REED REACTOR FACILITY

ANNUAL REPORT

September 1, 1997 -- August 31, 1998

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Consortium of the Willamette Valley

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EXECUTIVE SUMMARY

This report covers the period from September 1, 1997 to August 31, 1998. This report is intended to fulfill several purposes including the reporting requirements of the U.S. Nuclear Regulatory Commission, the U.S. Department of Energy, and the Oregon Department of Energy.

There were over 1400 individual visits to the Reactor Facility during the year. Most were students in classes at Reed College or area universities, colleges, and high schools. Including tours and research conducted at the facility, the Reed Reactor Facility contributed to the educational programs of seven colleges and universities in addition to nineteen pre-college groups. Most of the reactor use by non-Reed personnel was conducted under the auspices of the Nuclear Science Consortium of the Willamette Valley, supported by a grant from the U.S. Department of Energy through the Reactor-Use Sharing Program.

During the year, the reactor was operated almost 230 separate times. The total energy production was over 36 MW-hours.

The reactor staff consists of a Director, an Associate Director, a contract Health Physicist, and approximately twenty Reed College undergraduate students as hourly employees.

All radiation exposures to individuals during this year were well below one percent of the federal limits. There were no releases of liquid radioactive material from the facility and airborne releases were well within regulatory limits.

The facility experienced a fuel element leak during the previous year. The leaking element was identified and removed from service during this year.

INTRODUCTION

The Reed College Reactor Facility has been a resource for research and educational projects in the Portland area since its establishment in 1968. Cooperative programs between Reed and several public and private high schools, colleges, and universities in northwestern Oregon were established in 1970. These programs, fostered by the reactor staff, are an important part of the educational picture of the region. Partial funding from the U.S. Department of Energy's Reactor Use Sharing Program through the Nuclear Science Consortium of the Willamette Valley enables use of the reactor by educational institutions other than Reed.

The Reed College reactor is a TRIGA Mark I reactor with zirconium hydride / uranium hydride fuel elements in a circular grid array. The uranium fuel is enriched to 19.9% in uranium-235. The reactor is at the bottom of a 25-foot-deep tank of water and is surrounded by a graphite reflector.

The Reed Reactor operates at various steady power levels. The reactor is brought up to a desired power level (up to the license ceiling of 250 kW-thermal) and is kept at that power until the experiment or irradiation is completed. This power level is usually maintained for periods ranging from a few minutes to several hours. Repeated operation over several days are possible for long-term irradiations.

The main uses of the Reed Reactor Facility are instruction and research, especially trace-element analysis. In addition to providing student research opportunities, the reactor staff works to educate the surrounding community on the principles of nuclear energy and radiation safety.

PERSONNEL

Facility Staff

During the period from September 1, 1997 to August 31, 1998, the facility staff consisted of:

Director:	Stephen Frantz (4/94 – Present)
Associate Director:	Chris Melhus (8/97 – Present)
Reactor Supervisor:	Chris Melhus (5/98 – 8/98) Zoe VanHoover (8/97 – 5/98)
Radiation Safety Officer:	Cindy Savage (4/93 – Present)
Contract Health Physicist:	Marshall Parrott (8/91 – Present)

Senior Reactor Operators:
- Tobias Boes
- Joshua Filner
- Stephen Frantz
- Ryan Gaffney
- Chris Melhus
- Greta Vanderbeek
- Zoe VanHoover

Reactor Operators:
- Jeanette Blaine
- Jesse Brown
- Amaria George
- Chris Meacham
- Lien Ngo
- Emmi Olson
- Michael Perry
- Patrick Reuther
- Ryan Richter
- Matt Shaw
- Ben Tombaugh
- Eric Weis

Operators who held licenses during the period but who no longer have licenses:
- Nate Carstens
- Brian Halbert
- Claire Jouseau

All staff members were Reed College undergraduates during the report period with the following exceptions. Mr. Frantz and Mr. Melhus are the Director and Associate Director, respectively. Mr. Filner is the former Associate Director. Ms. Savage is the Reed Campus Safety Officer. Dr. Parrott works on contract to Reed College as Reactor Health Physicist. Nate Carstens was a student at Rex Putnam High School.

The Reed Reactor Facility has two oversight committees: the Radiation Safety Committee and the Reactor Operations Committee. The Radiation Safety Committee is concerned with emergency preparedness, health physics, radiation safety, physical security, environmental impact, and the interface between the Reed Reactor Facility and the Reed College Campus 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 requalification. The membership of the committees during the reporting period is shown below:

Radiation Safety Committee

Voting Members:

Curt Keedy (Chair) *(Chair of Chemistry Department, Lewis and Clark College)*
John Frewing *(Oregon Independent College Foundation)*
Wayne Lei *(Environmental Director, Portland General Electric)*
Jack Mahoney *(Neighborhood Resident)*
Tom Meek *(Radiation Protection Manager, Trojan Nuclear Power Plant)*
Cindy Savage *(Radiation Safety Officer, Reed College)*

Ex Officio:

