION CENTER
Margaret Goodwin (M.S. Student), Dr. Steve Reese (Advisor)

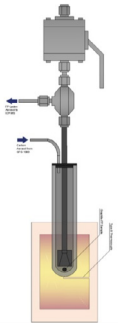
TRANSITION CORE ANALYSIS AT MURR



The University of Missouri Research Reactor (MURR®), in collaboration with Argonne National Laboratory and the National Nuclear Security Administration Office of Material Management and Minimization Reactor Conversion Program, has completed design, performance, and safety calculations leading to a preliminary SAR for conversion from the use of highly enriched uranium (HEU) to low-enriched uranium (LEU) fuel. A new type of LEU fuel based on an alloy of uranium and molybdenum is expected to allow the conversion of MURR and other U.S. high-performance research and test reactors requiring high density fuel. In preparation for conversion, the present work has designed a sequence of MURR transition cores from all-fresh to typical equilibrium burnup LEU operations. Following the initial conversion from HEU to LEU fuel, MURR will operate atypically for a brief period. The control blade position required to compensate for the large excess reactivity of the fresh LEU element core loading will shift the neutron flux from the experiment positions located above the core midplane. As a result, performance metrics above the middle of the core will initially be reduced. However, with the planning that has been completed for the transition cycles the experimental performance will return to MURR's normal shape in less than 23 weeks. Given the constraints of MURR operation and experiments, the transition scheme analyzed minimizes the time MURR operates before achieving equilibrium fuel management with the LEU fuel.

UNIVERISY OF MISSOURI RESEARCH REACTOR (MURR) / ANL / NNSA
Wilson Cowherd (PhD. Candidate - now completed), Dr. John Gahl (Advisor)

DIFFUSION RATES IN NUCLEAR GRAPHITE

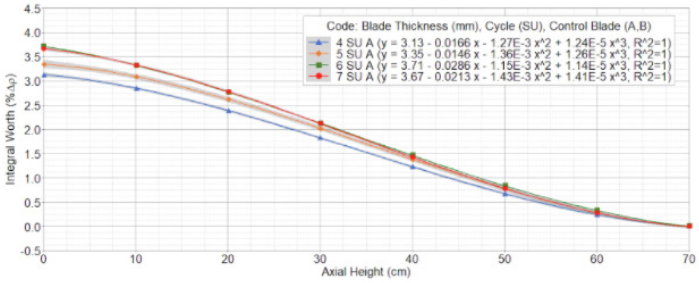


"In dissertation research being conducted by Taylor Weilert (MU PhD Candidate, Radiochemistry) and her advisor (Dr. John Brockman, Associate Professor of Chemistry / MURR Research Scientist), experimental measurements are currently being conducted on the rate of diffusion of various elements through nuclear graphite. These measurements are being done by "loading" small graphite spheres with the element of interest using a pressure vessel. The amount loaded into each sample is measured via comparator standard neutron activation analysis (NAA) in which samples and standards are irradiated in the University of Missouri Research Reactor (MURR®) and subsequent gamma decay counts are calibrated to the known masses of the standards. Once these loading contents have been determined, diffusion measurements will begin, also using MURR facilities. Several different procedures exist for measuring diffusion constants. The MU research team has elected to use the time-release method. This method, as the name suggests, involves measuring the rate of release of the diffusant with respect to time. Our group specifically does this using an enclosed diffusion cell (see diagram) connected to an inductively-coupled plasma mass spectrometer (ICP-MS). ICP-MS uses a high-temperature

UNIVERISY OF MISSOURI RESEARCH REACTOR (MURR)
Taylor Weilert (PhD Candidate in Radiochemistry), Dr. John Brockman (Advisor)

argon plasma to ionize samples introduced via a spray chamber, making this method ideal for measuring both large and small quantities of metals. This research will help define the high temperature chemical and structural stability of nuclear graphite to allow HTGR and other advanced reactor fuels to operate safely at temperatures upwards of 800 °C. Weilert is conducting the research as part of her DOE Nuclear Energy University Program Fellowship. Weilert's doctoral research is funded under a DOE Nuclear Energy University Program IUP Graduate Fellowship."

