REED COLLEGE

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August 7, 2012

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, 2011 -- June 30, 2012

REED RESEARCH REACTOR ANNUAL REPORT

July 1, 2011 -- June 30, 2012

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OVERVIEW

This report covers the period from July 1, 2011 to June 30, 2012, 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 2026 visitors from schools, colleges, universities, and special groups. Additionally, there were 806 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Seventy-nine members of emergency response organizations came for training. Finally, there were 19 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 8 colleges and universities in addition to 13 pre-college groups. During the year the reactor was taken critical 433 times on 167 days. The total energy produced was approximately 30 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. The licensed operating staff consists of 17 women and 31 men. During the reporting period, 12 out of 15 Reactor Operator candidates passed their NRC exams and all 13 of the Senior Reactor Operator candidates passed their NRC exams.

The license was renewed effective April 24, 2012.

There were no radiation exposures to individuals in excess of two percent 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 were no shipments of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission conducted inspections during November 28-30, 2011. No deficiencies were noted during the inspection.

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PEOPLE

Reactor Staff

During the period July 1, 2011 to June 30, 2012, the staff consisted of:

Reactor Director:	Melinda Krahenbuhl	(6/11 - present)
Associate Director:	Reuven Lazarus	(5/11 – present)
Radiation Safety Officer:	Kathleen Fisher	(1/03 – Present)
Reactor Supervisor:	Matt Carlson Ian Flower	(5/11 – 5/12) (5/12 – Present)
Training Supervisor:	Kathleen Conahan Mike Vignal	(5/11 – 5/12) (5/12 – Present)
Assistant Training Supervisor:	Mike Vignal Molly Maguire	(5/11 – 5/12) (5/12 – present)
Requalification Supervisor:	Ian Flower Kathryn Linthicum	(5/11 – 6/12) (starts 7/11)

Senior Reactor Operators (SRO)

Hannah Allen
Matthew Carlson
Kathleen Conahan
Daniel Dashevsky
Wesley Erickson
Ian Flower
Evan Green
Luke Howard
Austin Humphrey
Alina Kassenbrock
Isaac Khader
Melinda Krahenbuhl
Benjamin Larsen
Reuven Lazarus
Molly Maguire
Ellen McManis
Huy Nguyen
Neha Rao
Neal Reynolds
Michael Reichert
Ahmad Shabbar
Elisabeth Thomas
Erik Thomas
Mike Vignal
Christopher Vittal
Patrick Wijngaard
Florence Williams
Andrew Warren
Erin Weisenhorn

Reactor Operators (RO)

Praker Bajpai
Christina Barrett
Andrew Blount
Madelyn Brandt
Gray Davidson
Francis Dieterle
Elisabeth Grace
Gianmarco Greci
Alexander Harris
Kelsey Houston-Edwards
Trevor Lohrey
Jake Luton
Jared Milfred
Jossef Osborn
Evan Pikulski
Cristi Panda
Juliet Shafto
Erin Sheffels
Michaela Voorhees

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 2011-2012 year there are 7 women and 12 men with Reactor Operator licenses and 10 women and 19 men with Senior Reactor Operator licenses.

Reactor Review Committee

For the 2011 – 2012, the Reed Research Reactor (RRR) has two oversight committees: the Reactor Safety Committee and the Reactor Operations Committee. Together they comprise the Reactor Review Committee. The membership of the committees during the reporting period is shown below:

Reactor Safety 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)*
Thomas Wieting (*Mathematics Faculty, Reed College*)
Robert McCullough *(Community Member)*

Reactor Operations Committee

Lucas Illing – Chair (*Physics Faculty, Reed College*)
Juliet Brosing *(Physics Faculty, Pacific University)*
John Essick *(Physics Faculty, Reed College)*
Steve Reese *(Radiation Center Director, Oregon State University)*
Ron Ross *(Portland General Electric)*
Steven Congdon *(Community Member)*

Ex Officio without vote on both committees:

Pat McDougal *(Dean of the Faculty, Reed College)*
Melinda Krahenbuhl *(Director, RRR)*
Reuven Lazarus *(Associate Director, RRR)*
Matthew Carlson *(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 campus radioisotope committee. 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.

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, 12 out of 15 RO candidates and 13 out of 13 SRO candidates passed their NRC exams.

