ANNUAL REPORT
OF THE
OREGON STATE UNIVERSITY
RADIATION CENTER
AND
TRIGA REACTOR

July 1, 1994 - June 30, 1995

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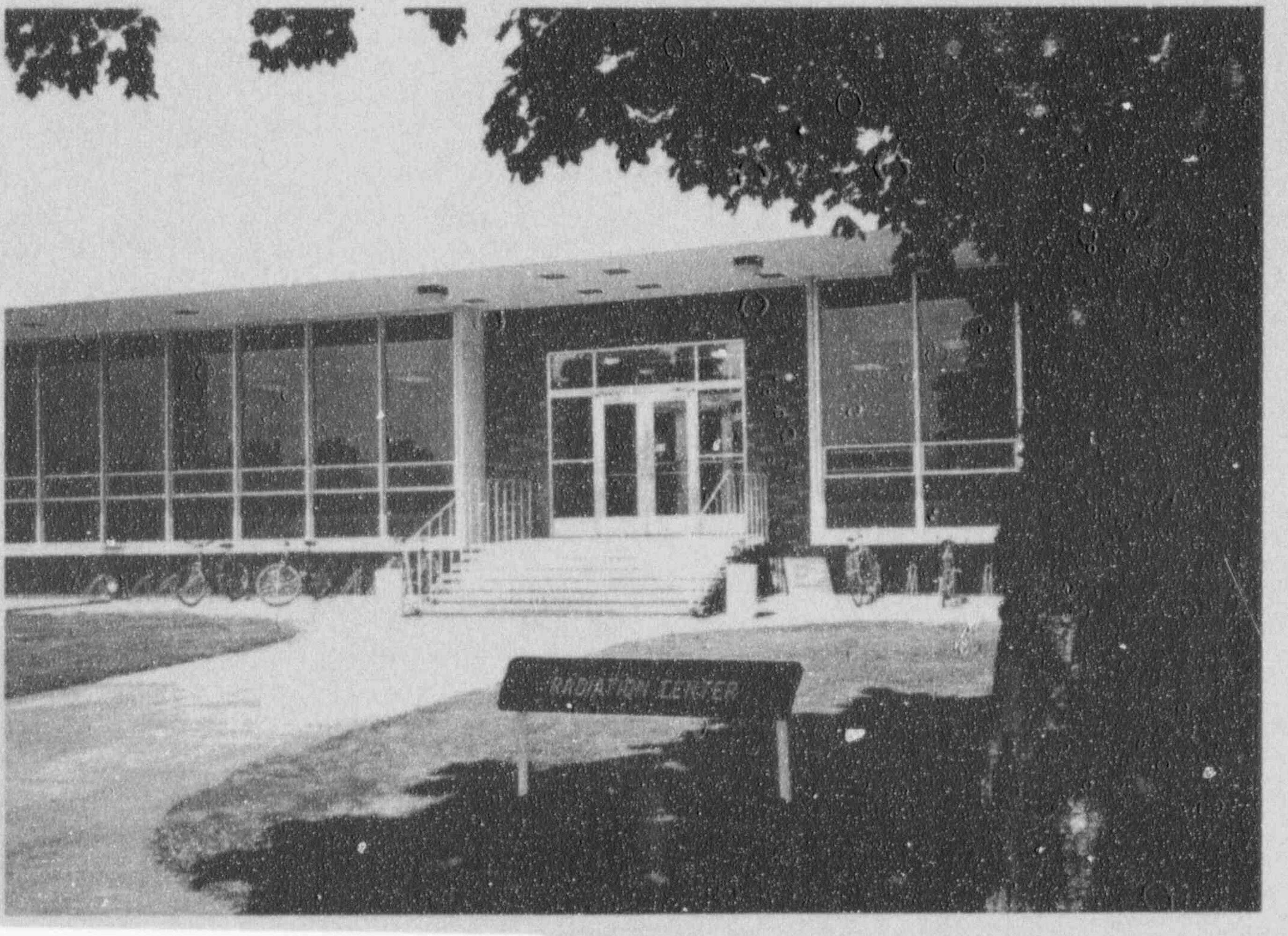

Annual Report of the
Oregon State University
Radiation Center and TRIGA Reactor

July 1, 1994 - June 30, 1995

To satisfy the requirements of:

A. U.S. Nuclear Regulatory Commission, License No. R-106 (Docket No. 50-243), Technical Specification 6.7(e).

B. Task Order No. 3, under Subcontract No. C84-110499 (DE-AC07-76ER01953) for University Reactor Fuel Assistance-AR-67-88, issued by EG&G Idaho, Inc.

C. Oregon Department of Energy, ODOE Rule No. 30-010.

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October 1995

Annual Report of the
Oregon State University
Radiation Center and TRIGA Reactor

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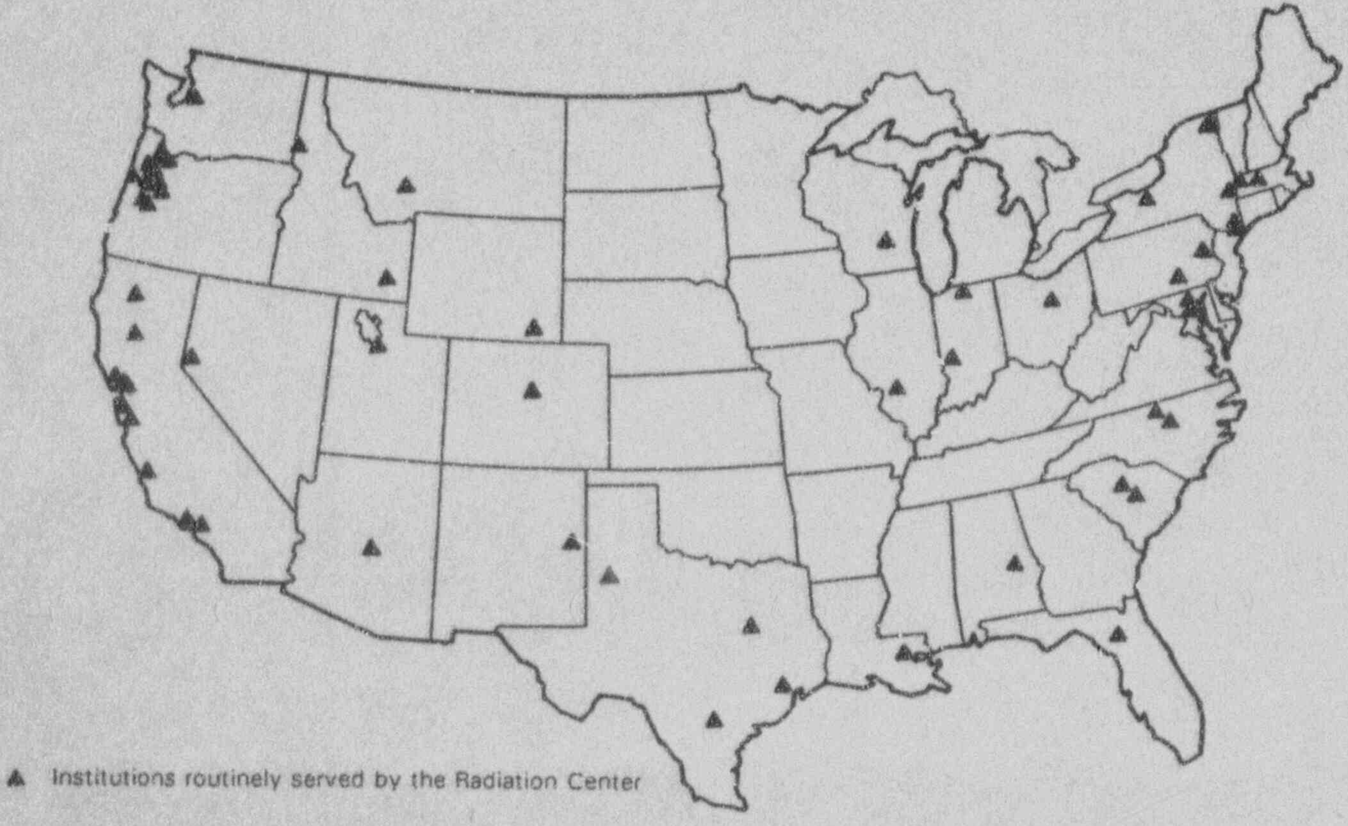
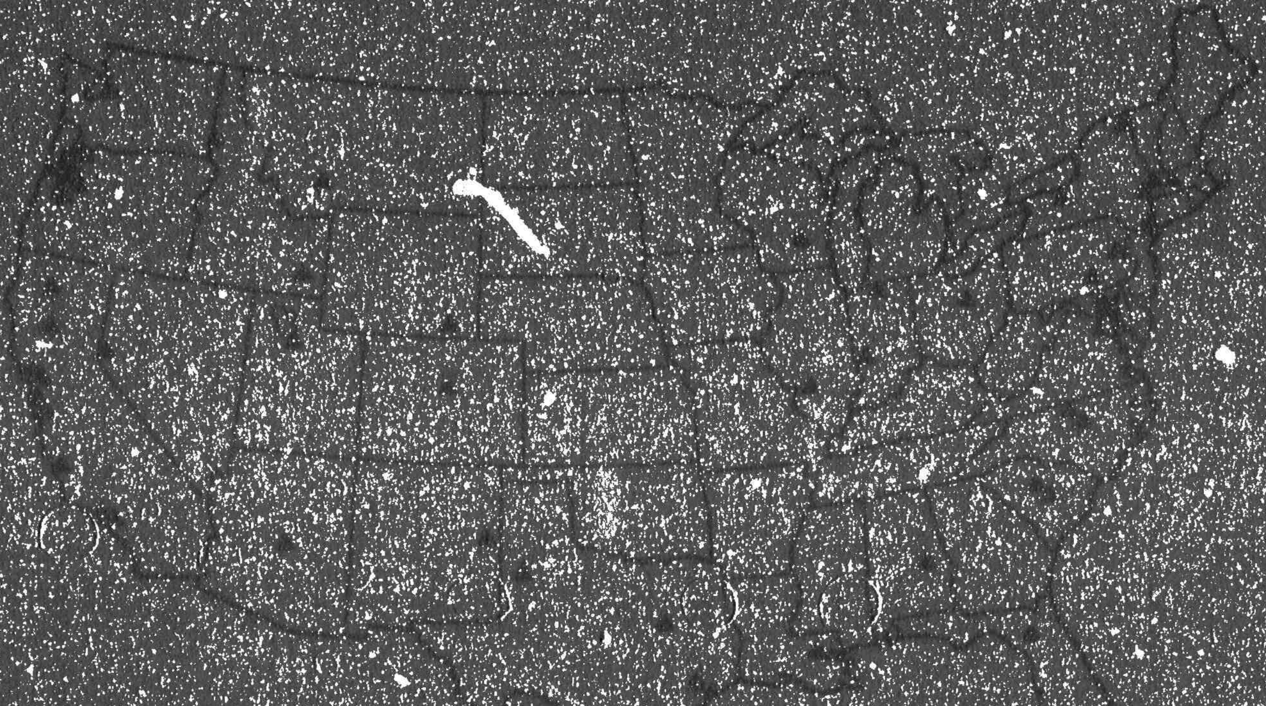
OVERVIEW