PYTHON AUTOMATED MCNP MODELING AT THE NIST CENTER FOR NEUTRON RESEARCH



After being selected for the now-cancelled Summer Undergraduate Research Fellowship (SURF) program at NIST, I am working remotely with Danyal Turkoglu and Dagistan Sahin for the NIST Center for Neutron Research (NCNR) where the 20 MW reactor provides neutrons for scientific research. My projects are focused on developing Python scripts that automate the generation and analysis of MCNP code to compute neutronics parameters for a potential NCNR replacement reactor. Recently, I have quantified the changes in control blade worth curve as a function of blade thicknesses. From there, I experimented with various regression methods, including ordinary, weighted, moving average, and locally weighted least squares, to improve worth curve plotting methods. Currently, I am surveying possible LEU fuel options (e.g. U-10Mo, U3Si2/Al) for the replacement reactor. As a junior physics student and a RO at Reed College's 250 kW TRIGA Mk.I, I am excited to share this new knowledge of MCNP techniques and fuel tests at my home facility. Since I hope to pursue nuclear science in graduate school, I am thankful to the NCNR Reactor Engineering team for welcoming me and to Melinda Krahenbuhl for helping me attain this opportunity. My NCNR experience has been incredibly helpful in developing my technical skills as well as expanding my breadth of knowledge in the nuclear industry.

* Shown above are predicted integral worths, with weighted regression and 1 standard deviation error bands, for 4 possible thicknesses of Control Blade A in the startup cycle state computed with MCNP. Although Control Blade A is designed to be 7 mm thick in the current replacement reactor concept core, the MCNP data suggests Control Blade A exhibits self-shielding behavior past 6 mm. In other figures not shown, automated scripts computed differential and integral worths for 4 different thicknesses of both Control Blades A and B at 8 axial heights in the startup and end-of-cycle states for a total of 128 unique core configurations in MCNP.

NIST CENTER FOR NEUTRON RESEARCH
Patrick Park - Reactor Operator (Reed College) / SURF Student (NIST), Dr. Turkoglu & Dr. Sahin (Advisors)

Know More Nukes

Reed College

Toria Ellis, Reactor Operations Manager at Reed College has provided answers for this edition of Know More Nukes.

What year did your reactor first go critical?

July 2, 1968

What is the reactor license number? Power level?

License number R-112, licensed for 250kW.

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

I'm the Reactor Operations Manager (ROM), and I was hired May 2019.

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

Not to my knowledge.

What is a unique feature of your reactor?

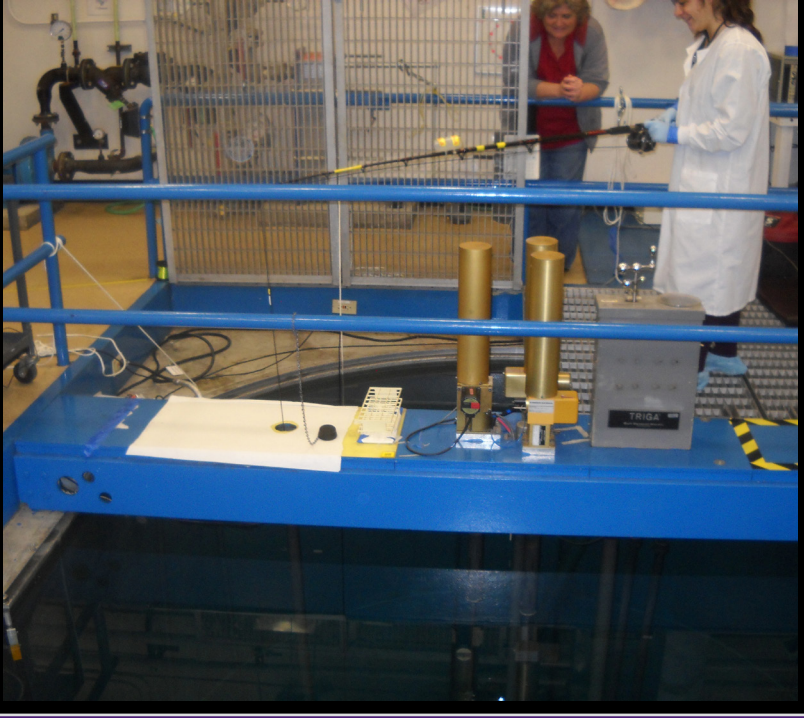
We are primarily run by undergraduate students; only two of our staff are full-time employees (the ROM and the Director) and the rest (~45) are students.