Figure 2 is a graph of the number of license application each year showing how many new RO and SRO licenses were awarded at Reed.

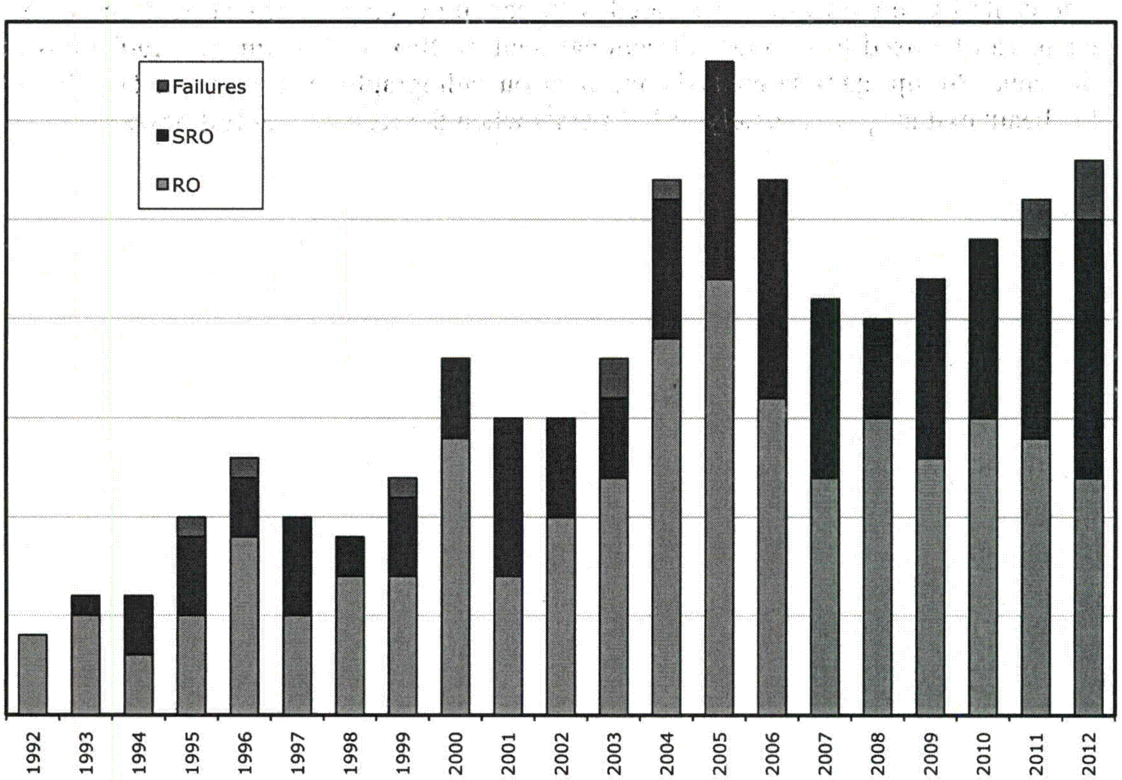

Figure 2 Reed Research Reactor License Exam Results

Outside Users

During the year there were 2026 visitors from schools, colleges, universities, and special groups. Additionally, there were 806 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Seventy-nine members of

emergency response organizations came for training. Finally, there were 19 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

- Clark College
- Columbia Gorge Community College
- Concordia University
- Oregon Health Science University
- Oregon Institute of Technology
- Pacific University
- Portland Community College
- Warner Pacific College

High Schools and Middle Schools

- Alliance High School
- Cascades Montessori
- Catlin Gabel
- Christ the King Catholic School
- Cleveland High School
- Corbett High School
- Gilkey Middle School
- Hosford Middle School
- Life Christian School
- Lewis Elementary
- Northwest Academy
- Portland Waldorf
- Smith Ridge High School

Special Groups

- Adsideo Church
- American Society for Non-Destructive Testing ASNDT
- Autistic Children's Activity
- Bend Science Station
- Calligraphy Northwest
- Intel
- Mathcamp
- Metropolitan Learning Center
- OSHER
- Oregon TAG
- PCC Cosmos Science Club
- Reed Neighborhood association
- Reed Latin Day
- RSO class
- Saturday Academy
- Uniquely Portland

Figure 3 is a graph showing the history of visiting groups.