PART I

OVERVIEW



PART I

OVERVIEW

A. Acknowledgements

During this reporting period, many individuals and organizations helped the Radiation Center succeed. In recognition of this, the staff of the OSU Radiation Center and TRIGA Reactor would like to extend its appreciation to all of those who contributed to the information and events contained in this report. To the University administration, especially President John Byrne, who consistently supported our program; to those who provided our funding, particularly the state of Oregon and the U. S. Department of Energy; to our regulators; to the researchers, the students and others who used the Radiation Center; to OSU Facilities Services, who patiently provided invaluable assistance through their engineering, maintenance, and other supporting programs; to OSU Security Services and the University Police, who were always there when we needed them; and to the OSU Department of Printing and Mailing, who consistently provided a quality service; we most earnestly say thank you.

As Director of the Radiation Center, I would like to recognize the fact that a facility such as this is only as good as its staff. The reason why this is such a high-quality, professional and successful place is because of you. You make me, the Radiation Center and the University look good. Thanks!

B. Executive Summary

This reporting period covers the first year after the major personnel changes which took place following the retirement of two of the Radiation Center's long-serving staff members: Director Art Johnson and Reactor Supervisor Terry Anderson. It is pleasing to see that the Center continued without missing a beat as evidenced by some of the statistics reviewed here.

The Oregon State University TRIGA research reactor continues to provide a service by filling a need for both teaching and research while still maintaining a rigorous regulatory compliance program. Use of the reactor for teaching increased by 5% during this reporting period; however, it should be noted that this was not at the expense of research. All requests for use by Oregon State University researchers were met at the same time that off-campus research use hours went up by 7%. An attempt to help new, young researchers get programs going resulted in a 120% increase in the time that unfunded projects used the reactor. It is hoped that several of these unfunded projects will produce the data necessary to result in future, funded research proposals.

Further evidence of the continued growth in the use of the reactor can be seen in the 7% increase in reactor irradiation requests and a similar 7% increase in the number of samples irradiated in the reactor for a recorded high of 4,148 samples. The time during which the reactor had multiple users also reached a record high this year with the two-user hours going up 13% and the four-user hours increasing 86%. The reactor use time for forensic sample irradiations doubled during this reporting year, which reflects on the nature of our society as well as the usefulness of such techniques to law enforcement agencies around the state.

One of the Radiation Center's veteran facilities, the Budd gamma irradiator was retired from service during this year, and will soon need to be replaced with a higher activity irradiator. In the meantime, the other ^{60}Co irradiator was used 39% more for a record 172 uses. This included several new users, as well as new uses for the facility such as research into gamma-induced color changes in semi-precious stones and radiation sensitivity of memory button devices.

The Radiation Center continues to develop the quality of its radiological instrument calibration program for state institutions and agencies. While the number of calibrations of Radiation Center detectors has remained steady, there has been a 6% increase in calibrations for Oregon State University departments, and a 17% increase in non-OSU agency instruments calibrated. It is gratifying to see that the number of instrument repairs the Center has performed has been steadily decreasing since this service was first provided four or five years ago (down 55% this year). This is taken to mean that the general state of repair of the state-owned radiological instruments is improving due to the care and attention that they are now receiving.

Public education and service continues to be a priority at the facility. The number of visitors this year (1,307) was a few percent above the five year average, while the number of tours performed went up nearly 20%. Being open to the state and local community is an important part of maintaining good relationships. Visitors to the reactor this year resulting from personal invitations included the Editor of the Corvallis Gazette Times, the Corvallis City Manager, the Corvallis City Engineer as well as members of the City Water staff.

Annual reports for the past several years have discussed the progress on the mandated requirement for the reactor to convert to low-enriched uranium fuel. This conversion schedule is almost entirely determined by the availability of funding from the U.S. Department of Energy. It should be no surprise to learn that such funding was not available this year and, therefore, no progress was made towards conversion.

The APEX facility successfully completed tests for Westinghouse Electric Corporation and began "beyond design basis" accident tests for the U. S. Nuclear Regulatory Commission during this reporting year. While this facility is not run by the Radiation Center staff, many of them make significant contributions in a supporting role.

On a final note, each year the Radiation Center serves about 120 faculty from 70 different institutions, in the performance of about 170 projects. Last year, as usual, all of this was done with no regulatory citations, no emergencies, and no security events. Furthermore, the increased use of the Radiation Center and reactor was accomplished with no increase in personnel radiation exposure or any impact on the environment. The comprehensive radiation protection program at the Radiation Center once again showed that the Center and the reactor can be operated safely and within the international goal of keeping personnel doses and releases of radionuclides as low as reasonably achievable (ALARA).

C. Introduction

The current annual report of the Oregon State University Radiation Center and TRIGA Reactor follows the usual format by including information relating to the entire Radiation Center rather than just the reactor. However, the information is still presented in such a manner that data on the reactor may be examined separately if desired. It should be noted that all annual data given in this report cover the period from July 1, 1994 through June 30, 1995. Cumulative reactor operating data in this report relate only to the FLIP-fueled core. This covers the period from August 1, 1976 through June 30, 1994. For a summary of data on the reactor's original 20% enriched core the reader is referred to Table IV.A.2 in Part IV of this report, or to the 1976-77 annual report if a more comprehensive review is needed.

In addition to providing general information about the activities of the Radiation Center, this report is designed to meet the reporting requirements of the U. S. Nuclear Regulatory Commission, the U. S. Department of Energy, and the Oregon Department of Energy. Because of this, the report is divided into several distinct parts so that the reader may easily find the sections of interest.

D. Overview of the Radiation Center

The Radiation Center is a unique facility which serves the entire OSU Campus, all other institutions within the Oregon State System of Higher Education, and many other colleges and universities throughout the nation. The Center also regularly provides special services to state and federal agencies, particularly agencies dealing with law enforcement, energy, health, and environmental quality, and renders assistance to Oregon industry. In addition, the Radiation Center provides permanent office and laboratory space for the OSU Department of Nuclear Engineering, the OSU Radiation Safety program, the Institute of Nuclear Science and Engineering, and for the OSU nuclear chemistry, radiation chemistry, and geo- and cosmochemistry programs. There is no other university facility with the combined capabilities of the OSU Radiation Center in the western half of the United States.

Located in the Radiation Center are major items of specialized equipment and unique teaching and research facilities. Figure I.D.1 shows the layout of these facilities at the Radiation Center. They include a TRIGA Mark II research nuclear reactor; two cobalt-60 gamma irradiators; a 300 kVp X-ray generator; a number of state-of-the art computer-based gamma radiation spectrometers and associated germanium detectors; a neutron radiography facility capable of taking still or very high speed radiographs; and a variety of instruments for radiation measurements and monitoring. Specialized facilities for radiation work include teaching and research laboratories with up-to-date instrumentation and related equipment for performing neutron activation analysis and radiotracer studies; laboratories for animal and plant experiments involving radioactivity; a facility for repair and calibration of radiation protection instrumentation; and facilities for packaging radioactive materials for shipment to national and international destinations.

A major non-nuclear facility housed in the Radiation Center is the one-quarter scale thermal hydraulic advanced plant experimental (APEX) test facility for the Westinghouse AP600 reactor design. The AP600 is a next-generation nuclear reactor design which incorporates many passive safety features as well as considerably simplified plant systems and equipment. APEX operates at pressures of up to 400 psia and temperatures up to 450°F using electrical heaters instead of nuclear fuel. All major components of the AP600 are included in APEX and all systems are appropriately scaled to enable the experimental measurements to be used for safety evaluations and licensing of the full scale plant. This world-class facility meets exacting quality assurance criteria to provide assurance of safety as well as validity of the test results.