Peter Steinberger *(Dean of the Faculty, Reed College)*
Stephen Frantz *(Director, Reed Reactor Facility)*
Chris Melhus *(Associate Director, Reed Reactor Facility)*
Marshall Parrott *(Contract Health Physicist)*
Zoe VanHoover *(Reactor Supervisor)*
Claire Jouseau *(Reactor Training Supervisor)*

Reactor Operations Committee

Voting Members:

Dan Gerrity (Chair) *(Chemistry Faculty, Reed College)*
Juliet Brosing *(Physics Faculty, Pacific University)*
John Essick *(Physics Faculty, Reed College)*
Johnny Powell *(Physics Faculty, Reed College)*
Josh Filner *(SRO and former Associate Director, Reed Reactor Facility)*
Michael Pollock *(Health & Safety Coordinator, AGRA Earth & Environmental, Inc.)*

Ex Officio:

Peter Steinberger *(Dean of the Faculty, Reed College)*
Stephen Frantz *(Director, Reed Reactor Facility)*
Chris Melhus *(Associate Director, Reed Reactor Facility)*
Marshall Parrott *(Contract Health Physicist)*
Zoe VanHoover *(Reactor Supervisor)*
Claire Jouseau *(Reactor Training Supervisor)*

Reactor Facility Floor Plan

In addition to the reactor, the Reed Reactor Facility has associated space for a radiochemistry lab. A floor plan appears as Figure 1.

The equipment available at the reactor facility includes four gamma spectrometers (with high purity germanium), surface barrier detectors, alpha spectrometers, silicon lithium X-ray detectors, a whole body counter, gas flow proportional counters, ion chambers, beta counters, geiger-müller tubes, and thermoluminescent dosimeter readers. The instruments are used for experiments in basic nuclear science and radiation detection. Hand and shoe monitors are used in the reactor bay and the lab. A liquid scintillation detector is available in the chemistry department and serves the campus radioisotope committee.

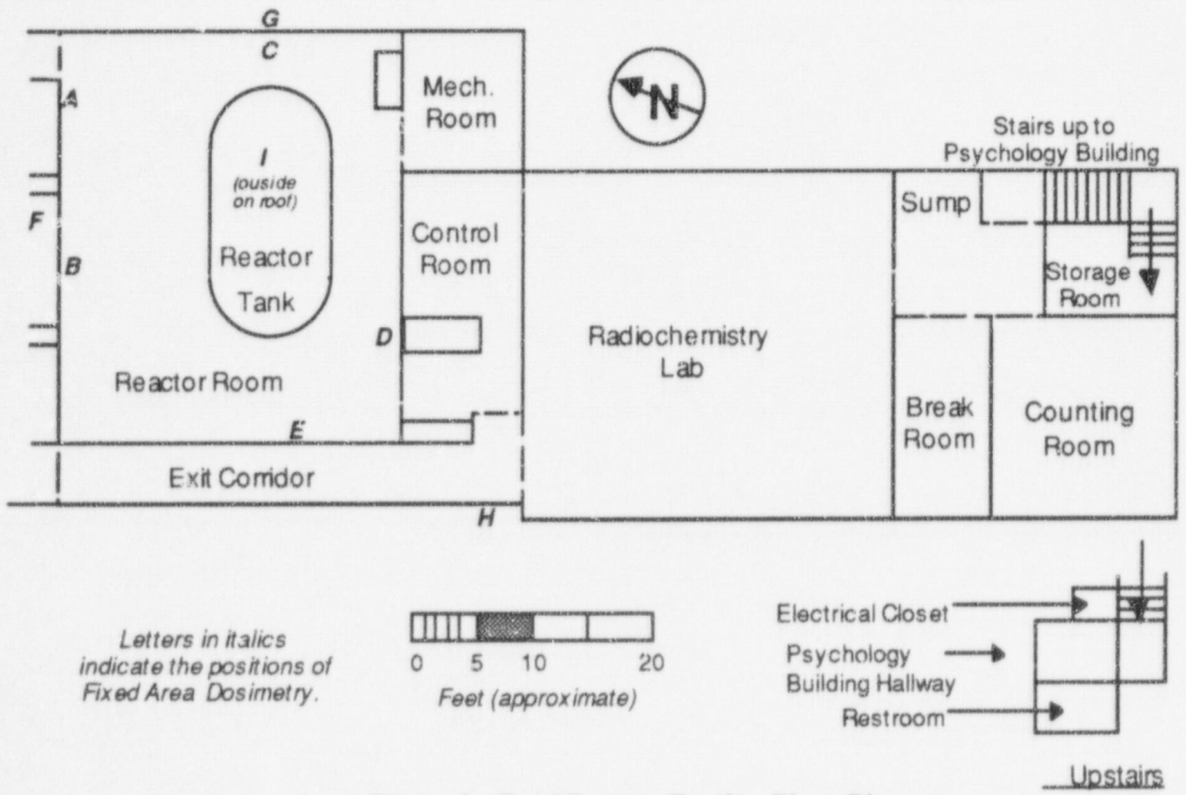

Figure 1 - Reed Reactor Facility Floor Plan

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 which surrounds the core. The rack consists of a circular array of 40 tubular receptacles. Each receptacle can accommodate two TRIGA-type irradiation tubes, so that up to 80 separate samples may be irradiated at any one time. Vials holding up to 17 ml (four drams) are routinely used in this system. Depending upon its geometry, a sample up to about 40 ml could be irradiated by joining two vials. 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, the rotating rack is used by researchers when longer irradiation times (generally greater than five

minutes) are required. The average thermal neutron flux in the rotating rack position is approximately 1.7 $x10^{12}$ n/cm^2s with a cadmium ratio of 6.0 at full power.

