REED COLLEGE

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August 7, 2013

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555

Docket 50-288

Enclosed is Reed College Reactor's Annual Report.

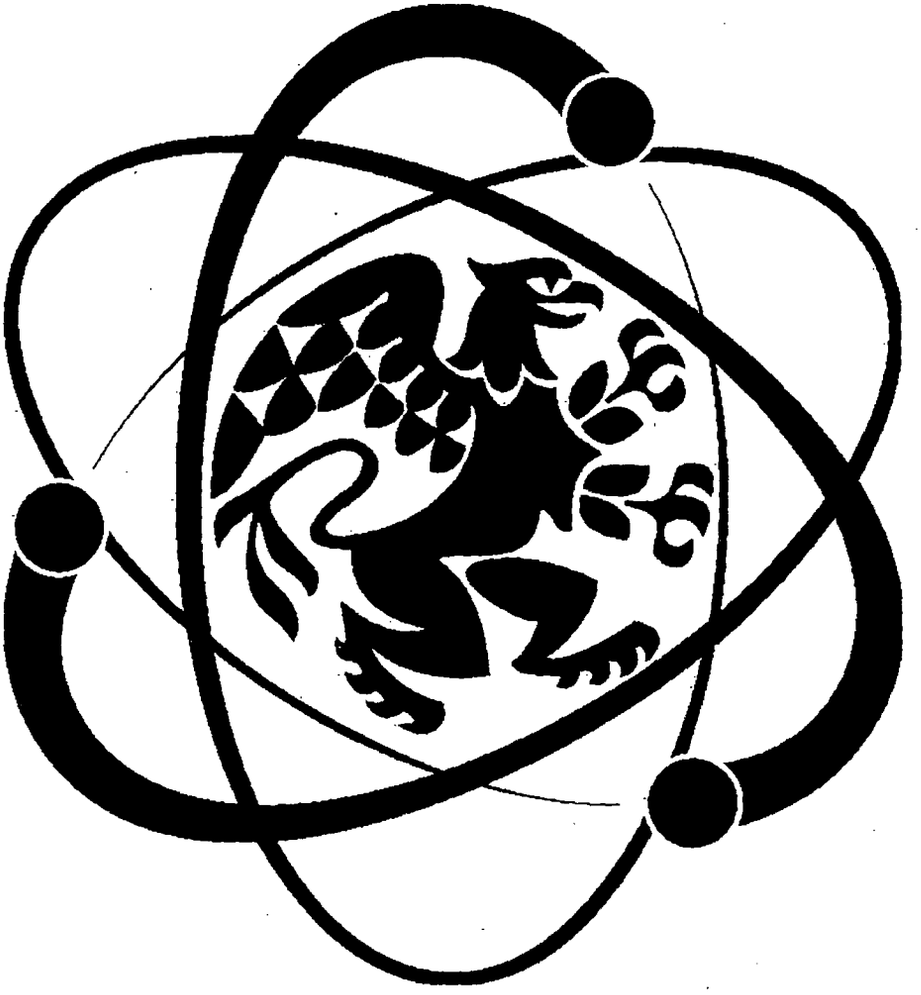
Please feel free to contact me for additional information.

Regards,

Melinda P. Krahenbuhl
Director, Reed College Reactor

A020
NRR

REED RESEARCH REACTOR
ANNUAL REPORT



July 1, 2012 -- June 30, 2013

REED RESEARCH REACTOR ANNUAL REPORT

July 1, 2012 -- June 30, 2013

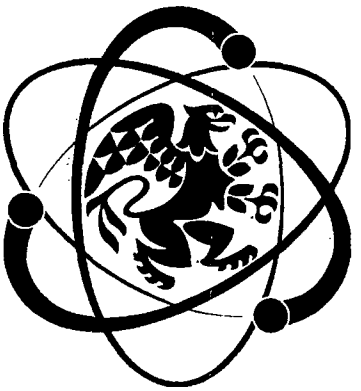


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TABLE OF CONTENTS

Overview 1

People 3
- Reactor Staff 3
- Reactor Operations Committee 4

Facilities 5
- Reactor Facility 5
- Rotating Specimen Rack Facility 5
- Pneumatic Transfer System 5
- In-Core Facilities 5
- In-Pool Facilities 6
- Beam Facilities 6