The Radiation Center staff regularly provides direct support and assistance to OSU teaching and research programs. Areas of expertise commonly involved in such efforts include nuclear engineering, nuclear and radiation chemistry, neutron activation analysis, neutron radiography, radiation effects on biological systems, radiation dosimetry, production of short-lived radioisotopes, radiation shielding, nuclear instrumentation, emergency response, transportation of radioactive materials, instrument calibration, radiation health physics, radioactive waste disposal, and other related areas.

In addition to formal academic and research support, the Center's staff provides a wide variety of other services including public tours and instructional programs, and professional consultation associated with the feasibility, design, safety, and execution of experiments using radiation and radioactive materials.

Figure I.D.1

Floor Plan of the Radiation Center

Radiation Center
Oregon State University

Revised November 1994

E. Summary of OSTR Environmental and Radiation Protection Data

1. Liquid Effluents Released (See Table V.B.1)

a.	Total estimated quantity of radioactivity released (to the sanitary sewer)(1)(2)	$< 1.60 \times 10^{-4}$ Curies(3)
b.	Detectable radionuclides in the liquid waste	None
c.	Estimated average concentration of released radioactive material at the point of release	$< 4.91 \times 10^{-6}$ μCi/cc(3)
d.	Percent of applicable MPC for released liquid radioactive material at the point of release	Not applicable
e.	Total volume of liquid effluent released, including diluent(4)	8301 gallons
	(1) OSTR contribution	0(5) gallons

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(1) OSU has implemented a policy to reduce the absolute minimum radioactive wastes disposed to the sanitary sewer.

(2) The OSU operational policy is to subtract only detector background from our water analysis data and not background radioactivity in the Corvallis city water.

(3) This is the lower limit of detection at the 95% confidence level.

(4) Total volume of effluent plus diluent does not take into consideration the additional mixing with the over 250,000 gallons per year of liquids and sewage normally discharged by the Radiation Center complex into the same sanitary sewer system.

(5) OSTR contribution does not include the volume of liquid effluent from the infrequently used reactor bay sink.

2. Airborne Effluents Released (See Table V.B.2)

a.	Total estimated quantity of radioactivity released	3.4 Curies
b.	Detectable radionuclides in the gaseous waste(1)	^{41}Ar ($T^{\frac{1}{2}}$ = 1.83 hr)
c.	Estimated average atmospheric diluted concentration of argon-41 at the point of release	2.2×10^{-8} μCi/ml
d.	Percent of applicable MPC for diluted concentration of argon-41 at the point of release	0.6%
e.	Total estimated release of radioactivity in particulate form with half-lives greater than 8 days(2)	None

3. Solid Waste Released (See Table V.B.3)

a.	Total amount of solid waste packaged and disposed of	46 ft^3
b.	Detectable radionuclides in the solid waste	^{14}C, ^{22}Na, ^{40}K, ^{45}Ca, ^{46}Sc, ^{54}Mn, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{82}Ba, ^{110m}Ag, ^{132}Te, ^{137}Cs, ^{141}Ce, ^{143}Ce, ^{152}Eu, ^{154}Eu, ^{210}Bi, ^{235}U
c.	Total radioactivity in the solid waste	1.2×10^{-1} Curies

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(1) Routine gamma spectroscopy analysis of the gaseous radioactivity in the stack discharge indicated that it was virtually all argon-41.

(2) Evaluation of the detectable particulate radioactivity in the stack discharge confirmed its origin as naturally occurring radon daughter products, predominantly lead-214 and bismuth-214, which are not associated with reactor operations.

4. <u>Radiation Exposure Received by Personnel (See Table V.C.1)</u>(1)

a.	Facility Operating Personnel	(mrem)
(1)	Average whole body	5
(2)	Average extremities	53
(3)	Maximum whole body	75
(4)	Maximum extremities	340
b.	Key Facility Research Personnel	
(1)	Average whole body	0
(2)	Average extremities	3
(3)	Maximum whole body	0
(4)	Maximum extremities	50
c.	Physical Plant Maintenance Personnel	
(1)	Average whole body	<1
(2)	Maximum whole body	5
d.	Laboratory Class Students	
(1)	Average whole body	0
(2)	Average extremities	0
(3)	Maximum whole body	0
(4)	Maximum extremities	0
e.	Campus Police and Security Personnel	
(1)	Average whole body	0
(2)	Maximum whole body	0
f.	Visitors	
(1)	Average whole body	<1
(2)	Maximum whole body	20

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(1) "0" indicates that each of the beta-gamma dosimeters during the reporting period was less than the vendor's gamma dose reporting threshold of 10 mrem or that each of the neutron dosimeters was less than the vendor's threshold of 30 mrem, as applicable.

5. Number of Routine Onsite and Offsite Monitoring Measurements and Samples

a. Facility Survey Data

(1) Area Radiation Dosimeters (See Table V.D.1)

(a)	Beta-gamma dosimeter measurements	148
(b)	Neutron dosimeter measurements	48

(2) Radiation and Contamination Survey Measurements (See Table V.D.3)	~6000

b. Environmental Survey Data

(1) Gamma Radiation Monitoring (See Tables V.E.1 and V.E.2)

(a)	Onsite monitoring	
	-- OSU TLD monitors	108
	-- Radiation Detection Co. TLD monitors	72
	-- Monthly μrem/h measurements	108
(b)	Offsite monitoring	
	-- OSU TLD monitors	264
	-- Radiation Detection Co. TLD monitors	104
	-- Monthly μrem/h measurements	252

(2) Soil, Water and Vegetation Surveys (See Table V.E.3)

(a)	Soil samples	16
(b)	Water samples	14
(c)	Vegetation samples	56

F. History

A brief chronology of the key dates and events in the history of the OSU Radiation Center and the TRIGA reactor is given below:

June 1964	Completion of the first phase of the Radiation Center, consisting of 32,397 square feet of office and laboratory space.
July 1964	Transfer of the 0.1 W AGN 201 reactor to the Radiation Center. This reactor was initially housed in the Mechanical Engineering Department and first went critical in January of 1959.
Oct. 1966	Completion of the second phase of the Radiation Center, consisting of 9,956 square feet of space for the TRIGA reactor and associated laboratories and offices.
March 1967	Initial criticality of the Oregon State TRIGA Reactor (OSTR). The reactor was licensed to operate at a maximum steady state power level of 250 kW, and was fueled with 20% enriched fuel.
Oct. 1967	Formal dedication of the Radiation Center.
August 1969	OSTR licensed to operate at a maximum steady state power of 1 MW, but could do so only for short periods of time due to lack of cooling capacity.
June 1971	OSTR cooling capacity upgraded to allow continuous operation at 1 MW.
April 1972	OSTR Site Certificate issued by the Oregon Energy Facility Siting Council.
Sept. 1972	OSTR area fence installed.
Dec. 1974	AGN-201 reactor permanently shut down.
March 1976	Completion of 1600 square feet of additional space to accommodate the rapidly expanding nuclear engineering program.
July 1976	OSTR refueled with 70% enriched FLIP fuel.
July 1977	Completion of a second 1600 square feet of space to bring the Radiation Center complex to its current total of 45,553 square feet.

Jan. 1980	Major upgrade of the electronics in the OSTR control console.
July 1980	AGN-201 reactor decommissioned and space released for unrestricted use.
June 1982	Shipment of the original 20% enriched OSTR fuel to Westinghouse Hanford Corporation.
Dec. 1984	Founding Director C. H. Wang retired.
Aug. 1986	Director C. V. Smith left to become Chancellor of the University of Wisconsin.
Dec. 1988	AGN-201 components transferred to Idaho State University for use in their AGN-201 reactor program.
Dec. 1989	OSTR licensed power increased to 1.1 MW.
June 1990	Installation of a 7000 Ci ^{60}Co Gammacell irradiator.
March 1992	25th anniversary of the OSTR initial criticality.
Nov. 1992	Start of APEX plant construction.
June 1994	Retirement of Director A. G. Johnson.
August 1994	APEX inauguration ceremony.
August 1995	Major external refurbishment: new roof; paint; rebuilt parking lot; landscaping and lighting.

PART II

PEOPLE

PART II

PEOPLE

PART II

PEOPLE

This part contains a listing of all people who were residents of the Radiation Center or who worked a significant amount of time at the Center during this reporting period. Sections A, B and C list the academic staff, trainees and students, while sections D through G give the Radiation Center's operating staff. Section H shows the OSU Radiation Safety Office staff and section I provides the composition of committees involving Center personnel.

It should be noted that not all of the faculty and students who used the Radiation Center for their teaching and research are listed in this part. Summary information on the number of people involved is given in Table VI.C.1, while individual names and projects are listed in Tables VI.C.2 and VI.C.3.

A. Faculty

*Dodd, Brian
Director, OSU Radiation Center
Director, OSU Institute of Nuclear Science and Engineering
Professor of Nuclear Engineering and Radiation Health Physics

*Albertson, Barry D.
Professor, School of Medicine,
Division of Endocrinology, Diabetes and Clinical Nutrition
Oregon Health Sciences University, Portland, OR

*Binney, Stephen E.
Professor of Nuclear Engineering
Chairman, OSTR Reactor Operations Committee

*Conard, Bobbi, L.
Senior Faculty Research Assistant
Oceanic and Atmospheric Sciences

*Conrady, Michael R.
Faculty Research Assistant
Analytical Support Manager

Craig, A. Morrie
Professor, College of Veterinary Medicine

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*Reactor users for research and/or teaching.