The specimen rack can also be used for gamma irradiations when the reactor is shutdown. The shutdown dose rate in the specimen rack is approximately 3 R/min.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outer ring of the core with 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 $5x10^{12}$ n/cm^2s when the reactor is at full power.

In-Core Facilities

The central thimble, which is a water-filled irradiation chamber about 3 cm in diameter, provides the highest available neutron flux, about $1x10^{13}$ n/cm^2s. Special sample holders can be designed for the central thimble to provide maximum flexibility in experiment design.

A source holder assembly can also be used. The chamber fits into a fuel-element position within the core itself. However, it holds only one specially positioned irradiation container, containing a cavity 7.5 cm in length and 2.5 cm in diameter. Use of the chamber as an irradiation facility necessitates special arrangements.

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.

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. Neutron radiography is also possible. The flux above the beam exit is approximately $1x10^3$ n/cm^2s when the reactor is at full power.

REACTOR USERS

Reactor Visitors

A total of 1402 individuals visited the Reed Reactor Facility during the year, as derived from the visitors log - Entry List B. Individuals who visited more than once are counted for each visit. Visitors include all individuals who are not listed as facility staff. A large percentage of these were students in classes at area universities, colleges, and high schools as discussed below. A monthly breakdown of the number of visitors is shown on Table A.

Reactor Operations Seminar

The Reed Reactor Facility conducts a annual seminar series for students from Reed and other area educational institutions. 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 license. If successful, the individual may be hired to operate the reactor. In addition, existing reactor operators may take the NRC senior reactor operator exam to upgrade their licenses.

During the reporting period, all eight reactor operator candidates and all five senior reactor operator candidates passed the NRC exams.

Nuclear Science Consortium

In order to better use the resources of the Reed Reactor Facility, Dr. Scott and representatives of several area colleges and universities established the Nuclear Science Consortium of the Willamette Valley in 1970. Funding for the Consortium has been derived from Reactor Use Sharing Grants of the U.S. Department of Energy. This made the facility available without charge to classroom groups and unfunded research projects for consortium members.

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

COLLEGE TOURS

Concordia University
Clackamas Community College
Clark College
Osaka Women's University
Pacific University
Portland Community College
Portland State University

HIGH SCHOOL & MIDDLE SCHOOL TOURS

Beaumont Middle School
Century High School
Elmira High School
Glencoe High School
Gold Beach High School
Hillsboro High School
Hood River High School
Jesuit High School

Leone Middle School
Lincoln High School
North Marion High School
Oregon Episcopal School
Rex Putnam High School
Rogue River High School
St. Francis Academy
Westview High School
WinterHaven High School

Special Groups

Academy of Certified Hazardous Materials Managers (ACHMM) (Professional)
Association Supporting Women in Engineering and Mathematics (ASWEM)
Russian Scientists Visiting American Colleges
Saturday Academy (Pre-College)
NIEP College Preview (High School Counselors)
Test, Research, and Training Reactors (TRTR)

Many of the reactor tours include actual hands-on use of facility equipment to conduct experiments in basic radiation science, health physics, and nuclear physics. The most popular experiments for middle school students are a demonstration of the inverse square law and the absorption of radiation by different types of material. For high school classes, a typical lab experience would involve determining the background of a geiger-müller scalar system and then determining the half-life of a 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 used the reactor. 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 Projects

The Reed Reactor Facility continued to be used in independent science projects initiated by students from several Oregon high schools. Students from Elmira High School, Gold Beach High School, Lincoln High School, and Oregon Episcopal School performed special science research projects at the reactor this year.

Pacific University Science and Technology Camp for Girls

The Pacific University Science and Technology Camp for Girls holds a summer camp for 7th and 8th grade girls. This camp is funded by the U.S. Department of Energy. The goal is to encourage the participants to continue in math and science.

Portland State University

Each year the reactor provides irradiation services for the Geology Department at Portland State University. This is usually accompanied by a tour for the students.

Pacific University Modern Physics Lab

Each year the Modern Physics Lab at Pacific University spends two lab sessions (4-5 hours each) at the reactor. The students do several labs including basic health physics, subcritical multiplication, and neutron activation analysis.

Concordia University

Two or three times each year the Environmental Remediation & Hazardous Material Management Program (ERHMM) at Concordia University visits the facility. The reactor provides training and experiments involving radiation, radioactive material, environmental sampling, and trace element analysis.

Reed Classes, Theses, and Faculty Research

The Reed College Reactor Facility was used in two Reed College Classes and one senior thesis.

