REED COLLEGE

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August 1, 2011

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

AD20
NRR

REED RESEARCH REACTOR
ANNUAL REPORT

July 1, 2010 -- June 30, 2011

REED RESEARCH REACTOR ANNUAL REPORT

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OVERVIEW

This report covers the period from July 1, 2010 to June 30, 2011, 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 1,227 visitors from schools, colleges, universities, and special groups. Additionally, there were 531 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Forty members of emergency response organizations came for training. This year the reactor was visited by 6 news/publication organizations including Popular Science and US News and World Report. Finally, there were 55 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 7 colleges and universities in addition to 9 pre-college groups. During the year the reactor was taken critical 488 times on 156 days. The total energy produced was approximately 66 megawatt-hours.

The reactor staff consists of a Director, an Associate Director, a Health Physicist, 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 22 women and 35 men. During the reporting period, all 14 Reactor Operator candidates passed their NRC exams and 8 of the 10 Senior Reactor Operator candidates passed their NRC exams. Additionally, Stephen Frantz, the Director for the past 17 years retired. Melinda Krahenbuhl has assumed this role.

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 two shipments of low-level radioactive waste from the facility.

The facility did receive and ship fuel this year. The license was amended to increase the special nuclear material inventory to accommodate the receipt and possession of the University of Arizona fuel.

The Nuclear Regulatory Commission conducted inspections during December 6 through December 9, 2010 and June 5 through June 10, 2011. No deficiencies were noted during either inspection.

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PEOPLE

Reactor Staff

During the period July 1, 2010 to June 30, 2011, the staff consisted of:

Reactor Director:	Stephen Frantz	(4/94 – 6/11)
	Melinda Krahenbuhl	(6/11 – Present)
Associate Director:	Robin Bjorkquist	(7/09 – 5/11)
	Reuven Lazarus	(5/11 – present)
Reactor Supervisor:	Celia Oney	(5/10 – 5/11)
	Matt Carlson	(5/11 – Present)
Training Supervisor:	Mary Solbrig	(5/10 – 5/11)
	Kathleen Conahan	(5/11 – Present)
Assistant Training Supervisor:	Kathleen Conahan	(5/10 – 5/11)
	Mike Vignal	(5/11 – present)
Requalification Supervisor:	Jeremy Silver	(5/10 – 5/11)
	Ian Flower	(5/11 – Present)
Radiation Safety Officer:	Kathleen Fisher	(1/03 – Present)
Health Physicist:	Rupinder Kaur	(1/10 – 6/11)

Senior Reactor Operators (SRO)

Robin Bjorkquist	Alina Kassenbrock	Jeremy Silver
Matthew Carlson	Benjamin Larsen	Mary Solbrig
Kathleen Conahan	Reuven Lazarus	Erik Thomas
Rosie Cottingham	Ellen McManis	Mariah Tobin
Wesley Erickson	Celia Oney	Mike Vignal
Ian Flower	Neal Reynolds	Stephen Von Kugelgen
Stephen Frantz	Michael Reichert	Patrick Wijngaard
Evan Green	Laura Sard	Florence Williams
Luke Howard	Ahmad Shabbar	

Reactor Operators (RO)

Kaileigh Ahlquist	Isaac Khader	Marcus Robinson
Hannah Allen	May-Ling Li	Brandy Ryan
Praker Bajpai	Daniel Lidral-Porter	Nick Salter
Daniel Dashevsky	Trevor Lohrey	Juliet Shafto
Gray Davidson	Molly Maguire	Elisabeth Thomas
Francis Dieterle	Huy Nguyen	Harry Traulsen
Todd Garon	Briana Patton	Christopher Vittal
Gianmarco Greci	Evan Pikulski	Andrew Warren
Kelsy Houston-Edwards	Neha Rao	Erin Weisenhorn
Austin Humphrey	Cristi Panda	

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 2010-2011 year there are 11 women and 19 men with Reactor Operator licenses and 11 women and 16 men with Senior Reactor Operator licenses.