Daniels, Malcolm
Professor of Chemistry

Groome, John T.
Faculty Research Assistant
APEX Facility Operations Manager
Nuclear Engineering

Gunderson, Chris E.
Faculty Research Assistant
APEX Facility Operator/Test Engineer
Nuclear Engineering

Hart, Lucas P.
Faculty Research Associate
Chemistry

Haytas, John J.
Faculty Research Assistant
APEX Facility Operator
Nuclear Engineering

*Higginbotham, Jack F.
Reactor Administrator
Associate Professor of Nuclear Engineering and Radiation Health Physics

Higley, Kathryn A.
Assistant Professor of Nuclear Engineering and Radiation Health Physics

Hovermale, Jeannette T.
Faculty Research Assistant
College of Veterinary Medicine

Johnson, Arthur G.
Director Emeritus, OSU Radiation Center
Professor Emeritus of Nuclear Engineering and Radiation Health Physics

Klein, Andrew C.
Director, Oregon Space Grant Program
Associate Professor of Nuclear Engineering

Lafi, Abd Y.
Faculty Research Associate
APEX Research Analyst
Nuclear Engineering

*Leon, Daryl A.
Faculty Research Assistant
Radiation Protection Technologist

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*Reactor users for research and/or teaching.

*Liu, Yun-Gang
Faculty Research Associate
Chemistry

*Loveland, Walter D.
Professor of Chemistry

*Lyons, Kathryn M.
Faculty Research Assistant
Health Physicist

MacVicar, Robert
President Emeritus, OSU

*Martsolf, Steven W.
Faculty Research Assistant
Nuclear Engineering

Meggs, Deanna
Faculty Research Assistant
Radiation Center

*Meredith, Charlotte C.
Faculty Research Assistant
Oceanic and Atmospheric Sciences

*Millan, Monica
Visiting Researcher
Oregon Health Sciences University, Portland, OR

Miller, Lenny L.
Faculty Research Assistant
APEX Data Acquisition System Operator/Test Engineer
Nuclear Engineering

Miller, Michael D.
Faculty Research Assistant
APEX Facility Operator
Nuclear Engineering

*Mumford, Margaret
Faculty Research Assistant
Oceanic and Atmospheric Sciences

Palmer, Todd S.
Assistant Professor of Nuclear Engineering

*Pastorek, Christine
Senior Instructor of Chemistry

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*Reactor users for research and/or teaching.

Popovich, Milosh
Vice President Emeritus, OSU

*Pratt, David S.
Faculty Research Assistant
Senior Health Physicist

Reyes, Jr., José N.
APEX Principal Investigator
Associate Professor of Nuclear Engineering

Ringle, John C.
Professor of Nuclear Engineering
Associate Dean of the Graduate School, OSU

Robinson, Alan H.
Head, Department of Nuclear Engineering
Professor of Nuclear Engineering

*Schmidt, Stephen W.
Faculty Research Assistant
Oregon Health Sciences University, Portland, Oregon

*Schmitt, Roman A.
Professor Emeritus, Chemistry

Souliotis, George
Faculty Research Associate
Chemistry

*Sparrow, Margaret
Senior Research Assistant
Oceanic and Atmospheric Sciences

*Streck, Martin J.
Graduate Teaching Assistant
Radiation Center Geochemist

*Tharakan, Binesh
Faculty Research Assistant
Radiation Protection Technologist (from 4/1/94-8/12/94)

*Thompson, David E.
Faculty Research Assistant
Oregon Health Sciences University, Portland, Oregon

*Torne, Erwin G.
Faculty Research Assistant
Radiation Center Project Manager

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*Reactor users for research and/or teaching.

Wang, Chih H.
Director Emeritus, Radiation Center
Professor Emeritus, Nuclear Engineering, OSU

Willis, David L.
Professor Emeritus
General Science, OSU

Young, Roy A.
Professor Emeritus, OSU
Botany and Plant Pathology, OSU

Yundt, Michael S.
Faculty Research Assistant
APEX Instrument Specialist/Test Engineer
Nuclear Engineering

*Zhang, Lihua
Graduate Teaching Assistant
Radiation Center Geochemist

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*Reactor users for research and/or teaching.

B. Visiting Scientists and Special Trainees

Name	Field (Affiliation)	Advisor or Research Program Director
Altschul, Brett D.	Saturday Academy Mentorship Program, Sprague High School (Salem, Oregon)	W. D. Loveland
Andersson, Mia T.	Royal Institute of Technology Chemistry (Sweden)	W. D. Loveland
Grier, Nathaniel J.	Saturday Academy Mentorship Program, South Eugene High School (Eugene, Oregon)	W. D. Loveland
*Liedtke, James D.	Visiting Associate Professor (Portland Community College)	B. Dodd
*Vlčáková, Jana	Visiting Fulbright Fellow Chemistry (Czech Republic)	W. D. Loveland

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*Reactor users for research and/or teaching.

C. OSU Graduate Students

Name	Degree Program	Field	Advisor
Al-Hussan, Khalid A.	PhD	Nuclear Engr.	A. C. Klein
Asghar, Sabooh	MS	Nuclear Engr.	J. N. Reyes
Bahmaid, Mohammad R.	MS	Radiation Health	J. F. Higginbotham
*Bae, Jung Soo	MS	Radiation Health	J. F. Higginbotham
Betts, Curt M.	PhD	Nuclear Engr.	A. C. Klein
Baik, Seung-Hyuk	PhD	Nuclear Engr.	J. F. Higginbotham
Brannan, Charles T.	MS	Radiation Health	J. F. Higginbotham
Brock, Terry A.	MS	Radiation Health	J. F. Higginbotham
Cantaloub, Michael	MS	Radiation Health	J. F. Higginbotham
*Day, Travis D.	PhD	Chemistry	W. D. Loveland
*Dunn, John R.	PhD	Chemistry	W. D. Loveland
*Eversmeyer, Bruce	MS	Chem. Ocean.	R. W. Collier
Franz, Scott C.	PhD	Nuclear Engr.	J. N. Reyes
Fundak, Robert	MS	Nuclear Engr.	J. F. Higginbotham
Hekkala, Darin	MS	Radiation Health	K. A. Higley
*Johnson, Jennifer E.	MS	Radiation Health	S. E. Binney
Kellar, Marvin	MS	Radiation Health	B. Dodd
Lee, Hsing H.	PhD	Nuclear Engr.	A. C. Klein
Lee, Taejin	PhD	Civil Engineering	A. M. Craig
Leon, Laura M.	MS	Radiation Health	J. F. Higginbotham
Lotrario, Joseph	MS	Environmental Engr.	A. M. Craig
*Martin-Bandin, Fernando	MS	Radiation Health	J. F. Higginbotham
Miller, Robert E.	MS	Radiation Health	J. F. Higginbotham
Nasir, Adil	MS	Chem. Engr.	J. McGuire
Pagh, Richard T.	MS	Nuclear Engr.	A. C. Klein
Pimental, David A.	MS	Nuclear Engr.	J. N. Reyes
Potter, Nathan K.	MS	Radiation Health	K. A. Higley
Radley, Jason D.	MS	Nuclear Engr.	A. C. Klein
Richardson, Kira L.	MS	Radiation Health	S. E. Binney
Rynders, David G.	MS	Radiation Health	J. F. Higginbotham
Saiyut, Kittiphong	MS	Radiation Health	J. F. Higginbotham
Siadal, Jeremy C.	MS	Radiation Health	S. E. Binney
Stevens, Owen L.	MS	Nuclear Engr.	J. N. Reyes
Stewart, Donald N.	MS	Radiation Health	B. Dodd
*Streck, M.	PhD	Geosciences	A. Grunder
Tiyapun, Kanokrat	MS	Radiation Health	J. F. Higginbotham
*Torne, E.	MS	Geosciences	C. Field
*Vostmyer, Chris	MS	Radiation Health	S. E. Binney
Will, Yvonne	PhD	Biochemistry	A. M. Craig
Wu, Renpo	MS	Radiation Health	B. Dodd
Zyromski, Kristiana E.	PhD	Chemistry	W. D. Loveland

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*Reactor users for research and/or teaching.