- The Chemistry 110 class conducted a lab using neutron activation analysis to analyze for potassium in a compound synthesized earlier in the course.
- Chemistry 315 students conducted a lab using neutron activation analysis to evaluate the presence of impurities in aluminum foil.
- Brian Halbert used the Reactor in his senior thesis "Gamma Induced Radiation Damage in DNA Using FTIR Spectroscopy". Advisor: Johnny Powell.

Industrial and Commercial Applications

The Reed Reactor Facility is available for use by industrial or commercial concerns when it does not conflict with our educational goals. As in past years, the primary operations involve neutron activation analysis of materials or environmental samples. Arrangements may be made either on a time lease basis or the industry may contract for sample analysis.

This year work included attempts to find trace elements in soil samples and renting analytical equipment. The facility also provides radiation protection training to interested parties and schools in the area.

Scalar Kits

Portland General Electric donated experiment kits which contained a scalar, a geiger-müller tube, lead and plastic absorbers, and small radioactive sources. The Reed Reactor Facility has assumed maintenance of these kits and presently loans them out to local schools. If a school doesn't have the ability to visit the Reactor Facility, the kits can be sent as a viable alternative to learning about radiation and radioactive decay. Five schools used the kits this year.

REACTOR OPERATIONS

Operations

During the year the reactor was taken critical 228 times on 110 days. The total energy production was 36.45 MW-hr. Operations by month appear in Table A:

Table A - Operations History

	Times Critical	Days Operated	MW-hrs	Visitors
Sep.	27	15	16.71	58
Oct.	26	9	1.95	142
Nov.	32	15	2.12	183
Dec.	8	4	0.31	61
Jan.	16	11	1.24	120
Feb.	18	9	3.74	178
Mar.	23	10	0.80	77
Apr.	28	10	2.70	299
May	28	11	1.83	117
Jun.	6	3	2.34	41
Jul.	8	7	0.21	40
Aug.	8	6	2.49	86
Total	228	110	36.45	1402

Unplanned Reactor Shutdowns

There were nine unplanned reactor shutdowns (scrams) during the period, as shown in Table B. All were classified as inadvertent. The number of unplanned reactor shutdowns is consistent with the historical numbers. As usual, the most reactor scrams are associated with improper operation of the Linear Power Range Switch. All but one scram were due to operator error.

Table B - Unplanned Reactor Shutdowns

Date	Type	Cause Of Shutdown
9/3/97	Reactor Scram	Reactor key not fully reset to operate position
9/4/97	Linear Power	Ranged wrong direction
11/19/97	Linear Power	Ranged wrong direction
1/20/98	Linear Power	Ranged down twice
3/3/98	Linear Power	Ranged wrong direction
3/17/98	Linear Power	Ranged wrong direction
3/17/98	Linear Power	Ranged wrong direction
5/6/98	Period	Instrument noise
6/2/98	Period	Operator inattention

Fuel Element Leak

Note: this event was reported in the last annual report, but since the time of the event extended over both reporting periods, it is repeated here.

On Friday, 8/22/97, the Reed Reactor experienced a fuel element leak. A month was spent locating the leaking element and then removing it from service. Presumably this is the same element which leaked momentarily in November 1991 and January 1994.

Chronology

On 8/22/97 the reactor had been operating at 240 kW (96% of full power) for eight hours and the water temperature was over 30 C. These are the same conditions that existed during the two previous fuel leaks. Pool temperature is normally 15-25 C.

The staff were completing an the eight hour run with a reactor operator (trainee) who was regaining his Licensed Requalification status and a licensed reactor operator (RO) who holds a senior reactor operator license. The Senior Reactor Operator (SRO) of record was the facility Director. The RO noticed the Air Particulate Monitor (APM) was higher than normal. The trainee shutdown the reactor as scheduled a minute later. The RO saw that the APM continued to increase. The Gaseous Stack Monitor (GSM) was also above normal. The Continuous Air Monitor (CAM) which samples inside the reactor room did not show any increase. The filters for the APM and CAM were taken to the gamma spectroscopy detectors for counting. The APM filter showed clear peaks for Rubidium-89 and Cesium-138, decay products for the fission product gases Krypton-89 and Xenon-138 respectively. This is the expected indication of a fuel element leak. The CAM filter did not show much unusual activity. The leak stopped after the reactor was shut down.

The SRO and the RO started the Emergency Implementation Procedures (EIPs) and calculated the off-site dose. The release was well below all Effluent Concentration limits and the event was below any classification threshold. Estimated off site dose was five microrem. The NRC and Oregon were notified. The EIPs were completed, and plans were made for the next day.

During the next week the staff tried to identify which fuel element had leaked in accordance with SOP-91 (Looking for Leaking Fuel Elements). This procedure uses a funnel (either a large one to cover approximately sixteen elements or a small one to cover just one) connected through a tygon tube and a peristaltic pump to a marinelli beaker. The beaker sits on top of a high purity germanium detector. The water then returns to the pool. There is a long delay loop inside a lead shield before the pump to allow for N-16 decay (7 second half-life). The germanium detector and multi-channel analyzer are inside the reactor room; the computer is in the control room.