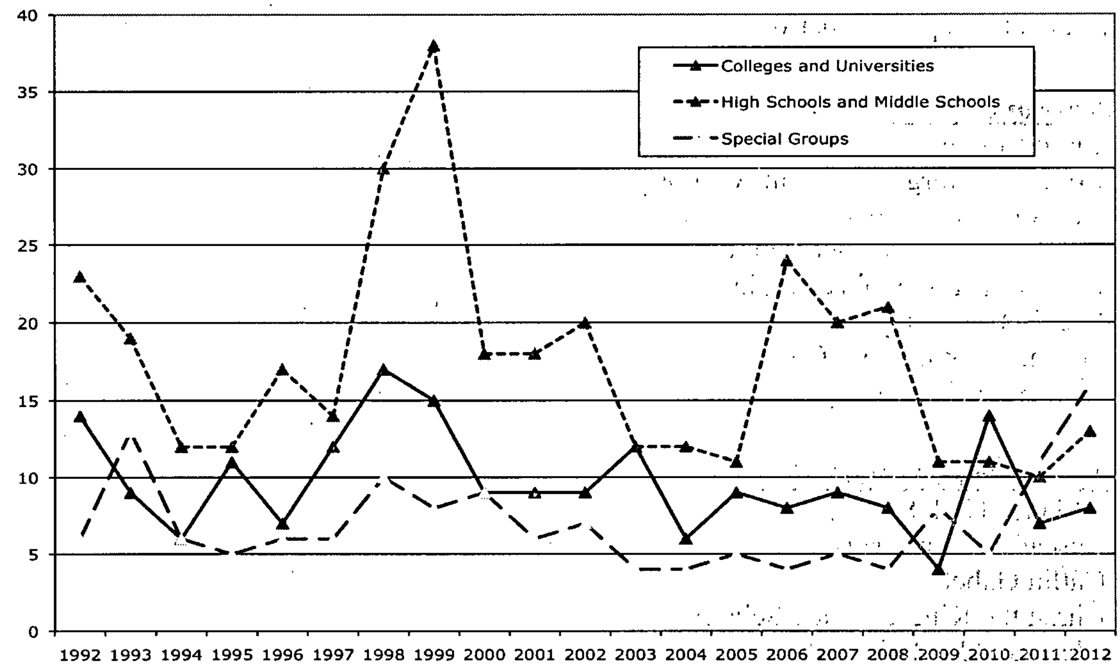

Figure 3 Visiting Groups

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 determined the half-lives of chemical forms of vanadium.
- Chemistry 311 Extent of Chemical Reaction using potassium as the tracer
- One Reed student used the reactor as part of his senior thesis.

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 443 times on 167 days. The total energy produced was approximately 30 megawatt-hours. Operating history by month appears in table 1. A history of the data is shown in figure 4.

Table 1 Operating History 2011-2012

	TIMES CRITICAL	DAYS OPERATED	MW-HOURS
July 2011	14	10	2.31
August 2011	26	12	2.45
September 2011	76	13	2.43
October 2011	50	18	2.67
November 2011	50	17	2.98
December 2011	14	8	2.16
January 2012	15	13	1.53
February 2012	42	17	3.11
March 2012	47	18	2.66
April 2012	46	15	2.97
May 2012	41	16	2.90
June 2012	22	10	1.72
Total	443	167	29.90