D. Business, Administrative and Clerical Staff

Director, Radiation Center	B. Dodd
Business Manager	S. C. Campbell
Administrative Assistant	D. K. Dalton
Office Specialists	C. L. Phillips J. R. Smith
Custodian	E. Cimbri
Office Coordinator (Nuclear Engineering)	D. L. Cramer
Word Processing Technician (Nuclear Engineering)	R. A. Keen
Word Processing Technician, Part time (Nuclear Engineering)	P. A. Spoon
Word Processing Technician (APEX - Nuclear Engineering)	T. L. Culver

E. Reactor Operations Staff

Principal Security Officer, Senior Reactor Operator	B. Dodd
Reactor Administrator, Senior Reactor Operator	J. F. Higginbotham
Reactor Supervisor, Senior Reactor Operator	(through 7/29/94) T. V. Anderson (from 8/1/94) A. D. Hall
Senior Reactor Operator	S. P. Smith
Reactor Operator	J. S. Bae

F. Radiation Protection Staff

Senior Health Physicist	D. S. Pratt
Health Physicist	(from 9/1/94) K. M. Lyons
Radiation Protection Technologist	(through 8/12/94) B. Tharakan (from 8/1/94) D. A. Leon
Health Physics Monitors (Students)	J. Armstrong M. Cunningham A. Dow T. Johnson D. Stewart G. Wade

G. Scientific Support Staff

Senior Neutron Activation Analyst	R. A. Schmitt
Neutron Activation Analysis Specialist	M. R. Conrady
Geochemists	M. J. Streck E. G. Torne
Neutron Activation Analysis Technicians (Students)	R. Claussen M. Hilyard K. Mammone C. Payne J. Templeton L. Zhang
Scientific Instrument Technician	S. P. Smith
Nuclear Instrumentation Support	T. Brannan D. Hekkala

H. OSU Radiation Safety Office Staff

Radiation Safety Officer	R. H. Farmer
Radiation Specialists	D. L. Harlan E. F. Forrer
Office Manager	K. L. Miller
Student Technicians	A. Arevalo J. Armstrong T. Brock S. Fike J. Maxwell R. Miller S. Naguib G. Wade

I. Committees

1. Reactor Operations Committee

Name	Affiliation
S. E. Binney, Chair	Nuclear Engineering
D. L. Amort	Electrical and Computer Engineering
T. V. Anderson (through 7/29/94)	Radiation Center
B. Dodd	Radiation Center and Nuclear Engineering
A. D. Hall (from 8/1/94)	Radiation Center
J. F. Higginbotham	Radiation Center and Nuclear Engineering
A. G. Johnson	Radiation Center and Nuclear Engineering
D. S. Pratt	Radiation Center
J. C. Ringle	Nuclear Engineering and Graduate School
A. H. Robinson	Nuclear Engineering
R. A. Schmitt	Chemistry and Radiation Center
W. H. Warnes	Mechanical Engineering

2. Radiation Safety Committee (OSU)

Name	Affiliation
C. Rivin, Chair	Botany and Plant Pathology
R. Farmer, Secretary & RSO	Radiation Safety Office
R. Collier	Oceanic and Atmospheric Sciences
T. Dreher	Agricultural Chemistry
B. Francis	Environmental Health and Safety
J. Higginbotham	Radiation Center and Nuclear Engineering
D. Keszler	Chemistry
P. McFadden	Biochemistry/Biophysics
W. Lee Schroeder (ex officio)	Chief Business Officer
J. Steiner	USDA-ARS/Crop and Soil Science
T. Wolpert	Botany and Plant Pathology

3. Radiation Center Safety Committee

Name	Affiliation
W. D. Loveland, Chair	Chemistry
S. C. Campbell	Radiation Center
M. R. Conrady	Radiation Center
B. Dodd	Radiation Center and Nuclear Engineering
A. D. Hall	Radiation Center
J. F. Higginbotham	Radiation Center and Nuclear Engineering
S. P. Smith	Radiation Center

PART III

FACILITIES

PART III

FACILITIES

PART III

FACILITIES

A. Research Reactor

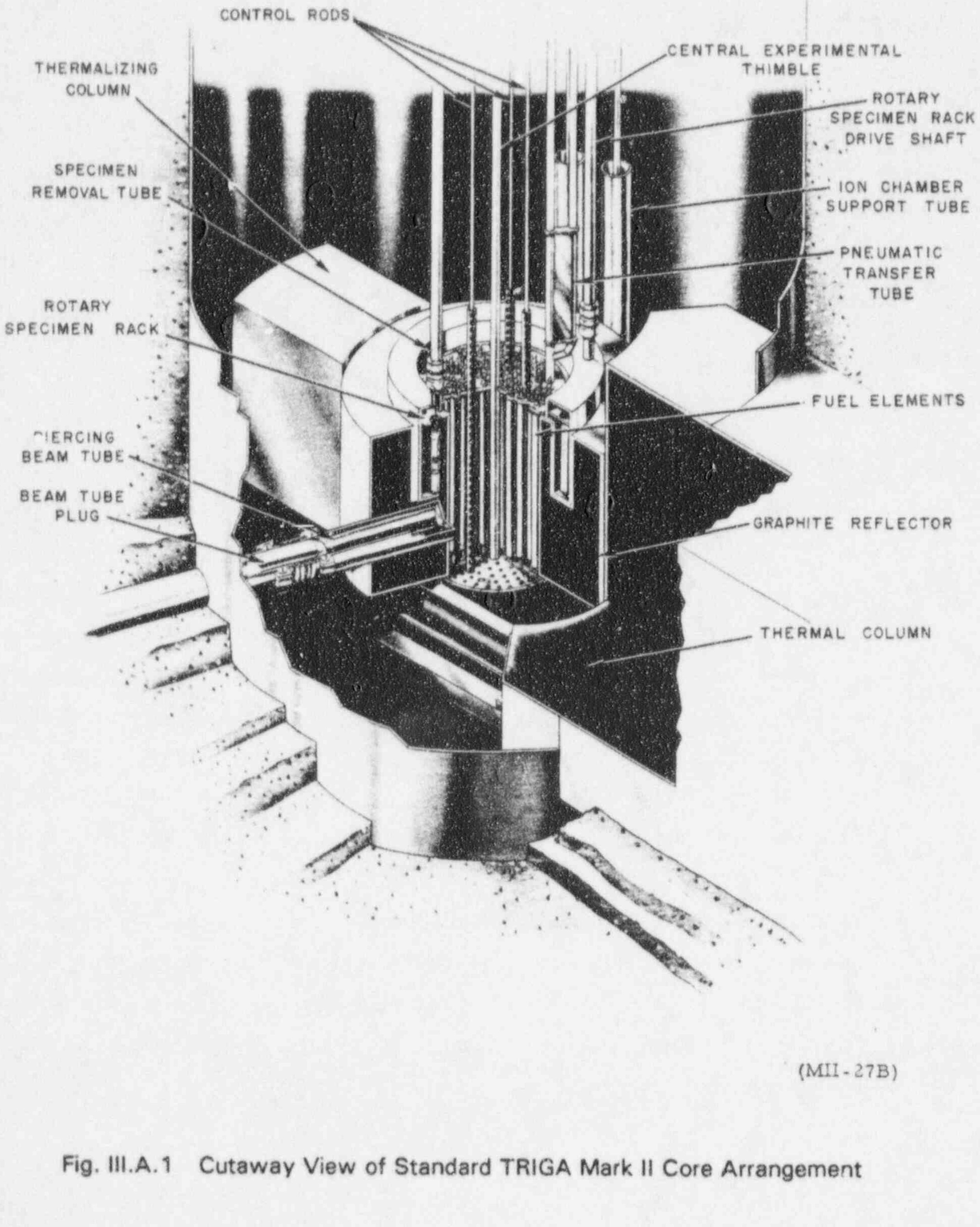
1. Description

The Oregon State University TRIGA Reactor (OSTR) is a water-cooled, swimming pool type of research reactor which uses uranium/zirconium hydride fuel elements in a circular grid array. The reactor core is surrounded by a ring of graphite which serves to reflect neutrons back into the core. The core is situated near the bottom of a 22-foot deep water-filled tank, and the tank is surrounded by a concrete bioshield which acts as a radiation shield and structural support. See Figures III.A.1, III.A.2 and III.A.3.

The reactor is licensed by the U.S. Nuclear Regulatory Commission to operate at a maximum steady state power of 1.1 MW, and can also be pulsed up to a peak power of about 3000 MW.

The OSTR has a number of different irradiation facilities including a pneumatic transfer tube, a rotating rack, a thermal column, four beam ports, five sample-holding (dummy) fuel elements for special in-core irradiations, and a cadmium-lined in-core irradiation tube for experiments requiring a high energy neutron flux.

The **pneumatic transfer facility** enables samples to be inserted and removed from the core in a few seconds. Consequently, this facility is normally used for neutron activation analysis involving short-lived radionuclides. On the other hand, the **rotating rack** is used for much longer irradiation of samples (e.g., hours). The rack consists of a circular array of 40 tubular positions, each of which can hold two sample tubes. The rotation of the rack ensures that each sample will receive the same amount of irradiation.