Reactor Review Committee

The Reed Research Reactor has two oversight committees: the Reactor Safety Committee and the Reactor Operations Committee. Together they comprise the Reactor Review Committee. The Reactor Safety Committee is concerned with emergency preparedness, health physics, radiation safety, physical security, environmental impact, and the interface between the Reed Research Reactor, Reed College, and the surrounding community. The Reactor Operations Committee deals with the day-to-day operations of the reactor, reactor maintenance, reactor safety, operator training, and operator requalification. 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)*
Robert McCullough *(Community Member)*

Reactor Operations Committee

Juliet Brosing – Chair *(Physics Faculty, Pacific University)*
Darrell Schroeter - *(Physics Faculty, Reed College)*
Steve Reese *(Radiation Center Director, Oregon State University)*
Ron Ross *(Portland General Electric)*
Steven Congdon *(Community Member)*
Rupinder Kaur *(Health Physicist, RRR)*

Ex Officio without vote on both committees:

Ellen Stauder *(Dean of the Faculty, Reed College)*
Stephen Frantz *(Director, RRR)*
Robin Bjorkquist *(Associate Director, RRR)*
Celia Oney *(Reactor Supervisor, RRR)*
Rupinder Kaur *(Health Physicist)*

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 ("lazy susan") 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 lazy susan 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 1×10^6 n/cm^{2}s when the reactor is at full power.

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, 15 out of 15 RO candidates and 8 out of 10 SRO candidates passed their NRC exams.

Historically students who fail the NRC exam only fail one section and they are allowed to retake that section later. 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 and how many failed to obtain a license. Following the large class in 2005 we began limiting the number of license candidates to 15 ROs per year.

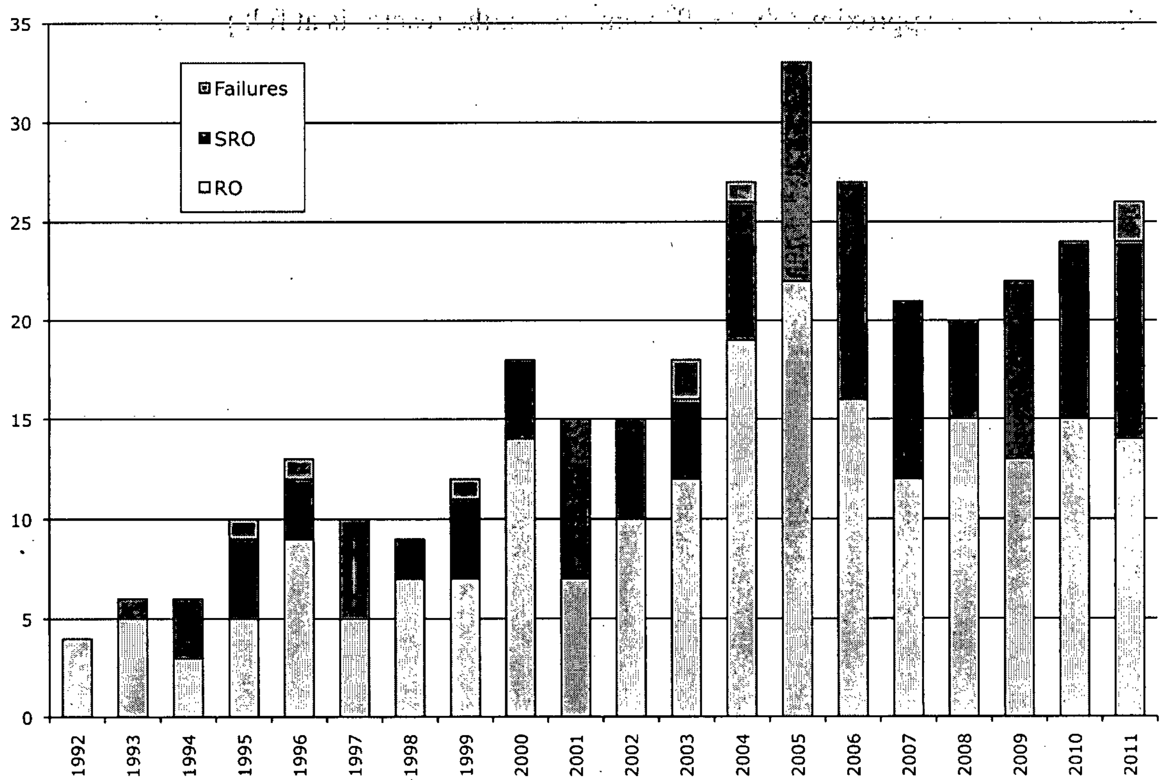

Figure 2 Reed Research Reactor License Exam Results

Outside Users

During the year there were 1,227 visitors from schools, colleges, universities, and special groups. Additionally, there were 531 visitors as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Forty members of emergency response organizations came for training. This year the reactor was visited by 6 news/publication organizations including Popular Science and US News and World Report. Finally, there were 55 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
- Pacific University
- Portland Community College
- Saint Martin's University