The staff was unsuccessful in re-creating the leak at low powers and low pool temperatures. With the reactor at full power and high temperature, however, fission products were detected in the APM filter and the silver zeolite breathing zone filter in the reactor room. The primary (pool) water samples had krypton and xenon as expected. The was no iodine in the water, stack monitor filters, or silver zeolite filters. There were no fission products in the control room air.

The large sniffer was used in the six regions of the core that it can reach (the large sniffer can reach 90% of the element; the other six elements are located in between control rods, the rabbit, etc., and must be sniffed one at a time), but did not find any fission products in the water. Sniffing did not was not successful during the entire week.

Since it was possible to make the fuel leaked by operating the reactor for several hours above 40 C, and since the sniffer was not providing useful information, the staff decided to replace some of the fuel elements with new ones, and see if it produced fission products.

On 9/2/97 three fuel elements were replaced with new stainless-steel c ad ones. Operations at high power and temperature produced fission products. On 9/8/97 four ele...ents were replaced and operations at high power and temperature produced fission products. On 9/1?/97 five elements were replaced with elements removed the previous week Operations at high power and temperature produced barely perceptible traces of fission products. The APM and GSM were elevated, but consistent with long operation with very warm pool water. The conditions were similar to before the leak. It was determined that the leaking fuel element was one of the five that were not in the core during these operations.

Operations over the next week identified which of the five elements was leaking. The element was in C-8 and had been in that location since initial loading. The inspections every five years showed nothing unusual. It is a standard aluminum clad element.

Release Data

All releases were less than the Effluent Concentration limit. Total gaseous activity released was approximately 3.5 millicuries. The concentration in the room was approximately one Derived Air Concentration. Neither of the concentrations were reportable or constituted a health risk. Only two operators entered the reactor room after the leak was detected and then exited the room quickly. Operators wore disposable gloves and booties while in the reactor room. Their gloves and booties were contaminated after entering the reactor room (short lived Rb and Cs), so a step-off pad and frisking zone was established outside the reactor room. The general radiation levels in the reactor room were less than 2 mrem/hr. The radiation levels in the control room were background. A silver zeolite breathing zone filter in the control room showed no activity other than background. In accordance with 10CFR20 the facility does not use respirators. The Director's whole body count later in the week showed only K-40 (naturally occurring).

The activity released is shown in Table C.

Table C - Fuel Element Failure Release Data

		Gaseous Stack Monitor					
Date	Duration *(hours)*	Reading *(cpm)*	Background *(cpm)*	In Room *(uCi/ml)*	At Boundary *(uCi/ml)*	EC-hours *(uCi-hr/ml)*	Total *(uCi)*
8/22/97	3	150	90	6.1E-6	6.9E-9	0.36	216
8/26/97	2	300	70	2.3E-5	2.6E-8	0.93	552
	1	200	70	1.3E-5	1.5E-8	0.26	156
	6	150	70	8.1E-6	9.2E-9	0.97	576
8/27/97	5	150	70	8.1E-6	9.2E-9	0.81	480
9/4/97	2	100	70	3.0E-6	3.4E-9	0.12	72
	2	125	70	5.6E-6	6.3E-9	0.22	132
	2	150	70	8.1E-6	9.2E-9	0.32	192
9/9/97	3	130	70	6.1E-6	6.9E-9	0.36	216
	4	120	70	5.1E-6	5.7E-9	0.40	240
9/22/97	4	100	70	3.0E-6	3.4E-9	0.24	144
	3	120	70	5.1E-6	5.7E-9	0.30	180
9/23/97	7	110	70	4.0E-6	4.6E-9	0.57	336
Total							**3492**

REACTOR MAINTENANCE

Significant Maintenance

Routine equipment checks are conducted by reactor staff members 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 which were not part of a regular schedule are listed in Table D.

Table D - Significant Maintenance Operations

Date	Maintenance
10/9/97	Changed Primary Filters
12/19/97	New Phone Intercom System Installed
1/27/98	Replaced Secondary Bleed Loop
5/13/98	Rabbit HEPA filter replaced
5/14/98	Reactor HEPA filter replaced

The phone intercom was manufactured by Bogen and has the ability to page throughout a speaker system in the facility. The secondary bleed loop needed to be replaced after an outdoor pipe had burst during the cold weather in January. The Reactor HEPA filter is the filter that reactor bay air is diverted through while in the isolation made.

Safety Reviews

There were six changes performed during the reporting period under the provisions of 10CFR50.59:

