REED COLLEGE

Reed Research Reactor
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September 20, 2023 2023-071

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Enclosed is the annual report for Reed College (Docket 50-288, License No. R-112) for the period July 1, 2022 through June 30, 2023.

Please contact me if you have any questions or concerns.

Jerry Newhouse

Digitally signed by Jerry Newhouse
Date: 2023.09.20 14:49:23 -07'00'

Jerry Newhouse
Director, Reed Research Reactor

Enclosure: Reed Research Reactor Annual Report July 1, 2022 – June 30, 2023
cc Dr. Kathryn C. Oleson, Dean of the Faculty, Reed College

REED RESEARCH REACTOR ANNUAL REPORT

July 1, 2022 -- June 30, 2023

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OVERVIEW

This report covers the period from July 1, 2022 to June 30, 2023, and is intended to fulfill the reporting requirements of the U.S. Nuclear Regulatory Commission License No. R-112, Docket 50-288, the U.S. Department of Energy, and the Oregon Department of Energy Rule No. 345-030-010.

Reed College operates a 250 kW TRIGA® Mark I reactor. The Reed College Research Reactor has been a resource for research and educational projects in the Portland area since 1968. The main uses of the Reed Research Reactor are instruction, research, and community engagement.

Through tours, the reactor facility supports Reed College's community engagement efforts. Tours for local high schools typically include a laboratory portion in which students monitor the decay of radioactive Vanadium-52 and calculate its half-life. During the reporting period 1,468 visitors toured the reactor facility.

During the reporting period the reactor was taken critical 378 times on 145 days. The total energy produced was approximately 19.81 megawatt-hours.

The reactor staff consists of a Director, a Reactor Operations Manager, and Reed College undergraduate students. The student staff consist of technicians, trainees, and students who are licensed by the U.S. Nuclear Regulatory Commission as reactor operators or senior reactor operators. During the reporting period, 12 RO candidates and 12 SRO-U candidates received licenses.

There were no radiation exposures to individuals in excess of any limits during the year. There were no releases of liquid radioactive material from the facility. Airborne releases were well within regulatory limits. There were no shipments of low-level radioactive waste from the facility.

The U.S. Nuclear Regulatory Commission conducted one inspection during this reporting period: April 17-20, 2023.

PEOPLE

Reactor Staff

During the reporting period the staff consisted of the following:

Table 1 Supervisory Staff

Reactor Director	Jerry Newhouse	10/20 - present
Reactor Operations Manager	Toria Ellis	6/19 - present
Radiation Safety Officer	April Sams	5/16 - present
Operations Supervisor	Amelia Schaeffer Vivian Chen	5/22 – 5/23 5/23 – present
Training Supervisor	Genevieve Childers Hope Palmer Laura Smith	5/21 – 5/23 5/22 – present 5/23 – present
Requalification Supervisor	Henry Jacques Miles McCall	5/22 – 5/23 5/23 – present
Projects Supervisor	Vivian Chen Nicholas Lutz Olive Ross Elijah Whitlam-Sandler	5/22 – 5/23 5/21 – 5/23 5/23 – present 5/23 – present

Table 2 Staff

Senior Reactor Operators (SRO)			
Conor Bekaert	Holden Doherty	Jerry Newhouse	Laura Smith
Leandra Bruggink	Toria Ellis	Auden Oliveri	Sydney Stitt
Vivian Chen	Henry Jacques	Hope Palmer	Sophia Subramanian
Genevieve Childers	Orion Lee	Olive Ross	Elijah Whitlam-Sandler
Daniel Collier	Nicholas Lutz	Amelia Schaeffer	ZiQi Xie
	Miles McCall		Nicole Xu
Reactor Operators (RO)			
Amelie Andreas	Joaquin Fernandez Odell	Heath Nevis	Ella Roundy
Hima Aramona	Connor Gilligan	Finlay Norton-Lindsay	Hades Schwarzwald
He Bai	Victor Kirchmeier	Ali Pardini	Acteon Tong
Vee Bartko	Clementine McTaggart	Victoria Parker	Kathryn Trent
Michael Dunn	Hart Monyatovsky	Johnny Protiva	Valerie Wu
Sarah Ellis		Oscar Pulliam	
Reactor Technicians			
Miranda Estrada	Rukayah Khediri	Sol McClain	Javier Rivera Romeu
Malori Graves	Jeremy Miesch		

The list of operators includes everyone who held a license at any time during the reporting period. Reactor Operators who upgraded their licenses to Senior Reactor Operators during

the reporting period are listed under Senior Reactor Operators. On June 30, 2023 there were 40 licensed operators at Reed College.