Regulatory Events 7

Audits and Inspections 8

Users 9
- Reactor Operations Seminar 9
- Outside Users 9
- Colleges and Universities 10
- High Schools and Middle Schools 10
- Special Groups 10
- High School Student Project 11
- Concordia University 11
- Scaler Kits 12
- Reed Classes 12
- Industrial and Commercial Applications 12

Reactor Operations 13
- Operations 13
- Unplanned Reactor Shutdowns 15

Reactor Maintenance 16
- Significant Maintenance 16
- 10 CFR 50.59 Screenings 16

Radiation Protection 17
- Personnel Dosimetry 17
- Gaseous Releases 18
- Liquid Waste Releases 18
- Solid Waste Disposal 19
- Environmental Sampling 19

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OVERVIEW

This report covers the period from July 1, 2012 to June 30, 2013, 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.

We specifically wish to thank Portland General Electric and Concordia University for their financial aid.

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 and research, especially in the field of trace-element analysis.

During the year there were 2578 visitors from schools, colleges, universities, and special groups. Specifically, there were 573 visitors were part of Reed College activities (prospective students, family of students, Reed classes, etc.). One hundred and thirty-nine members of emergency response organizations came for training. Finally, there were 31 entries by inspectors and regulators from state and federal agencies. Including tours and research conducted at the facility, the Reed Research Reactor contributed to the educational programs of 13 colleges and universities.

During the year the reactor was taken critical 495 times on 162 days. The total energy produced was approximately 33.02 megawatt-hours.

The reactor staff consists of a Director, an Associate Director, and Reed College undergraduate students who are licensed by the Nuclear Regulatory Commission as reactor operators or senior reactor operators. During the reporting period, 14 out of 15 Reactor Operator candidates passed their NRC exams and 6 out of 7 the Senior Reactor Operator candidates passed their NRC exams.

There were no radiation exposures to individuals in excess of the limit during the year. There were no releases of liquid radioactive material from the facility and airborne releases were well within regulatory limits. There was one shipment of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission conducted an inspection Dec. 3-6, 2012.

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PEOPLE

Reactor Staff

During the period July 1, 2012 to June 30, 2013, the staff consisted of:

Reactor Director:	Melinda Krahenbuhl	(6/11 - present)
Associate Director:	Reuven Lazarus	(5/11 – 6/2013)
Radiation Safety Officer:	Kathleen Fisher	(1/03 – present)
Reactor Supervisor:	Ian Flower Christina Barrett	(5/12 – 5/13) (5/13 – present)
Training Supervisor:	Mike Vignal Molly Maguire	(5/12 – 5/13) (5/13 – present)
Assistant Training Supervisor:	Molly Maguire Veronica Stewart	(5/12 – 5/13) (5/13 – present)
Requalification Supervisor:	Kathryn Linthicum Erin Weisenhorn	(5/12 – 7/13) (incoming)

Senior Reactor Operators (SRO)

Hannah Allen	Jake Luton	Rachael Otto
Christina Barrett	Isaac Khader	Erin Sheffels
Daniel Dashevsky	Melinda Krahenbuhl	Elisabeth Thomas
Wesley Erickson	Benjamin Larsen	Erik Thomas
Ian Flower	Reuven Lazarus	Mike Vignal
Evan Green	Molly Maguire	Christopher Vittal
Luke Howard	Huy Nguyen	Patrick Wijngaard
Austin Humphrey	Neha Rao	Andrew Warren
Trevor Lohrey	Michael Reichert	Erin Weisenhorn

Reactor Operators (RO)

Praker Bajpai	Alexander Harris	Evan Peairs
Lily Ben-Avi	Josh Hepworth	Evan Pikulski
Andrew Blount	Kelsey Houston-Edwards	Grace Poetzinger
Madelyn Brandt	Lydia Kerns	Nicole Scherm
Miguel Conner	Simran Mahtani	Nathan Showell
Gray Davidson	Jared Milfred	Juliet Shafto
Francis Dieterle	Charlie McIntyre	Natalie Stone
Elisabeth Grace	Stephan Okar	Riley Thornton
Gianmarco Greci	Ilana Novakoski	Michaela Voorhees
	Jossef Osborn	Reilly Villanueva

The list of operators includes everyone who held a license at any time during the reporting period. Reactor Operators who upgrade their licenses to Senior Reactor Operators during the reporting period are listed under Senior Reactor Operators. All of the licensed operators are Reed College undergraduate students with the exception of the Director and Associate Director.