(MII-27B)

Fig. III.A.1 Cutaway View of Standard TRIGA Mark II Core Arrangement

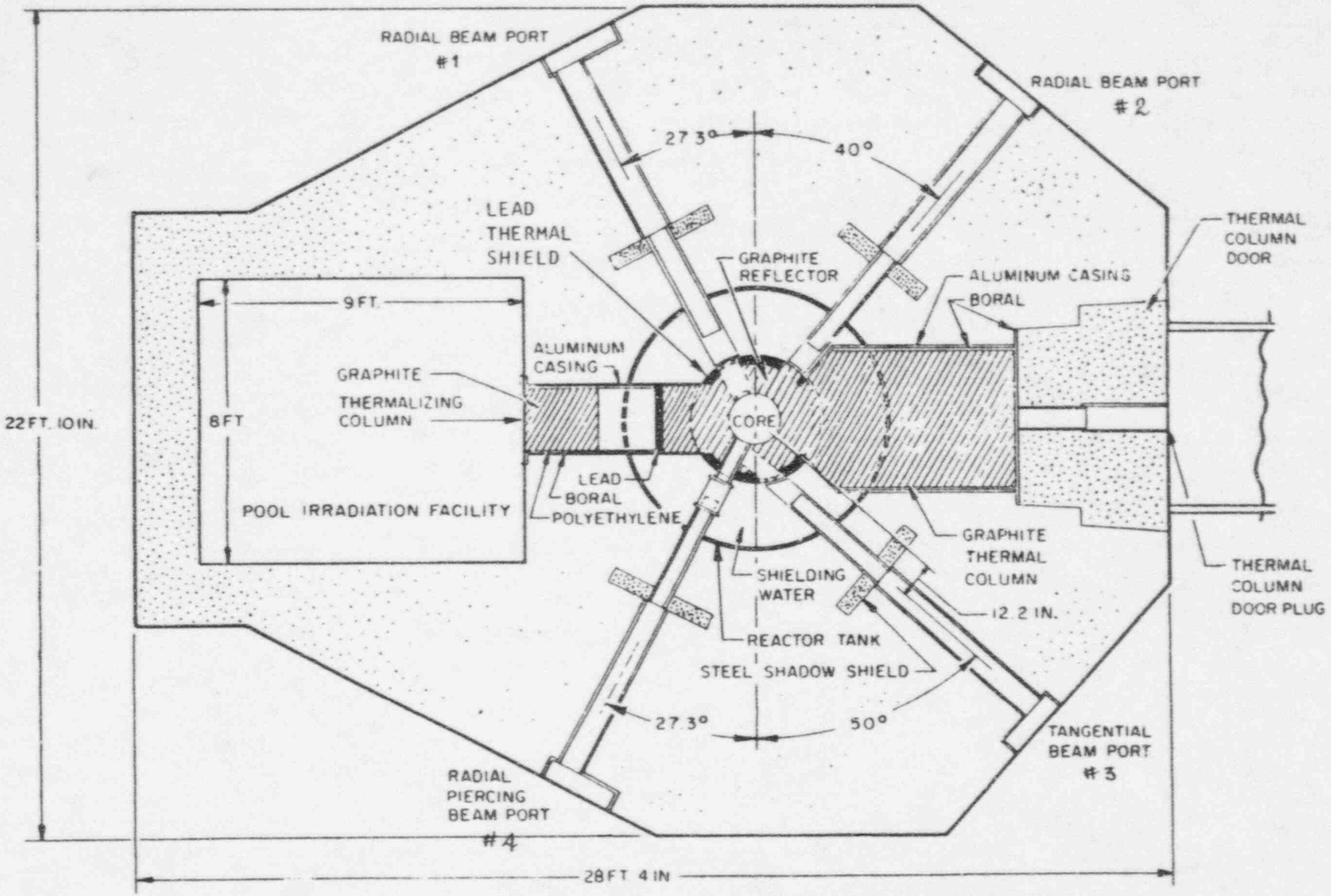


Fig. III.A.2 Horizontal Section of TRIGA Mark II Reactor

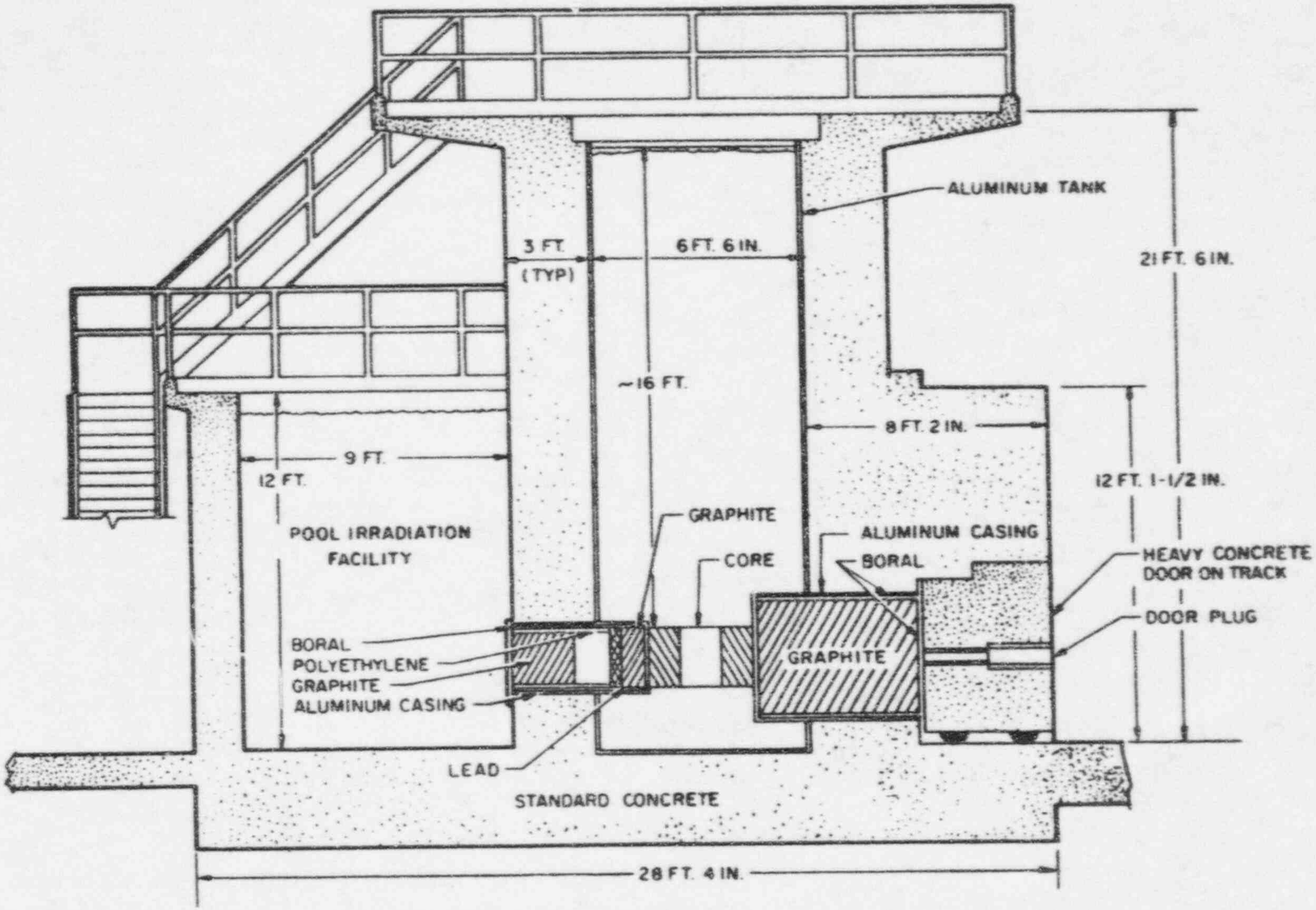


Fig. III.A.3 Vertical Section of TRIGA Mark II Reactor

The reactor's **thermal column** consists of a large stack of graphite blocks which slow down neutrons from the reactor core in order to increase thermal neutron activation of samples. Graphite blocks are removed from the thermal column to enable samples to be positioned inside for irradiation.

The **beam ports** are tubular penetrations in the reactor's main concrete shield which enable neutron and gamma radiation to stream from the core when a beam port's shield plugs are removed. Two of the OSTR's beam ports are permanently configured for neutron radiography while the other two may be used for a variety of experiments.

If samples which are to be irradiated require a large neutron fluence, especially from higher energy neutrons, then such samples may be inserted into a **dummy fuel element**. This device will then be placed into one of the core's inner grid positions which would normally be occupied by a fuel element.

The **cadmium-lined in-core irradiation tube** enables samples to be irradiated in a high flux region near the center of the core. The cadmium lining in the facility eliminates thermal neutrons and thus permits sample exposure to epithermal neutrons only. The cadmium-lined end of this air-filled aluminum irradiation tube is inserted into an inner grid position of the reactor core which would normally be occupied by a fuel element.

2. Utilization

The two main uses of the OSTR are instruction and research. During this reporting period, the reactor was in use an average of 39 hours during a typical 45-hour work week. Hence, the reactor was used approximately 87% of the available time.

a. Instruction

Instructional use of the reactor is twofold. First, it is used significantly for classes in nuclear engineering, radiation protection, and chemistry at both the graduate and undergraduate levels to demonstrate numerous principles which have been presented in the classroom. Basic neutron behavior is the same in small reactors as it is in large power reactors, and many demonstrations and instructional experiments can be performed using the OSTR which cannot be carried out with a commercial power reactor. Shorter-term demonstration experiments are also performed for many undergraduate students in physics, chemistry and biology classes, as well as for visitors from other universities and colleges, from high schools and from public groups.

The second instructional application of the OSTR involves education of reactor operators, operations managers, and radiation health physicists. The OSTR is in a unique position to provide such education since curricula must include hands-on experience at an operating reactor and in associated laboratories. The many types of educational programs that the Radiation Center provides are more fully described in Part VI (section VI.C.5) of this report.