Reactor Operations Committee (ROC)

The membership of the Reactor Operation committee during the reporting period is listed.

Reactor Operations Committee

- Dan Gerrity, ROC Chair (Chemistry Faculty, Reed College)
- Steve Reese (Radiation Center Director, Oregon State University)
- Wayne Lei (CTO, Restoration Fuels)
- Norm Dyer (OAR Services-retired)
- Kathy Oleson (Dean of the Faculty, Reed College)
- April Sams (Director, Reed Environmental Health and Safety)
- Charles McGuffey (Computer Science Faculty, Reed College)
- Paul Hovda, (Philosophy Faculty, Reed College)
- Jerry Newhouse (Director, RRR)
- Toria Ellis (Reactor Operations Manager, RRR)
- Amelia Schaeffer (Operations Supervisor, RRR)

FACILITIES

Reactor Facility

In addition to the reactor, the Reed Research Reactor has a radiochemistry lab. The equipment includes: high purity germanium gamma spectrometers, ion chambers, beta counters, Geiger Muller tubes, and alpha detectors. These instruments are used for experiments, and training in nuclear science and radiation detection. One exit monitor is in the control room. A liquid scintillation detector serves both the reactor and broad scope license users. The reactor facility has several systems for performing irradiations, described below.

Rotating Specimen Rack Facility

The rotating specimen rack is located in a well on top of the graphite reflector surrounding the core. The rack consists of a circular array of 40 tubular receptacles, each of which can hold two irradiation tubes. The rack automatically rotates during irradiation to ensure each sample receives the same neutron fluence. The thermal neutron flux in a rotating rack position at full power is approximately 1.7 $x10^{12}$ n/cm^2s with a cadmium ratio of 6.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outermost F-ring of the core and its associated glovebox, blower, and piping. This allows samples to be transferred in and out of the reactor core very rapidly while the reactor is at power. The flux in the core terminal at full power is approximately $5x10^{12}$ n/cm^2s.

In-Core Facilities

The central thimble is a water-filled irradiation chamber about 3 cm in diameter. It provides the highest available neutron flux at full power, approximately $1x10^{13}$ n/cm^2s.

Foil-insertion holes, 0.8 cm in diameter, are drilled at various positions through the grid plates. These holes allow the insertion of special holders containing flux wires into the core to obtain three-dimensional neutron flux maps of the core.

In-Pool Facilities

Near core, in-pool irradiation facilities can accommodate larger samples. Neutron fluxes are lower than in the rotary specimen rack. An iridium gamma irradiator is also in the reactor pool for gamma-only irradiations.

Beam Facilities

The central thimble can be evacuated with gas, producing a vertical neutron beam. The flux above the beam exit at full power is approximately $1x10^6$ n/cm^2s.

INSPECTIONS AND AUDITS

The U.S. Nuclear Regulatory Commission conducted one inspection during this reporting period: April 17-20, 2023.

This was a routine safety inspection, and one item related to a self-reported Technical Specification was opened and closed. Details of the inspection may be found in Inspection Report No. 05000288/2023201.

Dr. Mary Lou Dunzik-Gougar of Idaho State University performed an audit of the Reed Research Reactor for the Reactor Operations Committee August 9-11, 2022. Dr. Dunzik-Gougar found operations were in compliance with Technical Specifications, and provided several recommendations for improvements to checklists and procedures.