High Schools and Middle Schools

- Buckman Elementary
- Catlin Gabel
- Corbett High School
- Elkton Charter School
- Hosford Middle School
- Riverdale High School
- Roosevelt High School
- The International School
- Woodstock Elementary

Special Groups

- American Chemical Society
- Atlas Obscura
- Boy Scouts
- Cub Scouts
- nConnect
- Pop Atomic
- Reed Latin Day
- RSO class
- Saturday Academy
- Summer Science Camp
- TEPCO

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

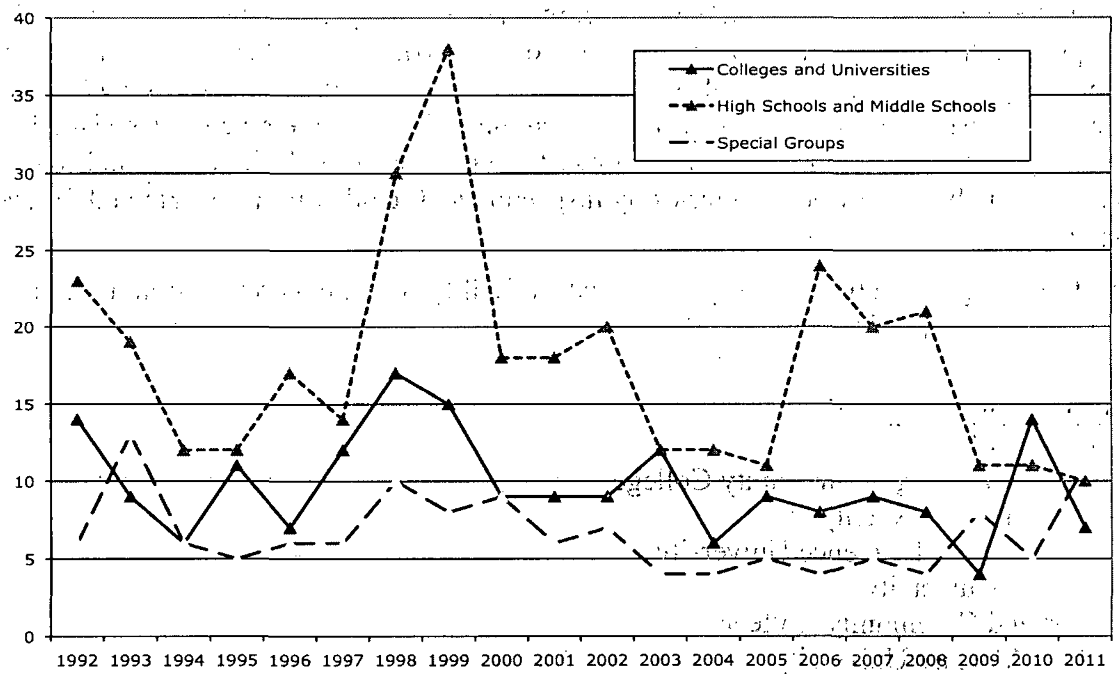

Figure 3 Visiting Groups

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 271 students used neutron activation analysis to determine chemical composition of an unknown compound.
- Chemistry 101 students determined the half-lives of chemical forms of vanadium.
- Two Reed students used the reactor as part of their 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 432 times on 111 days. The total energy produced was approximately 25 megawatt-hours. Operating history by month appears in table 1. A history of the data is shown in figure 4. Note that the number of times critical for the month of January, this is due to the change from aluminum clad fuel to stainless steel clad fuel received from University of Arizona.