For the 2012-2013 year there are 56 licensed operators at Reed College, 22 women and 34 men.

Reactor Operations Committee

For the 2012 – 2013, the membership of the Reactor Operation committee is shown below.

Reactor Operations Committee

Wayne Lei - Chair *(Director of Research and Development, Portland General Electric)*
Norm Dyer *(OAR Services)*
Daniel Gerrity *(Chemistry Faculty, Reed College)*
Kathleen Fisher *(Director, Reed Environmental Health and Safety)*
Lucas Illing – Chair *(Physics Faculty, Reed College)*
Steve Reese *(Radiation Center Director, Oregon State University)*
Pat McDougal *(Dean of the Faculty, Reed College)*
Melinda Krahenbuhl *(Director, RRR)*
Reuven Lazarus *(Associate Director, RRR)*
Ian Flower *(Reactor Supervisor, RRR)*

FACILITIES

Reactor Facility

In addition to the reactor, Reed College has a radiochemistry lab. The equipment available at the reactor facility includes high purity germanium gamma spectrometers, alpha spectrometers, a whole body counter, gas flow proportional counters, ion chambers, beta counters, Geiger Muller tubes, neutron detectors, alpha detectors, and thermo luminescent dosimeter readers. These instruments are used for experiments and training in nuclear science and radiation detection. Two exit monitors are in the control room. A liquid scintillation detector serves the 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 accommodate two irradiation tubes. Vials holding up to 17 ml (four drams) are used in this system. Samples are loaded in the specimen rack prior to the start-up of the reactor. The rack automatically rotates during irradiation to ensure each sample receives the same neutron flux. Typically, researchers use the rotating rack when long irradiation times (generally greater than five minutes) are required. The approximate thermal neutron flux in a rotating rack position at full power is 1.7×10^{12} n/cm^{2}s with a cadmium ratio of 6. The specimen rack can be used for gamma irradiations (approximately 8 Rad/min) when the reactor is shutdown.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outer F-ring of the core and its associated pump and piping. This allows samples to be transferred in and out of the reactor core very rapidly while the reactor is at power.

Routine use of the pneumatic transfer system involves placing samples into vials, which in turn are placed in special capsules known as "rabbits." The capsule is loaded into the system in the laboratory next to the reactor and is then transferred pneumatically into the core-irradiation position. At the end of a predetermined time the sample is transferred back to the receiving terminal, where it is removed for measurement. The transfer time from the core to the terminal is about seven seconds, making this method of irradiating samples particularly useful for experiments involving radioisotopes with short half-lives. The flux in the core terminal is approximately 5×10^{12} n/cm^{2}s when the reactor is at full power.

In-Core Facilities

The central thimble is a water-filled irradiation chamber about 3 cm in diameter. It provides the highest available neutron flux, about 1×10^{13} n/cm^{2}s. Special sample holders are used in the central thimble to provide maximum flexibility in experiment design.

A fuel replacement source holder assembly can also be used as an irradiation facility. The chamber fits into a fuel-element position within the core itself. It holds only one specially positioned irradiation container 7.5 cm in length and 2.5 cm in diameter.

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

In-Pool Facilities

Near core, in-pool irradiation facilities can be arranged for larger samples. Neutron fluxes will be lower than in the rotary specimen rack and will depend on the sample location.

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. This beam can be used to generate directional neutron flux, or for limited irradiations above the tank. Prompt gamma analysis and neutron radiography can be done. The flux above the beam exit is approximately $1x10^6$ n/cm^{2}s when the reactor is at full power.

REGULATORY EVENTS

The Nuclear Regulatory Commission conducted inspections during December 3-6, 2012. A Notice of Violation was issued Jan. 2, 2013. A reply was sent to the NRC on January 30, 2013. Corrective actions have been implemented.