Dr. Paul Hovda of the Reed College Faculty will perform an audit of the Reed Research Reactor for the Reactor Operations Committee in August 2022. Results of this audit will be discussed in the 2023-2024 annual report.

USERS

Reactor Operations Seminar

The Reed Research Reactor conducts an annual seminar series. This non-credit course serves as an introduction to nuclear reactor theory, health physics, and reactor operation. Up to 15 of the students are hired each year to continue with in-depth reactor operator training. Most subsequently apply for a Reactor Operator license.

The NRC administered two exams during the reporting period: one in March 2023, and one in May 2023. The March 2023 exam included initial RO exams. The May 2023 exam included SRO upgrade exams.

Figure 1 shows the pass rate for RO and SRO for the past ten years. Figure 2 shows the number of RO and SRO license candidates for the past ten years.

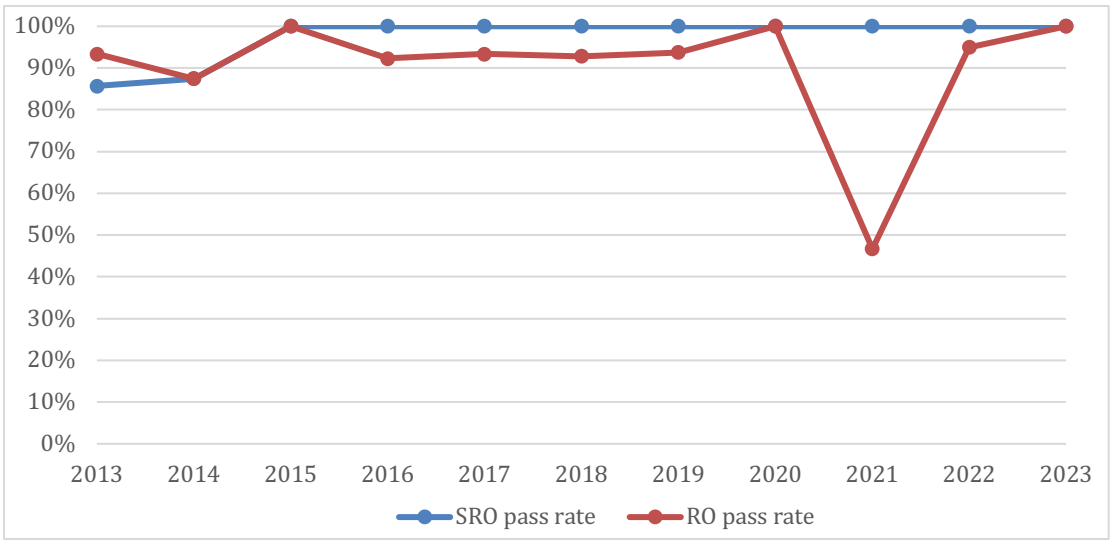

Figure 1 NRC License Exam Results

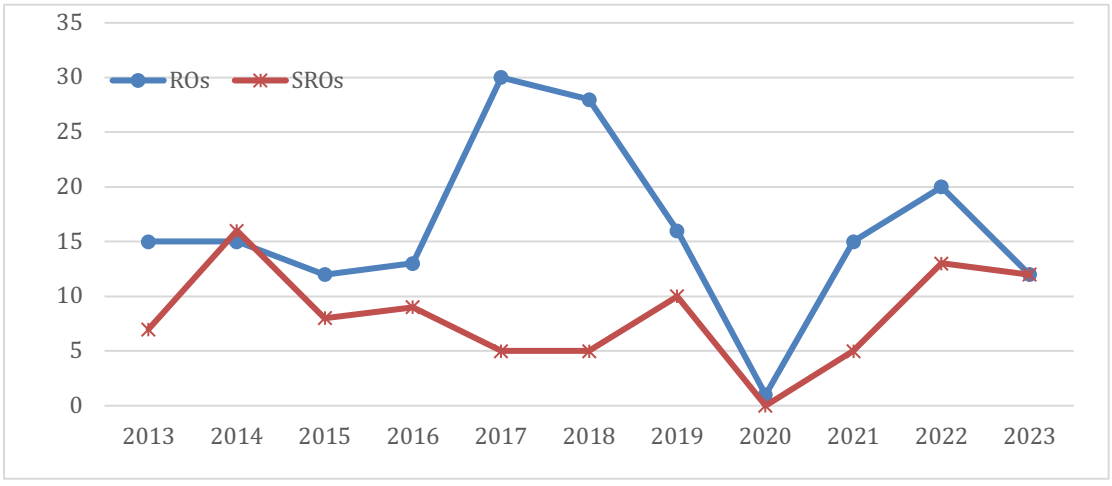

Figure 2 NRC License Candidates

Reed College Research

Theses:

- One Physics senior used the reactor facility to support her thesis, "Development, Modeling, and Radiation Characterization of the Reed Research Reactor Central Thimble and Neutron Beam Facilities through Monte Carlo Simulations and the Neutron Transport Equation"

Other Work:

- 43 students produced 35 internal research papers using the reactor and associated radiation facilities.