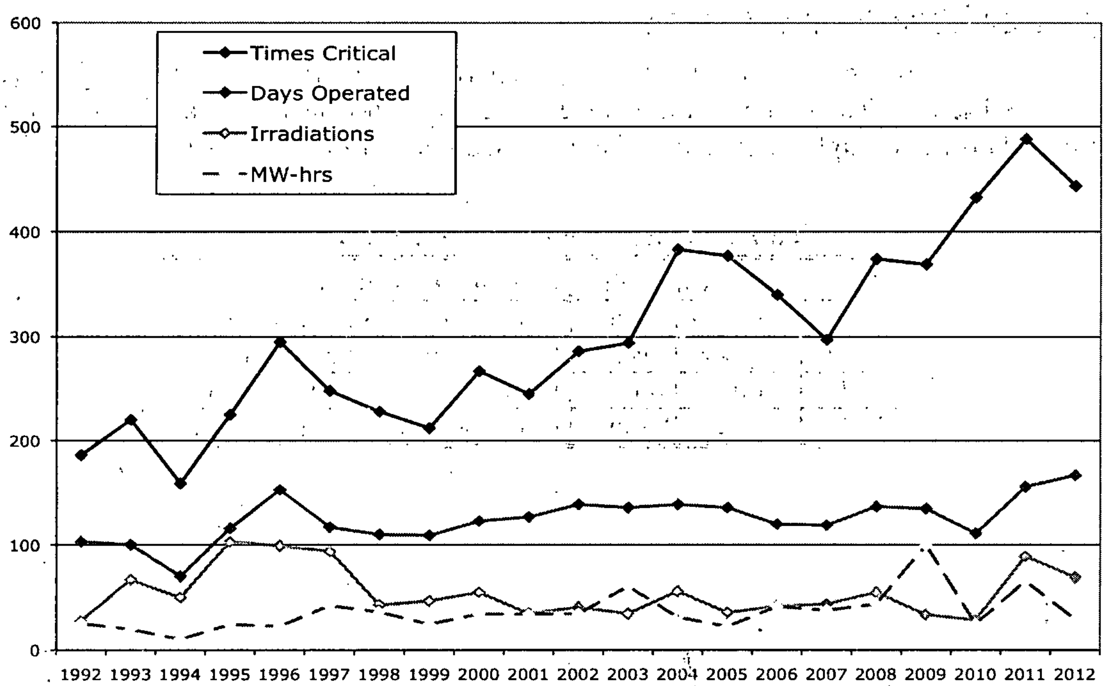

Figure 4. Operations

Unplanned Reactor Shutdowns

There were 4 inadvertent reactor shutdowns (scrams) as shown in table 2. There was one unexplained scram. The number of unplanned reactor shutdowns is increasing as shown in figure 5. This trend might be linked to the increased number of operations as seen in figure 4.

Table 2 Unplanned Reactor Shutdowns

DATE	SCRAM TYPE	CAUSE OF SCRAM
9/17/11	Linear Power	Operator overshot target power
9/18/11	Linear Power	Operator overshot target power
2/24/12	Linear Power	Operator overshot target power
3/20/12	Linear Power	Operator overshot target power

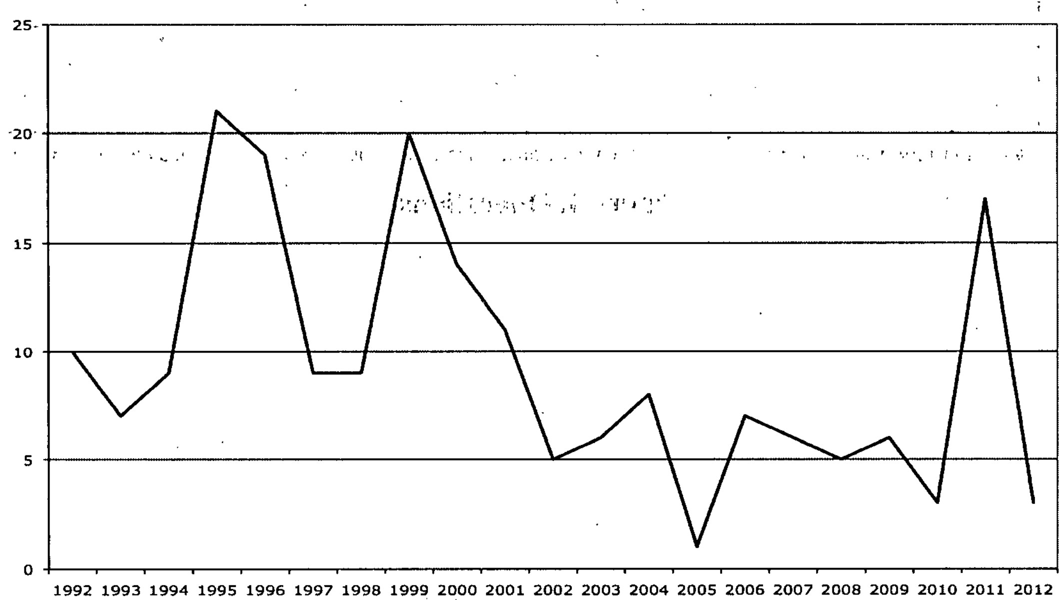

Figure 5 Unplanned Shutdowns

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. Significant maintenance operations that were not part of a regular schedule are listed in table 3.