AUDITS AND INSPECTIONS

Two audits and one inspection were completed during this period. Norm Dyer completed an internal audit on Dec. 11, 2012. On July 30-31, 2012. Phillip Campbell conducted an audit of the Campus Radiation Safety program. Additionally, Ed Everett from ANI Nuclear Liability Insurance completed an inspection. Recommendations that are still being addressed are Emergency Plan revisions, Record Retention and Radioactive waste storage and documentation.

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. Some of the students continue with in-depth reactor operator training and subsequently apply for a Reactor Operator (RO) license. If successful, the individual may be hired to operate the reactor. In addition, existing ROs may take the NRC Senior Reactor Operator (SRO) exam to upgrade their licenses.

During the reporting period, 14 out of 15 RO candidates and 5 out of 6 SRO candidates passed their NRC exams.

Figure 1 is a graph of the number of license application each year showing how many new RO and SRO licenses were awarded at Reed.

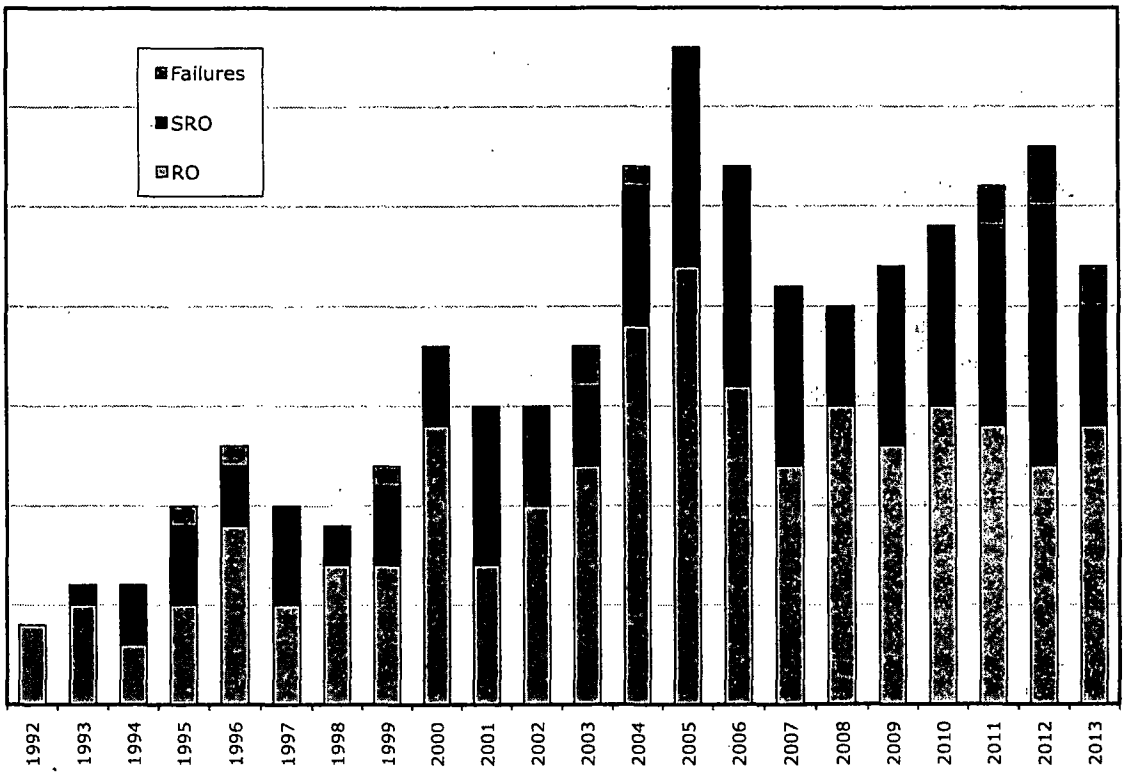

Figure 1 Reed Research Reactor License Exam Results

Outside Users

During the year there were 1871 visitors from schools, colleges, universities, and special groups. Additionally, there were 537 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). One hundred and thirty-

nine members of emergency response organizations came for training. Finally, there were 31 entries by inspectors and regulators from state and federal agencies.

The following institutions have participated in facility tours, experiments, and research projects in the reporting period.