- 2 students made presentations regarding reactor associated research or instructional work at the 2022 TRTR conference.

Academic Use by Other Institutions

Research

Students and professors from area institutions without nuclear facilities commonly conduct experiments at the Reed Research Reactor. During this reporting period the facility supported:

- Pacific University modern physics course's phantom lung experiment.
- Pacific University student's capstone research on TLD efficiency.
- George Fox University student's research on the efficacy a cell phone radiation app.
- Warner Pacific University physical chemistry course's radiation detection lab.

Community Engagement

Tours continued normally throughout the reporting period. There were 912 visitors from schools, institutions of higher learning, and special groups. Additionally, 556 individuals visited as part of Reed College Activities (prospective students, newly admitted students, family members of students, Reed classes, etc.). Figure 3 shows the history of visiting groups for the past 10 years.

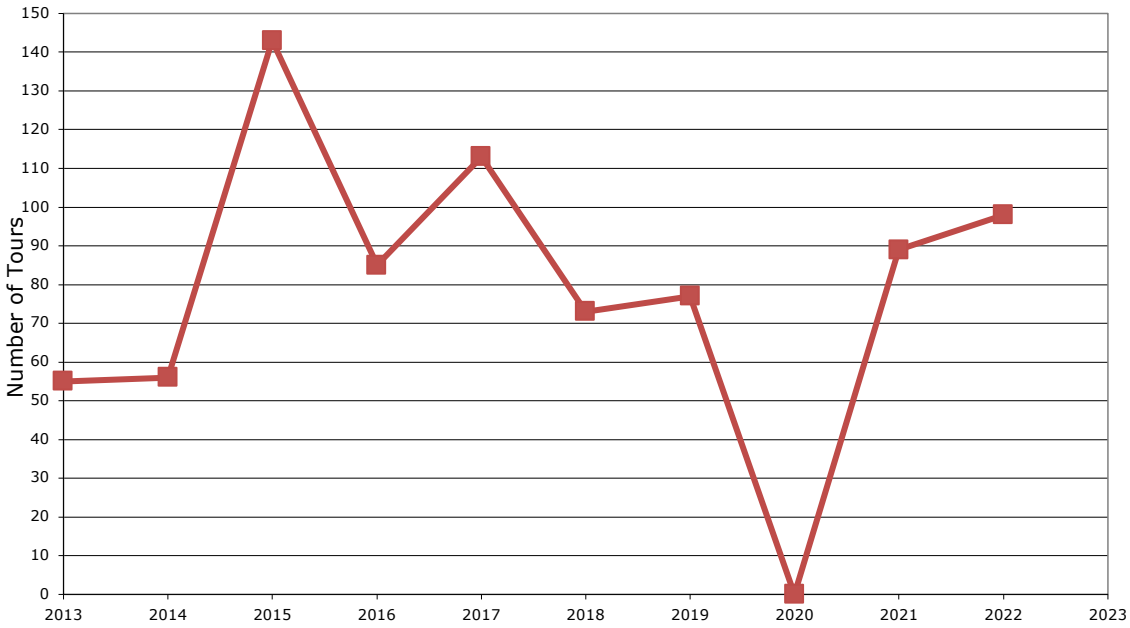

Figure 3 Number of Tours by Year since 2013

High School Student Projects

The reactor facility resumed hosting two high school interns through the ASE Saturday Academy program. The 2022 summer interns learned the basics of nuclear science, experiment design, and completed independent research projects monitoring environmental pollution.