- **Primary Filter Housing Vent Valve.** Added a vent valve to the primary filter housing. Replaced the existing threaded plug and with a small ball valve in the same opening. This allows venting and filling the housing following a filter change without removing the plug.
- **Continuous Air Monitor.** Replaced the installed Continuous Air Monitor (CAM) with a newer model, an Eberline AMS-3. The new model is solid state, more reliable, quieter, and more efficient. The only disadvantage is that it does not have a fail-safe light. The procedures have been modified to reflect this.
- **Moving Fuel Immediately After Power Operations.** Changed SOP-40 to give the Director authority to move fuel earlier than three days following power operation. The new wording is: "No movement of core fuel elements shall take place within 72 hours of operations above 1 kW without specific authorization of the Director."
- **Scram Circuit for Alternate Voltage Supply to Nuclear Instruments.** Added a loss of voltage scram for the alternate high voltage. The alternate high voltage is used for the linear and log-n channels due to instrument noise from the original high voltage supply.
- **Pneumatic Transfer System.** Resume use of the pneumatic transfer system ("rabbit").
- **Technical Specification Amendment.** Define allowable surveillance intervals. Reduced the frequency of fuel inspection to 1/5 of core every two years; the entire core over a ten year period. Allow for use of stainless steel clad control rods. Allow for use of any gamma sensitive dose-rate meter to replace RAM when necessary (not just a portable ion chamber). Correct "microhm" to "micromho". Remove gender-specific language. (This change has not yet been approved by the NRC).

RADIATION PROTECTION

Personnel Dosimetry

During the period from July 1, 1997 to June 30, 1998, personnel dosimeters were issued to 23 Reed students and staff and 1 contractor working at the reactor. Since dosimeters are changed on a calendar quarter schedule, this period is the closest to the reporting period. During the year 83 whole body dosimeters were issued of which 83 were below detection limit. During the year 83 ring dosimeters were issued of which 83 were below detection limit. Individuals were issued beta-gamma sensitive ring badges and a whole-body badges. The Director and Associate Director were issued beta-gamma-neutron sensitive dosimetry.

Gaseous Releases

The only routine release of gaseous radioactivity is from Ar-41 (1.83 hour half-life) and N-16 (7.13 second half-life). These come from activation of pool water and air dissolved in the pool water. For calendar year 1997, the average gaseous activity at the site boundary was 5.87×10^{-11} uCi/ml which would deliver a dose to a member of the public at the site boundary of approximately 0.29 mrem per year; well below regulatory guidelines and constraints.

Radioactive fission product gases were released during the fuel leak and during the process of locating the leaking element as explained earlier in this report. They are included in the numbers in the previous paragraph.

Liquid Waste Releases

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

Solid Waste Disposal

No solid radioactive waste was shipped from the Reed Reactor Facility during this report period.

Environmental Sampling

Soil samples taken from the area surrounding the facility showed no activity above background. Water samples taken from the facility's secondary cooling system showed no activity above background.

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. The locations of these dosimeters are shown on Figure 1. All are thermoluminescent dosimeters (TLDs) designed to monitor beta and gamma radiation. In addition, locations C and E have TLDs that measure neutron dose.

The radiation doses measured during the period beginning July 1, 1997 and ending June 30, 1998 are shown in Table E. Since dosimeters are changed on a calendar quarter schedule, this period is the closest to the reporting period. There are radioactive material sample storage locations along the north wall: a radioactive source storage safe and a lead enclosed sample box where samples are placed immediately upon removal from the reactor.

Table E - Area Radiation Dosimeters
(doses are in mR per calendar quarter)

	Location	height (m)		7/1-9/30	10/1-12/31	1/1-3/31	4/1-6/30	Total
A	North wall	1.5	β , γ	80	70	70	75	**295**
B	North wall	2.5	β , γ	20	0	20	25	**65**
C	East wall	1.7	β , γ	80	0	0	0	**80**
C	East wall	1.7	neutron	0	0	0	0	**0**
D	South wall	1.7	β , γ	15	0	0	0	**15**
E	West wall	1.0	β , γ	0	0	0	0	**0**
E	West wall	1.0	neutron	0	0	0	0	**0**
F	North outside	3.0	β , γ	0	0	0	35	**35**
G	East outside	1.5	β , γ	0	0	0	0	**0**
H	South outside	0.2	β , γ	0	0	0	0	**0**
I	Roof outside	0.0	β , γ	0	0	0	0	**0**