Colleges and Universities

University of Washington
Clark College
Columbia Gorge Community College
Concordia University
Oregon Health Science University
Oregon Institute of Technology
Oregon State University
Pitzer College
Pacific University
Portland State University
Portland Community College (Rock creek, Sylvania)
Warner Pacific College
Mount Hood Community College

High Schools and Middle Schools

Catlin Gabel
Christ the King Catholic School
Cleveland High School
Ekton Charter School
Gresham Barlow Academy
Grout High School
Marist High School
Putnam High School
Waldorf High School
Sunnyside Environmental School
Roosevelt High School

Special Groups

Thomas Deus Group
Rainbo PTG
Boy Scouts (597, 110)
nConnect
RSO class
Saturday Academy
ASE STEM Camp
Latin Forum
The Read Bleck Experience
PNCC
Science Outreach

Figure 2 is a graph showing the history of visiting groups.

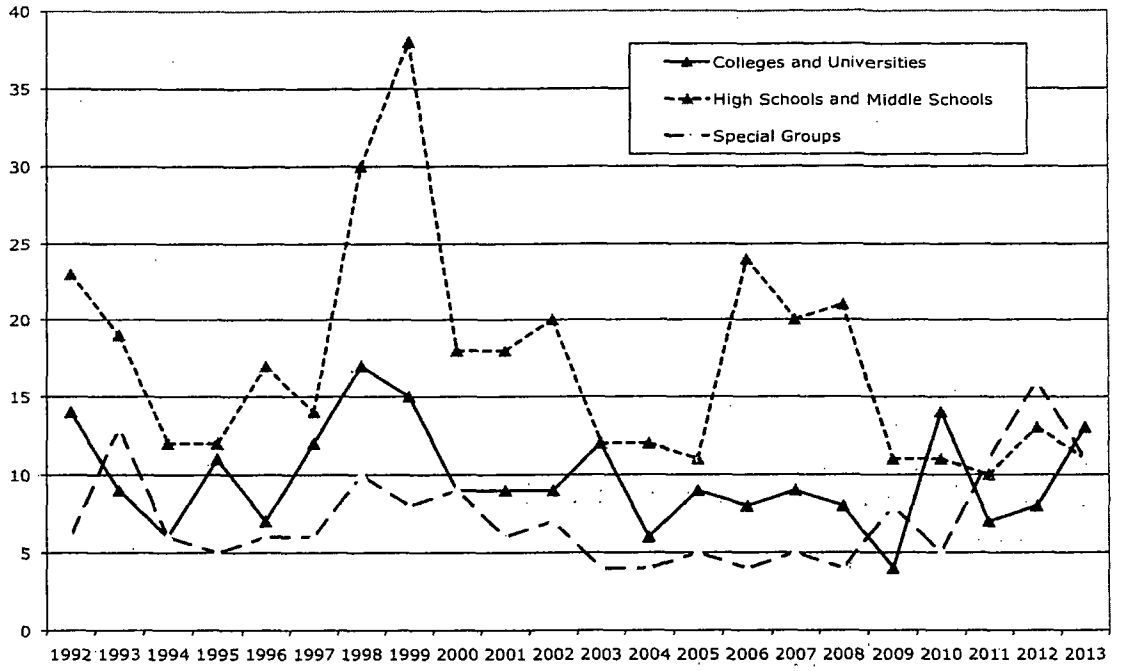

Figure 2 Visiting Groups

Many reactor tours include hands-on use of facility equipment to conduct experiments in radiation science, health physics, and nuclear physics. A typical lab involves determining the background of a Geiger Muller scalar system and then determining the half-life of a sample of radioactive material. College classes are generally more closely tailored to the individual interests and needs of the Consortium faculty member involved. Experiments include more direct use of the reactor itself by the students, more detailed analysis of materials, and emphasize the incorporation of other classroom activities as much as possible.

Several special programs for gifted children use the reactor for projects. These are designed to enrich their educational program and prepare them for college. Some of the groups who use the reactor target minority and disadvantaged youth who are historically under-represented in science professions.

High School Student Project

The Reed Research Reactor continues to be used in independent science projects initiated by students from several Oregon and Washington State high schools.

Concordia University

The reactor provides training and experiments involving radiation, radioactive material, and trace element analysis for Concordia University classes.

Scaler Kits

Through the generosity of Portland General Electric, the reactor lends out kits containing a Geiger counter, a scaler, and some small exempt sources to local high schools.