During this reporting period the OSTR accommodated 29 different OSU academic classes. In addition, portions of classes from other Oregon universities were also supported by the OSTR. The OSU teaching programs utilized 523 hours of reactor time. Tables III.A.1 and III.A.2 as well as Table III.E.1 provide detailed information on the use of the OSTR for instruction and training.

b. Research

The OSTR is a unique and valuable tool for a wide variety of research applications, and serves as an excellent source of neutrons and/or gamma radiation. The most popular experimental technique requiring reactor use is

Table III.A.1

OSU Courses Using the OSTR

Course Number	Course Name
NE 111	Introduction to Nuclear Engineering
NE 113	Introduction to Nuclear Engineering
NE 233	Nuclear Radiation Detection and Instrumentation
RHP 233	Nuclear Radiation Detection and Instrumentation
NE 406	Projects
NE 457	Nuclear Reactor Laboratory
NE 479	Individual Design Projects (Nuclear Engineering)
RHP 480	Field Practices in Radiation Protection (Undergraduate)
NE 484	Applied Radiation Safety
RHP 484	Applied Radiation Safety
NE 503	Thesis (Nuclear Engineering)
RHP 503	Thesis (Radiation Health Physics)
NE 549	Selected Topics/Hanford's Radioactive Waste: Technical & Social Issues
NE 557	Advanced Nuclear Reactor Laboratory
NE 580	Field Practices in Radiation Protection (Graduate)
RHP 580	Field Practices in Radiation Protection (Graduate)
RHP 584	Applied Radiation Safety (Graduate)
CH 219	General Chemistry Laboratory
CH 222	General Chemistry for Science Majors
CH 418	Nuclear Chemistry
CH 462	Experimental Chemistry II
CH 503	Thesis (Chemistry)
CH 518	Advanced Nuclear Chemistry
ENGR 119	Hands-On Engineering
GEO 300	Environmental Conservation
GEO 503	Thesis (Geosciences)
OC 503	Thesis (Oceanography)
BB 603	Thesis (Biochemistry)
Asia University, America Office (OSU)	Japanese Class
Adventures in Learning	Visiting Students
Saturday Academy	Visiting Students
SMILE Program	Teacher's Short Course

Table III.A.2

OSTR Teaching Hours

Description	Annual Values (hours)		Cumulative Values for FLIP Core (hours)
Departmental		469	4,995
Nuclear Engineering	399		
Chemistry	56		
Geosciences(1)	0		
Oceanic and Atmospheric Sciences(1)	0		
New Student Programs	2		
English Language Institute	2		
Asia University (OSU)	2		
Adventures in Learning	4		
Saturday Academy	2		
SMILE Program	2		
Special Classes and Projects(2)		54	1,021
Total Teaching Hours(3,4,5)		523	6,016

(1) Some use hours by these departments are not shown under "Teaching Hours," but are reflected under Thesis Research, both funded and unfunded.

(2) A variety of educational classes were conducted which involved one-time meetings for orientation or support purposes. These included: high school science classes, new student programs support, reactor operator orientation and training, community college classes and classes from other universities.

(3) See Table III.E.1 for classes and student enrollment.

(4) See Table IV.A.5 for a summary of all reactor use categories.

(5) Total teaching hours reflect all time the reactor was in use for teaching, and because of this the total hours include time the reactor itself may not actually have been in operation.

neutron activation analysis (NAA). This is a particularly sensitive method of elemental analysis which is described in more detail in Part VI (section VI.C.1). Part III.B provides a listing of equipment used in NAA at the Radiation Center.

The OSTR's irradiation facilities provide a wide range of neutron flux levels and neutron flux qualities, which are sufficient to meet the needs of most researchers. This is true not only for NAA, but also for other experimental techniques such as fission track dating of geological and anthropological materials.

During this reporting period, the OSTR accommodated 95 funded research projects which utilized 1,413 hours of reactor time, and 11 unfunded research projects which utilized 125 hours of reactor time. Details of the reactor's use specifically for research are given in Table III.A.3. Additional information regarding reactor use for research, thesis and service can be found in Tables VI.C.1 through VI.C.3. In these tables OSTR use is indicated with an asterisk.

Table III.A.3

OSTR Research Hours

Types of Research	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
OSU Research	172	7,448
Off-Campus Research	1,366	8,403
Total Research Hours(1)(2)	1,538	15,851

(1) Total research hours statistics:

- (a) 92% (1,413 hours) of the total research hours were user-funded by federal, state, or other organizations.
- (b) 8% (125 hours) of the total research hours were user-unfunded studies in support of graduate thesis research or other academic investigations. Reactor costs for this research were absorbed (funded) by the OSU Radiation Center.

(2) OSTR use hours in support of OSU teaching and research programs equal approximately 51% of the hours the OSTR operated for off-campus research projects. Of the off-campus research hours OSTR recorded, approximately 36 hours were used supporting several Oregon high school senior research projects, 21 hours supporting Willamette University, and 6 hours for the University of Oregon.

B. Analytical Equipment

1. Description

The Radiation Center has a great variety of radiation detection instrumentation. Much of this equipment involves the latest in counting technology as represented by the state-of-the-art gamma ray spectrometers with their associated computers and Ge(Li) or intrinsic germanium detectors. Tables III.B.1 through III.B.4 provide a brief listing of typical laboratory counting devices present at the Center. Much additional equipment for use in the classroom, and an extensive inventory of portable radiation detection instrumentation are also available.

2. Utilization

Radiation Center nuclear instrumentation receives intensive use in both teaching and research applications. In addition, service projects also use these systems and the combined use often results in 24-hour per day schedules for many of the analytical instruments. Use of Radiation Center equipment extends beyond that located at the Center and instrumentation is commonly made available on a loan basis to OSU researchers in other departments.

Table III.B.1

Radiation Center Spectrometry Systems: Gamma, Low Energy Photon, Alpha

Room	System	Rel. Effic. (%)
B100	Adcam 1, 8k Ortec, Ortec HP Ge	26.8
B100	Adcam 2, 8k Ortec, Ortec HP Ge	38.1
B100	Adcam 3, 8k Ortec, Canberra Ge(Li)	16.6
B100	Adcam 4, 8k Ortec, Ortec HP Ge	28.8
D102	Adcam 5, 8k Ortec, PGT Ge(Li)	12.1
C120	Ace 1, 4k Ortec, NaI(Tl) 3x3	N/A
C123	Ace 2, 4k Ortec, PGT Ge(Li)	18.7
A138	H.P. Scaler, NaI(Tl) 2x2	N/A
B136	Ortec HP Ge	30.0
A146	Ace, 4k Ortec, Ortec Ge(Li)	27.0
C134	Adcam 8k MCA, EG&G HPGe	33.5
C134	Adcam 8k MCA, PGT Ge(Li)	19.3
C134	Adcam 8k MCA, PGT LEP	N/A
C134	Adcam 8k MCA, Ortec LEP	N/A
C120	Ace 3, 4k Ortec, 576A Alpha Spectrometer	N/A

Table III.B.2

Radiation Center Liquid Scintillation Counting Systems

Room	System
C120	Beckman, Betamate
C120	Beckman, Betamate
C120	Beckman, Betamate
C120	Beckman, Betamate
B136	Beckman, LS 6500

Table III.B.3

Radiation Center Proportional Counting Systems

Room	System
C120	NMC 1, PC5
C120	NMC 2, PC5
C120	NMC 3, PC5
A138	NMC, PCC-11T and DS 2
A138	Tennelec Auto Counting System w/IBM PC

Table III.B.4

Thermoluminescent Dosimeter Systems

Room	System
C120	Teledyne TLD 7300
C120	Teledyne TLD 7300
C120	Teledyne TLD 7300
C120	Teledyne TLD 7300
B124	Harshaw Model 2000
A132	Harshaw Model 2000

C. Radioisotope Irradiation Sources

1. Description

The Radiation Center is equipped with two ^{60}Co irradiation facilities: an older Budd irradiator and a Gammacell 220 irradiator. These two irradiators complement each other and are capable of delivering high doses of gamma radiation over a range of dose rates to a variety of materials.

Typically, the irradiators are used by researchers wishing to perform mutation and other biological effects studies, studies in the area of radiation chemistry, dosimeter testing, sterilization of food materials, soils, sediments and other media, gamma radiation damage studies, and other such applications. In addition to the ^{60}Co irradiator, the Center is also equipped with a variety of smaller ^{60}Co, ^{137}Cs, ^{226}Ra, plutonium-beryllium, and other isotopic sealed sources of various curie levels which are available for use as irradiation sources.

2. Utilization

During this reporting period there was a diverse group of projects using the ^{60}C^{o} irradiators. These projects included the irradiation of a variety of biological cells as well as the irradiation of various seeds. In addition, the irradiators were used for radiation dosimeter analysis, sterilization of several media, and materials evaluation. Data showing uses of the Budd irradiator for this reporting period are given in Table III.C.1. Table III.C.2 provides use data for the Gammacell 220 irradiator.