In the fall of 2022, a high school student collaborated with a Reed College student to test the radiation shielding capability of C. sphaerospermum.

Industrial and Commercial Applications

The Reed Research Reactor is available for industrial or commercial concerns when it does not conflict with our educational goals. During the reporting period we conducted materials damage irradiation for Helion Energy.

The facility also provides radiation protection training to interested parties and schools in the area, including an annual Radiation Safety Officer (RSO) class, as well as provides radiation meter calibration if requested.

REACTOR OPERATIONS

Operations

During the reporting period the reactor was taken critical 378 times on 145 days. The total energy produced was approximately 19.81 megawatt-hours. Operating history by month appears in Table 3. A history of criticality and operating days data is shown in Figure 4. A history of energy production is shown in Figure 5.

Table 3 Operating History by Month

	Times Critical	Days Operated	MW-Hours
July 2022	10	5	0.68
August 2022	28	15	1.80
September 2022	32	17	1.42
October 2022	25	8	0.72
November 2022	43	13	2.60
December 2022	21	8	1.84
January 2023	0	0	0.00
February 2023	48	16	2.45
March 2023	68	22	2.42
April 2023	51	20	3.28
May 2023	29	12	1.57
June 2023	23	9	1.02
Total	**378**	**145**	**19.81**

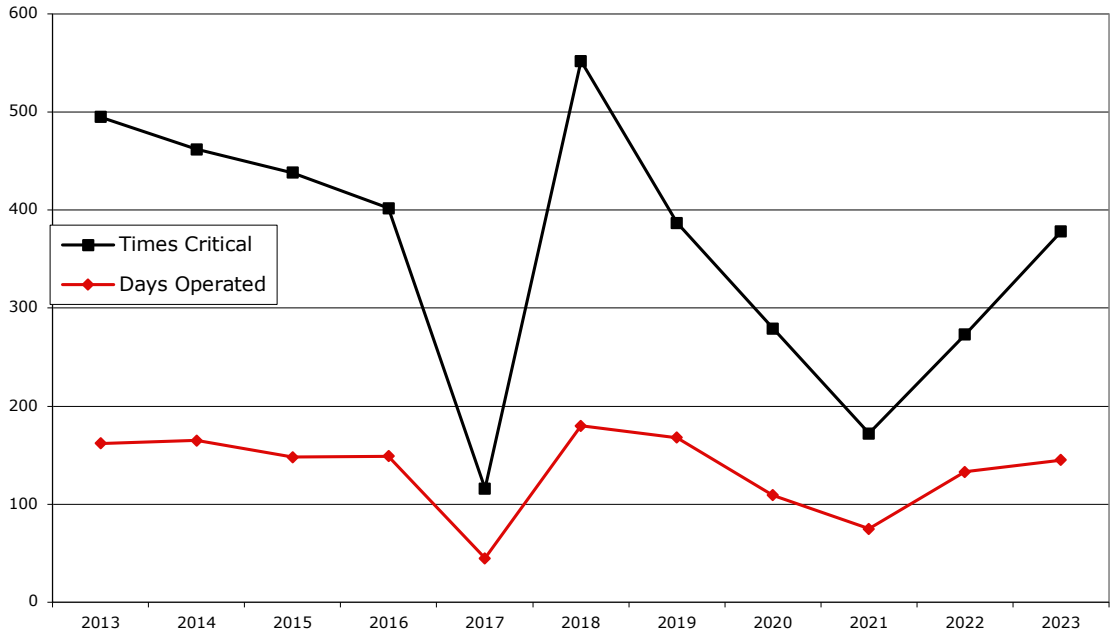

Figure 4 Operating History

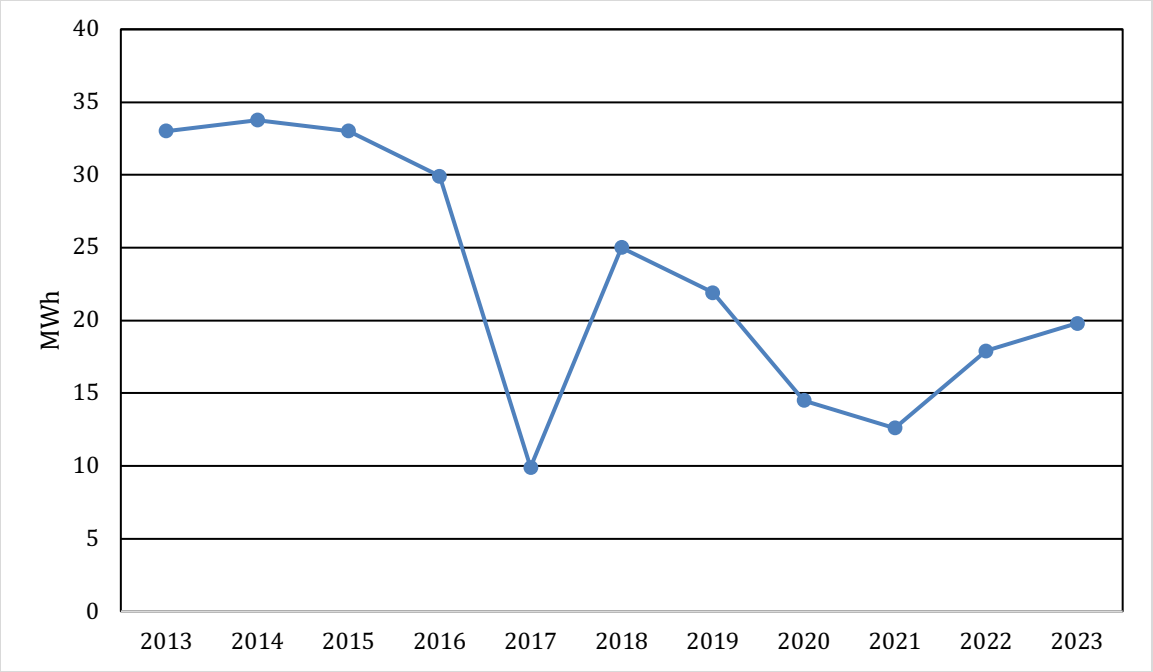

Figure 5 Energy Production History

Unplanned Reactor Shutdowns

2021-2022

In the 2021-2022 report, two unplanned shutdowns that occurred in December 2021 were omitted. These are shown in Table 4.

Table 4 Unplanned Shutdowns Omitted from 2021-2022 Report

Date	Scram Channel	Cause of Scram
Dec 4, 2021	Linear, Percent	Trainee operating under direction overshot desired power.
Dec 4, 2021	Percent	Trainee operating under direction overshot desired power.

There were three inadvertent reactor shutdowns (scrams) during the current reporting period as shown in Table 5. The number of unplanned reactor shutdowns in the past 10 years is shown in Figure 6.

Table 5 2022-2023 Unplanned Shutdowns

Date	Scram Channel	Cause of Scram
Aug 4, 2022	Percent	RO overshot desired power.
Feb 5, 2023	Linear	Slight power fluctuation while operating near scram setpoint in manual scaling mode during a calibration.
May 9, 2023	Percent	RO overshot desired power.