Table 3 Significant Maintenance Operations

DATE	MAINTENANCE
4/10/12	Set-screw tightened on the Regulating rod's shaft drive to prevent mechanical slippage.
6/28/12	Make - up water – moved brass meter to before ion exchange tank and installed a second particulate filter.

10 CFR 50.59 Screenings

10 CFR 50.59 screening were reviewed during this reporting period. None of these screenings were referred to the reactor operations committee.

11-3 Replace yellow filter caps in the demineralizer tanks

Filter cap was cracked allowing resin to leak into the pool. A new cap was manufactured and installed.

12-01 Installed pH probe

A pH probe was installed in the tank and the readout mounted to railing.

12-02 Installed an experiment apparatus to measure Cerenkov radiation

An aluminum pole with a horizontal arm was positioned in the empty core detector position. The apparatus was attached to railing. The railing bore the weight of the tool. The experiment was approved by the Reactor Operations Committee in a separate action.

RADIATION PROTECTION

Personnel Dosimetry

During the period July 1, 2011 to June 30, 2012 personnel dosimeters were issued to 54 Reed students and staff. Since dosimeters are changed on a calendar quarter schedule, this period is the closest to the reporting period. 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 annual whole body dose was 2 mrem deep dose equivalent. The largest annual extremity dose was 40 mrem shallow dose equivalent.

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	10	13	8	6	37
Reactor North Wall	1.6	β, γ	19	24	18	19	80
Reactor West Wall	1.0	β, γ, n	28	34	26	28	116
Reactor South Wall	1.6	β, γ, n	8	12	7	6	33
Reactor North Wall	2.3	β, γ	10	14	8	10	42
Control Room	1.5	β, γ	7	6	5	3	21
Outside North	2.8	β, γ	17	11	2	3	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 4.31 x 10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 2.16 mrem, well below regulatory guidelines and constraints. Figure 6 shows the gaseous releases for each year.

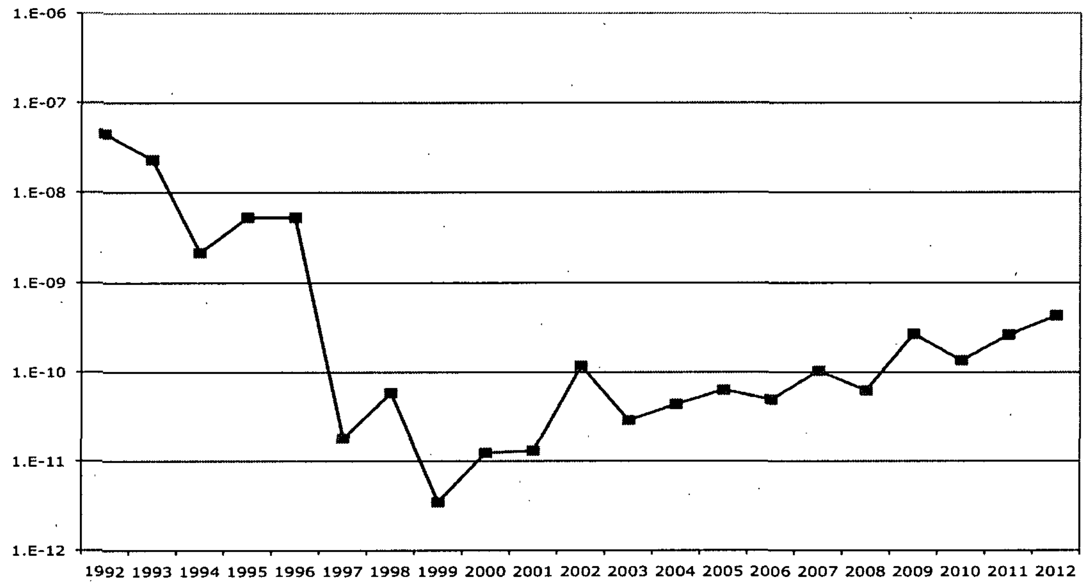

Figure 6 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

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

Solid Waste Disposal

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

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.