Table 1 Operating History 20010-2011

	Times Critical	Days Operated	MW-hours
July 2010	8	6	2.18
August 2010	28	10	3.88
September 2010	61	12	5.34
October 2010	66	14	2.17
November 2010	42	13	5.78
December 2010	23	8	1.45
January 2011	0	4	0.00
February 2011	57	21	5.71
March 2011	52	21	19.64
April 2011	68	22	13.05
May 2011	60	15	4.30
June 2011	23	10	2.09
Total	488	156	65.59

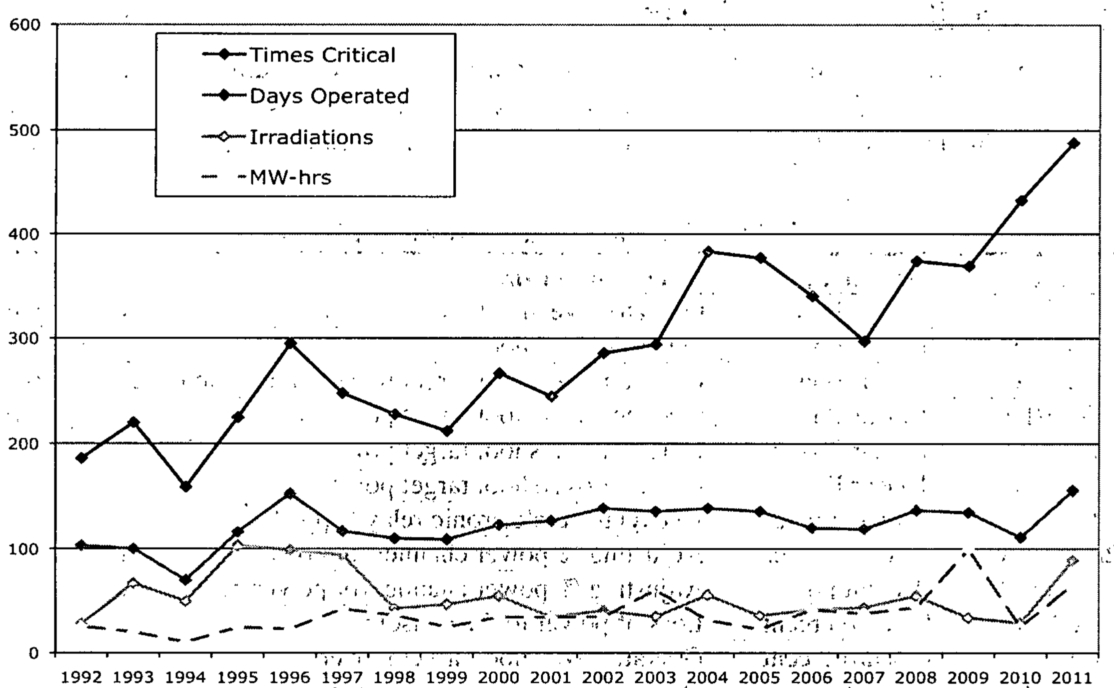

Figure 4. Operations

Unplanned Reactor Shutdowns

There were 17 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
8/10/10	Linear Power	Operator overshoot target power (auto/manual ranging switch
9/30/10	Linear Power	Operator overshoot target power
10/22/10	Linear Power	Operator overshoot target power (auto/manual ranging switch
10/24/10	Linear Power	Operator overshoot target power (auto/manual ranging switch)
11/7/10	Linear Power	Operator overshoot target power
11/6/10	Linear Power	Operator overshoot target power
12/9/10	Percent power	Unexplained electronic relay tripped
2/10/11-A	Percent power	Adjusting % power channel for power calibration
2/10/11-B	Percent power	Adjusting % power channel for power calibration
3/22/11	Linear/percent	Loss of power to the console
4/16/11	Linear/percent	Operator overshoot target power
4/9/11	Percent power	Operator overshoot target power
4/22/11	Percent power	Operator overshoot target power
4/27/11	Percent power	Operator overshoot target power
5/10/11	Linear Power	Operator overshoot target power
5/12/11	Linear Power	Operator overshoot target power
6/28/11	Linear Power	Operator overshoot target power