Reed Classes

- Chemistry 101 students explored the properties of alpha, beta and gamma irradiation.
- Chemistry 311 Extent of Chemical Reaction using potassium as the tracer
- Three Reed students used the reactor as part of their senior thesis.
    - *Deep Blue: Examining Cerenkov Radiation Through Non-traditional Media,* Ian Flower
    - *Thermal Mapping of the Reed Research Reactor Core,* Michael Vignal
    - *A Novel Synthetic Route to porous V_2O_5,* Ellen Murphy

Industrial and Commercial Applications

The Reed Research Reactor is available for industrial or commercial concerns when it does not conflict with our educational goals. As in the past, the primary operations involved neutron activation analysis of materials or environmental samples. The facility also provides radiation protection training to interested parties and schools in the area.

REACTOR OPERATIONS

Operations

During the year the reactor was taken critical 495 times on 162 days. The total energy produced was approximately 33 megawatt-hours. Operating history by month appears in table 1. A history of the data is shown in figure 3.

Table 1 Operating History 2011-2012

	TIMES CRITICAL	DAYS OPERATED	MW-HOURS
July 2012	14	10	0.97
August 2012	18	10	1.69
September 2012	48	12	2.44
October 2012	41	14	1.98
November 2012	37	14	3.71
December 2012	66	11	2.08
January 2013	19	12	1.74
February 2013	111	23	6.97
March 2013	35	15	2.00
April 2013	57	22	5.04
May 2013	37	14	3.73
June 2013	12	5	0.67
Total	495	162	33.02

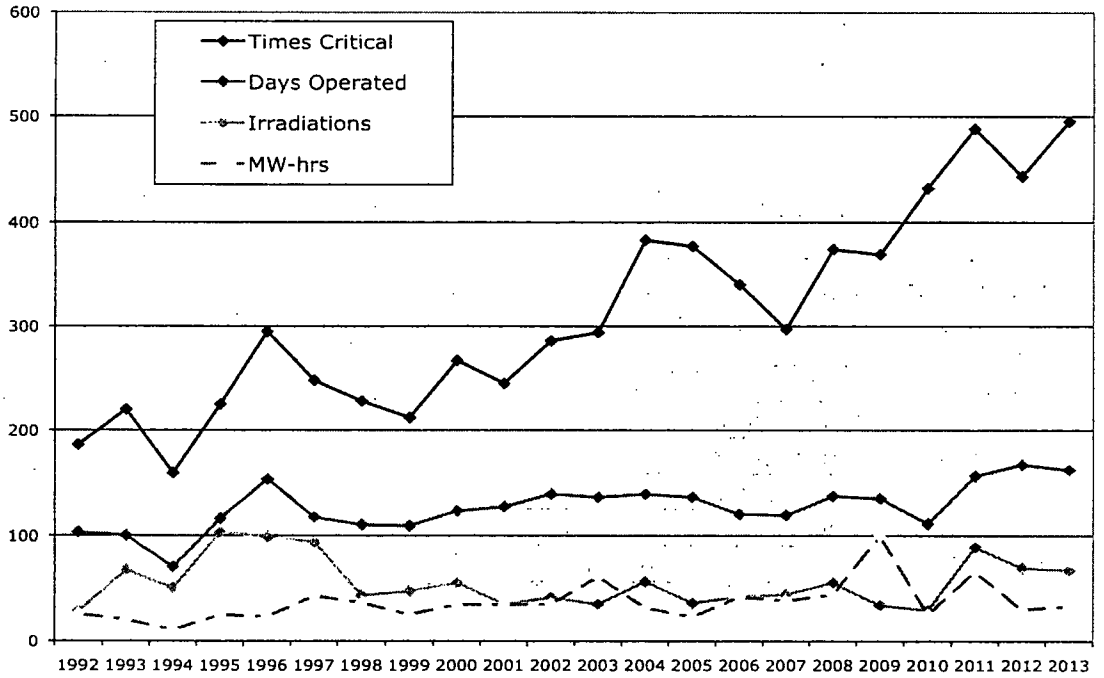

Figure 3. Operations

Unplanned Reactor Shutdowns

There were 9 inadvertent reactor shutdowns (scrams) as shown in table 2. The number of unplanned reactor shutdowns is increasing as shown in figure 4.