Appendix A
Reed Reactor Visitors 1997-1998

Date	Institution	Number	Comments
9/8/97	Reed Faculty	1	Tour
9/8/97	RSO	1	Tour/Inspection
9/13/97	Reed Students	4	Training
9/14/97	Citizens	3	Tour
9/18/97	Oregon Dept. of Energy	6	Inspection
9/18/97	Reed Student	1	Training
9/19/97	Reed Student	1	Training
9/23/97	Reed Students	2	Training
9/24/97	Reed Students	10	Training
9/25/97	NW Lab Hazardous Waste Tour	20	Tour
9/25/97	Reed Student	1	Training
9/26/97	Physical Plant	1	Maintenance
9/30/97	Reed Students	7	Training
10/1/97	Reed Student	1	Training
10/2/97	Citizens	2	Tour
10/6/97	Hood River High School	30	Tour
10/7/97	Pacific University	4	Thesis Projects
10/9/97	Reed Student	1	Training
10/9/97	University of Michigan	1	Tour
10/14/97	Reed Students	3	Training
10/16/97	Nuclear Regulatory Commission	1	NRC Exam
10/17/97	Nuclear Regulatory Commission	1	NRC Exam
10/23/97	Terry Lash, US Department of Energy	1	Tour
10/24/97	Test Research and Training Reactors	12	Tour
10/28/97	Reed Students	5	Training
10/28/97	Reed Students	20	CHEM 110
10/29/97	Reed Students	2	Training
10/29/97	Reed Students	17	CHEM 110
10/30/97	Reed Students	5	Training
10/30/97	Reed Students	17	CHEM 110
10/31/97	Reed Student	1	Training
10/31/97	Reed Students	18	CHEM 110
11/1/97	North Marion High School	9	Tour
11/3/97	Reed Student	1	Training
11/3/97	Reed Student	18	CHEM 110
11/4/97	Reed Students	2	Training
11/5/97	Pacific University, Honors Class	10	Tour
11/5/97	Reed Students	7	Training
11/6/97	Reed Students	7	Training
11/7/97	Citizens	2	Tour
11/8/97	North Marion High School	5	Tour
11/8/97	Reed Student	1	Training
11/11/97	Pacific University	3	Thesis Projects
11/11/97	Clark College	8	Tour
11/12/97	Reed Students	2	Training
11/13/97	Reed College President and Guests	3	Tour
11/14/97	Reed Student Parents	40	Tour
11/14/97	Reed Student	1	Training
11/18/97	Pacific University	8	Thesis Projects
11/18/97	Reed Students	4	Training
11/19/97	Reed Students	11	Training
11/20/97	Reed Students	4	Training
11/20/97	Reed Students	5	CHEM 315
11/20/97	Pacific University	9	Tour
11/20/97	Community Safety Officer	1	Maintenance
11/21/97	Community Safety Officers	8	Training
11/21/97	Pacific University	1	Thesis Project

Date	Institution	Number	Comments
11/21/97	Reed Students	5	CHEM 315
11/21/97	Reed Students	4	Training
11/24/97	Community Safety Officers	4	Training
11/24/97	Civilian	1	Tour
11/25/97	Pacific University	1	Thesis Project
11/25/97	Reed Students	2	Training
12/2/97	Pacific University	2	Thesis Project
12/3/97	Reed Students	8	Training
12/4/97	Reed Students	5	CHEM 315
12/4/97	Reed Students	5	Training
12/5/97	Pacific University	2	Thesis Project
12/5/97	Reed Students	6	CHEM 315
12/5/97	Reed Student	1	Training
12/8/97	Reed Student	1	Training
12/11/97	Portland Fire Bureau	13	Training
12/11/97	Portland Police Bureau	3	Training
12/12/97	Portland Fire Bureau	9	Training
12/15/97	Gold Beach High School	4	Projects
12/15/97	Pacific University	1	Thesis Project
12/17/97	Nuclear Regulatory Commission	1	Inspection
12/17/97	Physical Plant	1	Maintenance
1/6/98	Pacific University	2	Thesis Projects
1/9/98	Pacific University	2	Thesis Projects
1/10/98	Concordia College	4	Tour
1/12/98	Reed Students	3	Training
1/13/98	Reed Students	13	Training
1/14/98	Reed Students	18	Training
1/15/98	Reed Students	22	Training
1/15/98	Oregon Episcopal School	2	Project
1/16/98	Reed Students	18	Training
1/17/98	Reed Student and Parents	3	Tour
1/19/98	Reed Students	5	Training
1/19/98	Reed Faculty and Guests	3	Tour
1/20/98	Reed Students	7	Training
1/21/98	Reed Students	5	Training
1/22/98	Reed Students	12	Training
1/23/98	Red Student	1	Training
1/26/98	Elmira High School	2	Project
1/27/98	Reed Students	6	Training
1/28/98	Reed Students	2	Training
1/30/98	Reed Student	1	Training
2/3/98	Reed Students	11	Training
2/4/98	Physical Plant	1	Maintenance
2/4/98	Reed Students	2	Training
2/4/98	Civilian	1	Tour
2/7/98	Reed Students	3	Training
2/7/98	Concordia University	10	Tour
2/9/98	Reed Students	2	Training
2/12/98	Reed Students	2	Training
2/12/98	Leone Middle School	11	Tour
2/13/98	Oregon Episcopal School	2	Project
2/14/98	Civilian	1	Tour
2/16/98	Reed Students	2	Training
2/17/98	WinterHaven High School	27	Tour
2/17/98	Saturday Academy	10	Tour
2/17/98	Reed Students	5	Training
2/18/98	Reed Student	1	Training
2/19/98	Oregon Dept. of Energy	2	Inspection
2/19/98	Reed Students	3	Training
2/20/98	Merlo Station High School	1	Project