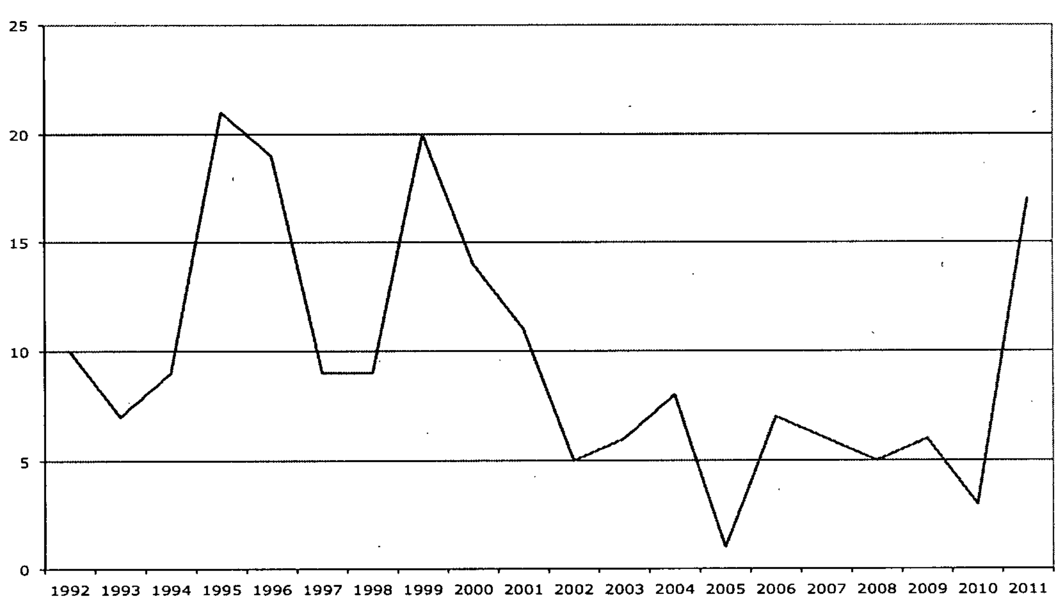

Figure 5 Unplanned Shutdowns

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
8/31/10	Installed manometer to detect reactor bay pressure
9/1/10	Core video monitor installed on the walkthough detector to allow the operator to view the core
9/13/10	Holes drilled in the rim on the reactor tank to all for future installation of up to 8 additional storage racks
10/710	One of the bolts holding on the exhaust fan belt cover in the loft was replaced.
10/8/10	New fuel storage racks were installed on the west end of the pool.
10/13/10	Moved south west pool light
11/1/2010	Console repairs including fixing safety rod up button, rod-source interlock, rod-rod interlock, tightened ground wire on the power supply.
11/4/2010	Moved primary and secondary shutdown switches
11/16/2010	Installed 7 fuel storage racks
11/24/10	Repaired ventilation dampers
1/6/11	Gas Stack Monitor (GSM) removed for repaired
1/21/11	Continuous Air monitor replaced
1/25/11	Retrieved allen wrench from the top of the core.
1/31/11	Organized log channel wiring
2/3/11	Solder wire for shim position indicator
2/15/11	Solder wire for shim position indicator
3/3/11	Replaced rabbit blower motor
3/17/11	GSM reinstalled after repairs
5/2/11	Removed PA system
5/2/11	Replaced ceiling tiles in the control room
6/4/11	Replaced pool thermocouple

10 CFR 50.59 Screenings

Three 10 CFR 50.59 screenings were reviewed during this reporting period. None of these screenings were referred to the reactor operations committee. Two of the three screenings were a direct result of the replacement of the aluminum-clad fuel in the core. A brief description of the screening is included.

10-2 Install additional fuel storage racks

Additional fuel storage racks were placed in the reactor pool to accommodate the stainless steel fuel. The storage racks were designed to hold 10 elements with a k_{eff} less than 0.80 (F. C. Foushee letter dated 3/1/1966.)

10-3 Replace Rabbit Blower Motor

Motor was replaced by physical plant.

11-01 Replacement of the remaining aluminum clad fuel in the reactor with stainless steel clad fuel.

The remaining aluminum clad fuel was replaced with stainless steel clad fuel as a Special Experiment. The fuel was loaded per the classic 1/M experiment. The number of fuel elements necessary for criticality was estimated from the known amount of fuel in core 46 and the known amount of fuel in the stainless steel clad fuel. U-235 in the fuel was estimated based on burn-up calculations. Core excess, shutdown margin, thermal power calibration and control rod worth procedures were completed. A comparison of the Al/SS mixed core parameters and the all stainless steel core parameters are listed in table 4. Parameters are within technical specifications. Specifically, the core excess is less than $3.00 and the shutdown margin is greater than $0.53.