What is a fun fact about your reactor?

One of our students, Deborah Hankins, was one of the first undergraduate woman to become an SRO in the US (she was licensed in 1973).

Left: Deborah Hankins
Above: Reed reactor core

Next page, left: Removing samples from the pool
Right: The RRR Cooling Tower



What is the biggest challenge facing your reactor?

Currently COVID-19 is the biggest challenge facing our reactor; we rely on having license exams every year in the spring due to our high rate of operator turnover, and the pandemic has delayed our exams. Hopefully our re-scheduled fall exams go smoothly and our spring exams won't be delayed!

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

We've gotten a couple requests from Reed art students. One of the projects involved creating a picture using specially made paint, irradiating the picture, and exposing film paper to the now radioactive paint. It worked reasonably well.

What drew you to your current position?

I really enjoyed working at the reactor as an undergraduate. When I learned that the ROM before me was leaving, I was excited to apply for the position because then I could continue working at the facility with a really great boss (Dr. Melinda Krahenbuhl) and continue the reactor's training and outreach programs.

What has been your favorite project?

One of my favorite projects I've worked on was my senior project in 2019. I measured the temperature just above the reactor core and compared the temperature graph with predicted fast neutron flux (in a bare reactor with no control rods). Perhaps predictably, the temperature map matched the fast neutron flux map; after all, fast neutrons are the main source of heat in our reactor!

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

I was an elections officer at my local polling station for California's presidential primary election day in 2016.

What do you find the most challenging at reactor?

Interacting with non-students, especially senior staff members at Reed.

What advice would you give to new reactor operators?

Ask questions! Don't be afraid to ask questions, even if they seem dumb to you. It is definitely scary asking older reactor staff questions as a new operator or trainee, but asking questions helped me learn more about the reactor than I could have on my own. As my dad always says, "there are no stupid questions, only stupid answers."

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

Networking, i.e. meeting other people in your field, is important; effective communication is an incredibly useful skill; how to work with many different people.

Atomic Word Search

R	E	D	E	E	R	B	D	S	F	C	O	C	Z	S	Z	D	C	A	R	E	R
C	I	M	O	T	A	S	E	I	O	A	N	R	I	C	I	L	R	N	A	L	L
Y	T	I	V	I	T	C	A	E	R	O	S	I	R	I	N	E	O	O	B	E	D
S	C	R	A	M	T	E	F	F	I	G	M	T	C	N	N	I	S	I	B	M	E
K	J	C	D	I	E	F	T	S	E	R	U	I	O	T	S	H	S	T	I	E	D
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V	O	E	M	R	A	D	I	A	T	I	O	N	M	A	T	L	E	T	A	E	H
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T	F	E	C	E	E	O	T	U	N	B	P	Y	E	O	E	P	Y	A	U	M	R
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Uranium
Water
Neutrons
Detector
Plutonium
Radiation
Zirconium
Console
Hexagonal
Coefficient
Energy
Critical
Core
Blade
Scram
Power
Heat
Element
Cross Section
Atomic
Breeder
Cesium
Fissile
Thermal
Epithermal
Rabbit
Zinn
Enriched
Thermal Shield
Fuel
Triga
Fission
Operator
Flux
Cherenkov
Geiger
Blue
Plate
Safety
Isotopes
Scintillator
Rod
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