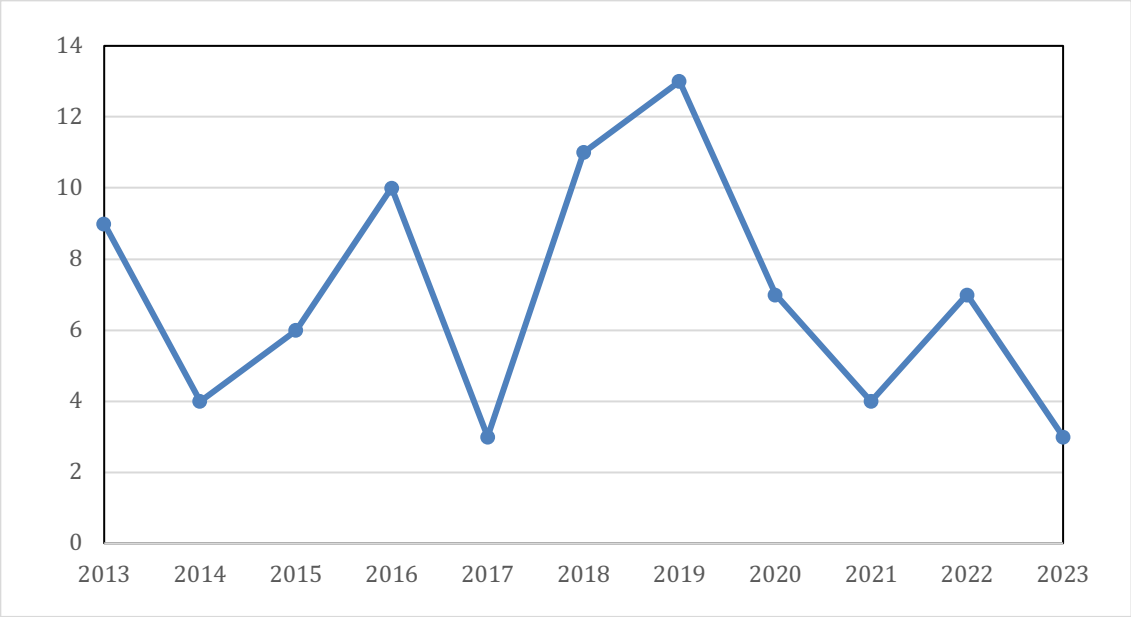

Figure 6 Number of Unplanned Shutdowns by Year

REACTOR MAINTENANCE

Significant Maintenance

Most maintenance items do not require a 50.59 Evaluation because they screen out. There were no 50.59 Evaluations required during the reporting period. Reactor staff performed routine equipment checks on a daily, biweekly, bimonthly, semiannual (January and July) and annual (January) basis as required by facility procedures. Reed College maintenance personnel assisted with routine preventative maintenance to auxiliary equipment. The following significant maintenance items were competed during the reporting period:

- Replaced aging Continuous Air Monitor pump with spare.
- Repaired a leak in the Air Particulate Monitor system to improve airflow.
- Replaced exhaust fan motor after previous motor was damaged by a degraded wiring short.
- Replaced aging pool temperature thermocouple.
- Replaced primary coolant pump motor.

RADIATION PROTECTION

Personnel Dosimetry

Dosimeters are changed on a calendar quarter schedule. Individuals are issued beta-gamma sensitive ring badges and whole-body badges.

The highest individual doses received were 55 mrem/quarter Deep Dose Equivalent (DDE) and 55 mrem/quarter Shallow Dose Equivalent (SDE). These doses are well below occupational dose limits and no further action was required.

Fixed Area Dosimetry

Radiation levels are continually monitored to provide an indication of the average radiation levels in the reactor bay and dose outside the facility. All dosimeters monitor beta and gamma radiation. Five locations also measure neutron dose.

The Deep Dose Equivalent (DDE) radiation measured by fixed dosimeters during the period April 1, 2022 to March 31, 2023 are shown in Table 5. The dosimeters from April 1, 2022 to June 30, 2022 are currently being processed. An "M" indicates less than 1 mrem above background during the quarter.