Table 4 Comparison of the SS/AL and SS only core parameters

Parameter	SS/AL mix	SS
Core excess	$1.50	$1.61
Shutdown margin	$5.96	$5.55
Control rod worth		
Safety	$3.10	$2.74
Shim	$3.05	$3.12
Regulating	$1.31	$1.30
Total	$7.46	$7.16

RADIATION PROTECTION

Personnel Dosimetry

During the period July 1, 2010 to June 30, 2011 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 21 mrem deep dose equivalent. The largest annual extremity dose was 640 mrem shallow dose equivalent. These doses are atypical of the facility and were the result of an experiment using the central thimble.

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, 2010 to June 30, 2011 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 North Wall	1.6	β, γ	24	30	31	67	152
Reactor North Wall	2.3	β, γ	25	13	28	59	125
Reactor East Wall	1.5	β, γ, n	15	7	72	640[i]	734
Reactor West Wall	1.0	β, γ, n	21	20	46	45	132
Reactor South Wall	1.6	β, γ	48	52	46	38	184
Control Room	1.5	β, γ	34	32	11	8	85
Outside North	2.8	β, γ	17	22	12	37	88
Outside Roof	0.4	β, γ, n	3	6	107	16	132
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

[i] Imaging results were inconclusive, second reading agreed photon energy less than 40 keV

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 2.62×10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 1.31 mrem, well below regulatory guidelines and constraints. Figure 6 shows the gaseous releases for each year.

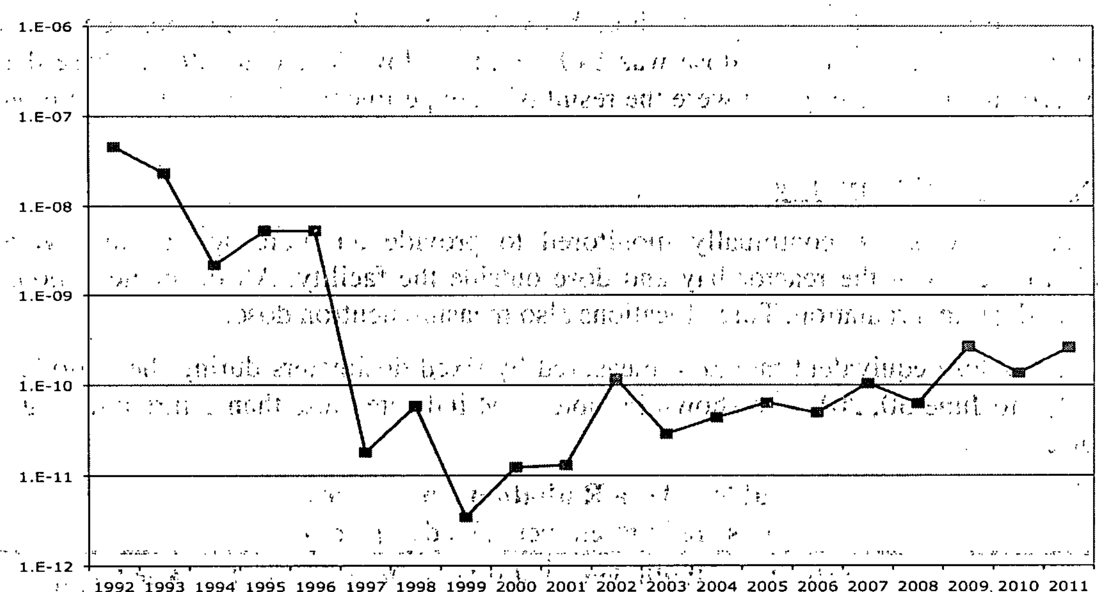

Figure 6 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

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

Solid Waste Disposal

There were two shipments of low-level radioactive waste from the facility during this reporting period. The shipments are summarized in table 6.

Table 6 Summary of Solid Waste Shipments

Date	Drum	Activity	Radionuclides
4/7/11	O	6.27076 MBq (0.1695 mCi)	Co60, Mn54, Sb124, Zn65
4/7/11	P	0.25578 MBq (0.0069 mCi)	Co60, Cr51, Cs134, Eu152, Eu154, Fe59, Mn54, Sb124, Sb125, Sc46, Se175, Sn 113, Ta 182, Zn 65
7/27/10	-	16.17307 MBq (0.4371mCi)	

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.