Table 2 Unplanned Reactor Shutdowns

DATE	SCRAM TYPE	CAUSE OF SCRAM
8/23/2012	-	Grounded magnet
9/13/2012	Linear Power	Auto range not selected
9/22/2013	Linear Power	Operator overshot target power
9/23/2013	Linear Power	Operator overshot target power
11/13/2013	Linear Power	Operator overshot target power
1/28/2013	Percent power	Test signal inadvertently actuated during operations
2/7/2013	Linear Power	Operator overshot target power
2/23/2013	Linear Power	Operator overshot target power
2/24/2013	Linear Power	Auto range not selected

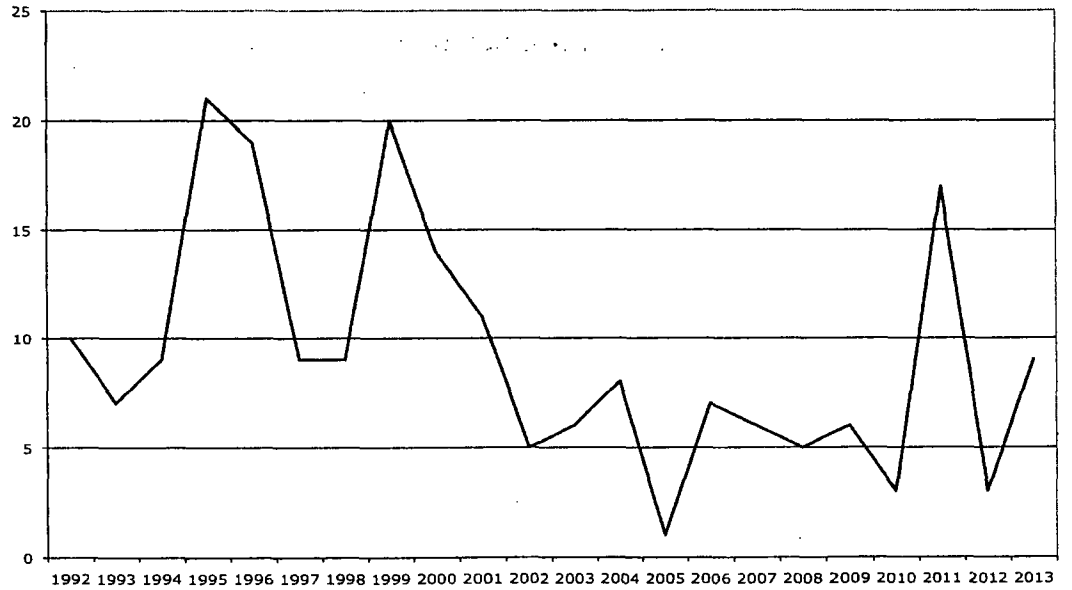

Figure 4 Unplanned Shutdowns

REACTOR MAINTENANCE

Significant Maintenance

Reactor staff performs routine equipment checks on a daily, weekly, bimonthly, semiannual (January and July) and annual (January) basis as required by facility procedures. Reed College maintenance personnel assist with routine preventative maintenance to auxiliary equipment.

10 CFR 50.59 Screenings

12-04 Replace the secondary cooling tower

The secondary cooling tower was replaced as a turn-key installation. Some superfluous piping was removed. Drawings in the Facility reference manual and Training Manuel were replaced.

12-05 Replaced the electromagnet on the safety control rod

The electromagnet on the safety control rod was replaced with an electromagnet from a spare control rod drive.

12-06 Replaced the air pump for the APM and GSM

12-07 Mount the thermocouple apparatus. Special Experiment #4

Two thermocouple mounts were designed to fit over adjacent fuel element pins. The design did not impede water flow through the core. The experiment was approved by the Reactor Operations Committee.

12-08 Add Check valve to the primary clean-up line (not implemented yet)

13-01 Replaced the Reg Rod Switch

The Reg rod up button was replaced with a similar button.

13-02 Single fuel element replacement

During fuel inspection, a single fuel element had a suspect spot. The element was replaced with an element with a similar operational history.

13-03 Revised calculation for Rod worth measurements.

The mathematical modeling for the rod worth measurements were updated.