Table 5 Area Radiation Dosimeters
(doses are in mrem per calendar quarter)

Location	Height (m)	Radiation Detected	Apr 1 - Jun 30	Jul 1 - Sep 30	Oct 1 - Dec 31	Jan 1 - Mar 31	Total
Reactor East Wall	1.5	β, γ, n	M	4	6	3	**13**
Reactor North Wall	1.6	β, γ, n	1	5	6	5	**17**
Reactor West Wall	1.0	β, γ, n	6	6	6	6	**24**
Reactor South Wall	1.6	β, γ, n	3	4	4	5	**16**
Reactor North Wall - High	2.3	β, γ	1	5	4	3	**13**
Control Room	1.5	β, γ	5	6	5	6	**22**
Outside North	2.8	β, γ	M	2	M	M	**<5**
Outside Roof	0.4	β, γ, n	M	M	M	M	**<4**
Outside East	1.5	β, γ	M	M	M	M	**<4**
Outside South	0.4	β, γ	M	M	M	M	**<4**
Counting Room	1.5	β, γ	M	M	M	M	**<4**

Gaseous Releases

The only routine release of gaseous radioactivity is from ^{41}Ar (1.83-hour half-life) and ^{16}N (7.13-second half-life). These come from activation of pool water and air in the pool water and in the irradiation facilities. For the reporting period, the average gaseous activity at the site boundary was 2.33 x 10^{-10} µCi/ml. This release is well below the Technical Specification limit of 1 x 10^{-8} µCi/ml. The release was calculated to deliver a dose to a member of the public of approximately 1.16 mrem, well below regulatory limits. Figure 7 shows the gaseous releases for the past 10 years.

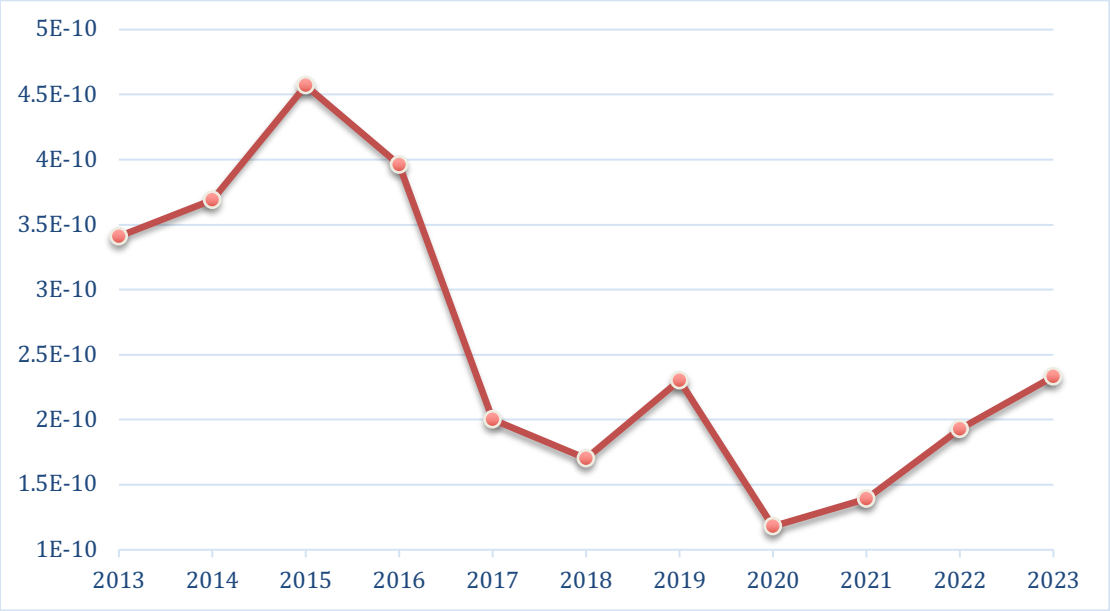

Figure 7 Gaseous Release Activity (µCi/ml) at Site Boundary

Liquid Waste Releases

No liquid radioactive waste was released from the Reed Research Reactor during this reporting period.

Solid Waste Disposal

There were no shipments of low-level radioactive waste from the facility during this reporting period.

Environmental Sampling

All environmental samples were counted in a high purity germanium gamma spectroscopy system. Soil samples taken from the area surrounding the facility showed no activity above background. Water from the facility's secondary cooling system and the nearby canyon were sampled for activation products and tritium; the water samples showed no activity above background.