Date	Institution	Number	Comments
2/20/98	Reed Students	4	Training
2/24/98	Reed Students	11	Training
2/24/98	NIEP College Preview	19	Tour
2/25/98	Rex Putnam High School	33	Tour
2/25/98	Civilian	1	Tour
2/25/98	Reed Students	3	Training
2/26/98	Reed Students	5	Training
2/27/98	Reed Students	1	Training
2/27/98	Pacific University	1	Tour
3/3/98	Reed Students	2	Training
3/3/98	Saturday Academy	8	Tour
3/5/98	Pacific University	7	Tour
3/6/98	Reed Student	1	Training
3/6/98	Assoc. Supporting Women in Engineering and Math.	12	Tour
3/10/98	Reed Alumni	2	Tour
3/11/98	Reed Student	1	Training
3/17/98	Sabin News Network	2	Tour/Interview
3/17/98	AAA Indoor Air Quality	1	Maintenance
3/17/98	Reed Students	3	Training
3/19/97	Reed Students	2	Training
3/21/98	University of California at Santa Cruz	1	Tour
3/25/98	Civilians	5	Tour
3/31/98	Oregon Episcopal School	25	Tour
3/31/98	Reed Students	4	Training
4/3/98	Russian Scientists	10	Tour
4/8/98	Rogue River High School	10	Tour
4/8/98	Reed Students	4	Training
4/9/98	Portland State University	1	Project
4/9/98	Reed Student	1	Training
4/10/98	Reed Admissions Office	1	Tour
4/15/98	Lincoln High School	20	Tour
4/15/98	Pacific University	1	Thesis Project
4/15/98	Civilians	2	Tour
4/16/98	Lincoln High School	24	Tour
4/16/98	Portland State University	1	Project
4/16/98	Reed Students	3	Training
4/17/98	Westview High School	21	Tour
4/17/98	Reed Students	3	Training
4/17/98	Accepted Reed Students	21	Tour
4/17/98	Pacific University	2	Thesis Project
4/20/98	High School Counselors	39	Tour
4/20/98	Reed Student	1	Training
4/20/98	Accepted Reed Students	16	Tour
4/21/98	Reed Students	3	Training
4/22/98	Reed Students	2	Training
4/22/98	Pacific University	15	Tour
4/23/98	Bring Your Child to Work Day	28	Tour
4/23/98	Reed Student	1	Training
4/24/98	Accepted Reed Students	26	Tour
4/24/98	Reed Student	1	Training
4/25/98	Reed Students	2	Training
4/27/98	Accepted Reed Students	23	Tour
4/27/98	Reed Student	1	Training
4/28/98	Civilian	1	Tour
4/28/98	Reed Students	7	Training
4/29/98	Civilian	2	Tour
4/30/98	Portland State University	1	Project
4/30/98	Reed Students	2	Training
5/3/98	Reed Student	1	Training
5/4/98	Reed Students	5	Training

Date	Institution	Number	Comments
5/5/98	Physical Plant	1	Maintenance
5/5/98	Reed Students	4	Training
5/6/98	Nuclear Regulatory Commission	5	NRC Exams
5/6/98	Reed Students	3	NRC Exams
5/7/98	Nuclear Regulatory Commission	4	NRC Exams
5/7/98	Reed Students	5	NRC Exams
5/8/98	Portland State University	1	Project
5/8/98	Portland State University	8	Tour
5/8/98	Reed Student	1	Training
5/11/98	Reed Student	1	Training
5/13/98	AAA Indoor Air Quality	3	Training
5/18/98	Civilians	5	Tour
5/19/98	Portland Community College	8	Tour
5/19/98	Reed Faculty and Guests	4	Tour
5/20/98	Portland Community College	18	Tour
5/21/98	Portland Community College	13	Tour
5/21/98	Portland State University	1	Project
5/22/98	St. Francis Academy	11	Tour
5/22/98	Portland Community College	15	Tour
5/27/98	Oregon Episcopal School	1	Project
5/27/98	Reed Student	1	Training
5/29/98	Civilian	1	Tour
6/2/98	Portland Community College	15	Tour
6/3/98	Clackamas Community College	10	
6/3/98	Oregon Episcopal School	1	Project
6/10/98	Jesuit High School	1	Project
6/11/98	Jesuit High School	1	Project
6/11/98	Civilians	2	Tour
6/12/98	Jesuit High School	1	Project
6/15/98	Jesuit High School	1	Project
6/18/98	Neighborhood citizens	3	Tour
6/22/98	Oregon Episcopal School	1	Project
6/23/98	Oregon Episcopal School	2	Project
6/23/98	Reed Student	1	Training
6/23/98	Civilian	1	Tour
6/29/98	Oregon Episcopal School	1	Project
6/30/98	Oregon Episcopal School	1	Project
6/30/98	Noise Consultant	1	Advising
6/30/98	Reed Radiation Safety Officer	1	Advising
7/1/98	Oregon Episcopal School	1	Project
7/6/98	Summer Science Camp for Girls	31	Tour
7/6/98	Community Safety Director	1	Tour
7/28/98	Osaka Women's U.	5	Tour
7/31/98	Civilians	2	Tour
8/4/98	Civilians	2	Tour
8/5/98	Civilians	4	Tour
8/6/98	Civilians	1	Tour
8/7/98	Civilians	5	Tour
8/8/98	Civilians	1	Tour
8/12/98	Civilians	2	Tour
8/13/98	Clackamas Community College	11	Tour
8/20/98	Watermetrics	1	Maintenance
8/25/98	Reed Student Parents	44	Tour
8/26/98	Civilians	2	Tour
8/27/98	Reed Students	12	Tour
8/27/98	Civilian	1	Tour
8/31/98	Portland State University	2	Project