RADIATION PROTECTION

Personnel Dosimetry

Dosimeters are changed on a calendar quarter schedule. Individuals were issued beta-gamma sensitive ring badges and whole-body badges. The Director and Associate Director were issued beta-gamma-neutron sensitive dosimetry.

During the year the largest whole body dose reported for this year was 2 mrem deep dose equivalent. The largest extremity dose reported was 30 mrem shallow dose equivalent. However, all individuals with used dosimetry for that quarter were assigned 30 mrem shallow dose due to loss of the control badge.

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. Three locations also measure neutron dose.

The deep dose equivalent radiation measured by fixed dosimeters during the period July 1, 2011 to June 30, 2012 are shown in table 5. M indicated less than 1 mrem during the quarter.

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

LOCATION	HEIGHT (M)	RADIATION DETECTED	JUL 1 – SEP 30	OCT 1 - DEC 31	JAN 1 - MAR 31	APR 1 - JUN 30	TOTAL
Reactor East Wall	1.5	β, γ	4	7	15	16	37
Reactor North Wall	1.6	β, γ	11	14	10	8	80
Reactor West Wall	1.0	β, γ, n	37	42	24	25	116
Reactor South Wall	1.6	β, γ, n	5	6	7	6	33
Reactor North Wall	2.3	β, γ	4	8	7	3	42
Control Room	1.5	β, γ	0	4	3	2	21
Outside North	2.8	β, γ	3	6	3	2	33
Outside Roof	0.4	β, γ, n	M	M	M	M	M
Outside East	1.5	β, γ	M	M	M	M	M
Outside South	0.4	β, γ	M	M	M	M	M
Counting Room	1.5	β, γ	M	M	M	M	M

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 3.41 x 10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 1.70 mrem, well below regulatory guidelines and constraints. Figure 5 shows the gaseous releases for each year.

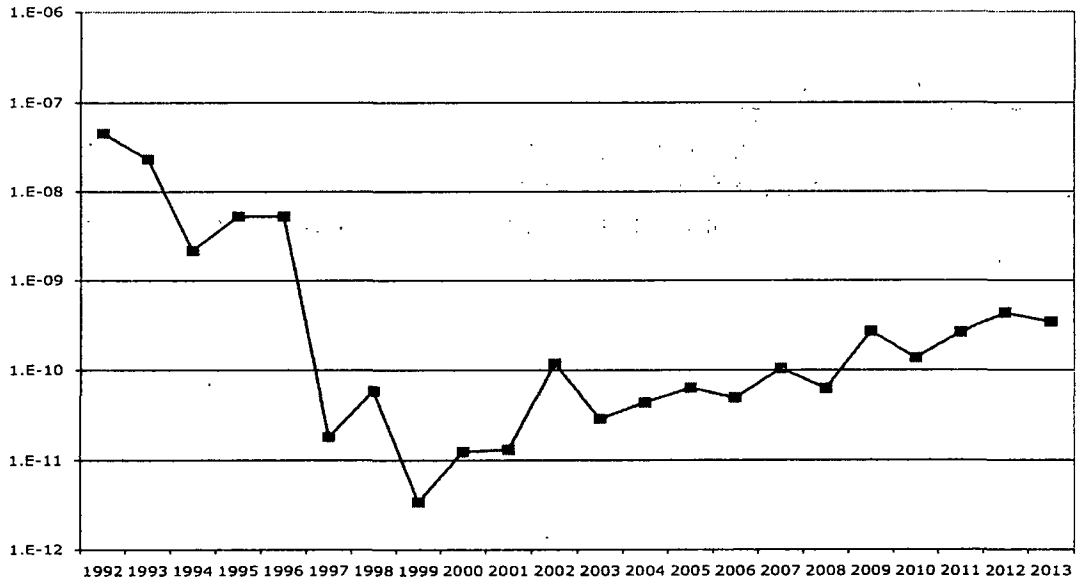

Figure 5 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

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

Solid Waste Disposal

There was one shipments of low-level radioactive waste from the facility during this reporting period.

Table 6 Solid Waste Disposal

Date	Drum	Activity	Radionuclide
7/25/2012	Q	2.257 MBq (0.061 mCi)	Co60, Mn54, Sc46, Zn65

Environmental Sampling

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, but showed no activity above normal background.