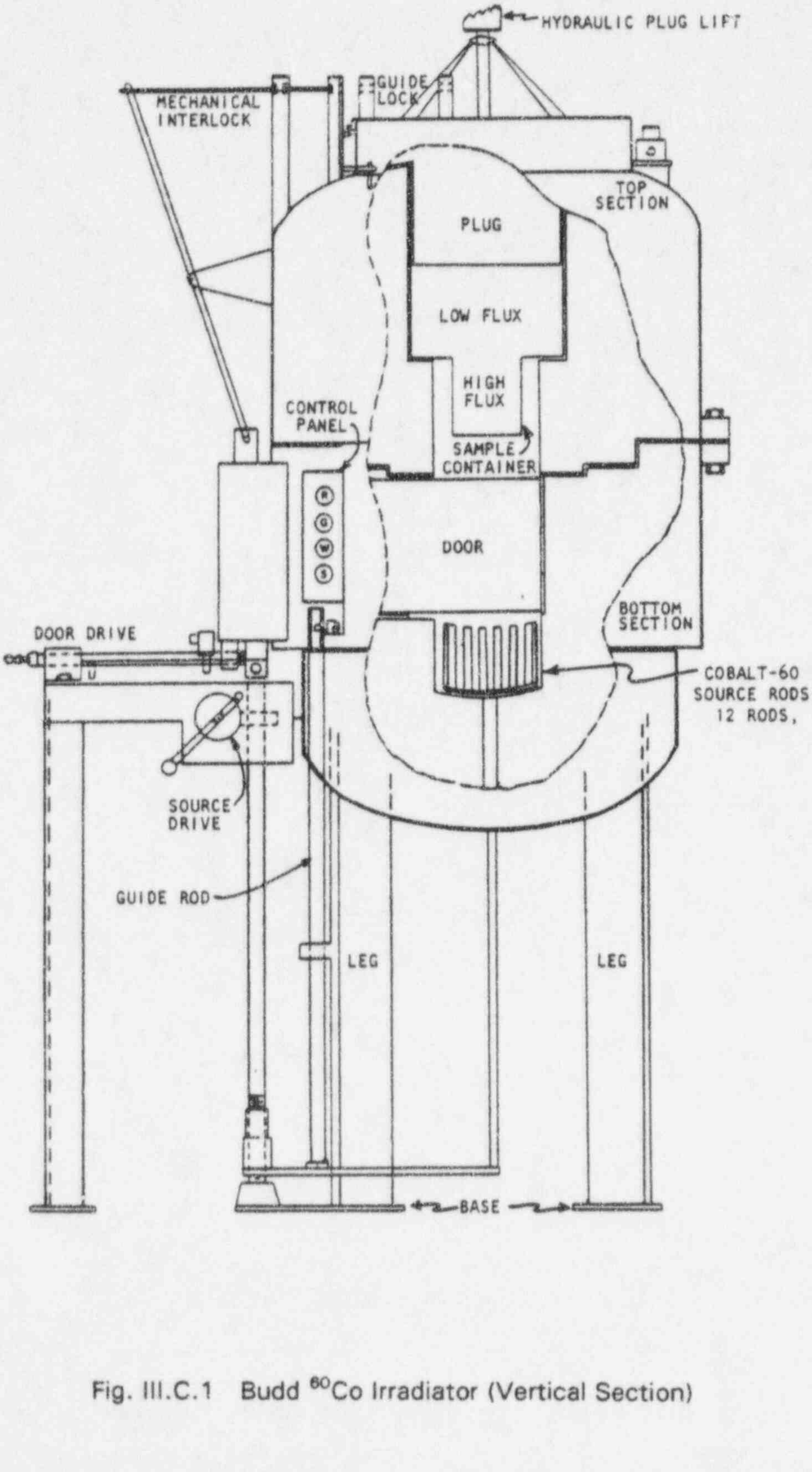


Fig. III.C.1 Budd ^{60}Co Irradiator (Vertical Section)

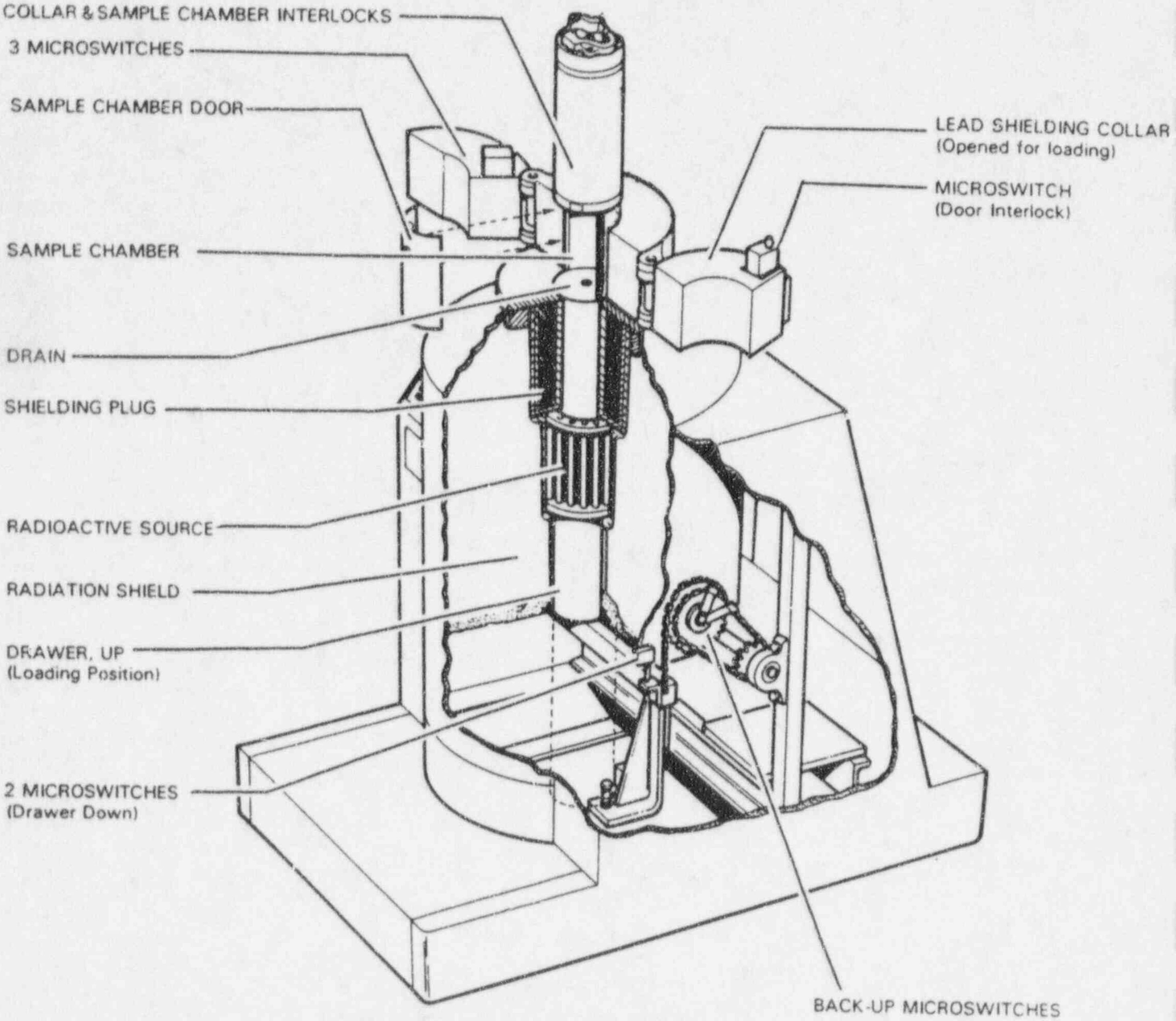


Fig. III.C.2 Gammacell 220 ^{60}Co Irradiator

Table III.C.1

Budd ^{60}Co Irradiator Use
(53 Ci: 7/11/94)

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Biological Studies	DNA, seed, mice	1.0×10^2 to 2.6×10^3	7	4
Dosimeter Analysis	TLDs, other dosimeters	1.0×10^2 to 6.0×10^2	5	15
Material Evaluation	Memory chips	1.0×10^3 to 9.0×10^3	2	3
TOTALS	---	---	14	22

Table III.C.2

Gammacell 220 ^{60}Co Irradiator Use
(4169 Ci: 7/1/95)

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Sterilization	Talc, blood serum, wood, latex, soil	1.5×10^6 to 5.0×10^6	123	1,468
Material Evaluation	Memory chips, quartz	0.9×10^5 to 3.0×10^7	13	411
Botanical Studies	Corn and bean seeds	1.0×10^3 to 8.0×10^3	3	<1
Biological Studies	Spleen cells, cells	3.0×10^3	25	<1
Gemstone Enhancement Studies	Tourmaline, topaz	7.0×10^6 to 3.0×10^7	5	622
TOTALS	---	---	172	2,502

D. X-Ray Machine

1. Description

A General Electric Maxitron 300 kVp X-ray generator is located in the Radiation Center. This device is situated in a shielded room which is large enough to accommodate a wide variety of experiments. The machine is capable of operating at 300 kVp and 20 mA, and devices for calibrating the beam intensity are available.

2. Utilization

The X-ray machine continued to be used as a radiation source where students could perform state-required radiation surveys of a fixed X-ray machine installation and carry out other safety checks required for such a facility.

E. Laboratories and Classrooms

1. Description

The Radiation Center is equipped with a number of different radioactive material laboratories designed to accommodate classes offered by various OSU academic departments or off-campus groups.

Instructional facilities available at the Center include a laboratory especially equipped for teaching radiochemistry and a nuclear instrumentation teaching laboratory equipped with modular sets of counting equipment which can be configured to accommodate a variety of experiments involving the measurement of many types of radiation. The Center also has three student computer rooms equipped with a large number of personal computers and engineering workstations.

In addition to these dedicated instructional facilities, many other research laboratories and pieces of specialized equipment are regularly used for teaching. In particular, classes are routinely given access to appropriate state-of-the-art gamma spectroscopy equipment located in Center laboratories. A number of classes also regularly use the reactor and the reactor bay as an integral part of their instructional coursework.

There are two classrooms in the Radiation Center which are capable of holding about 16 and 35 students. In addition, there are two smaller conference rooms and a library that are suitable for graduate classes and thesis examinations. As a service to the student body, the Radiation Center also provides an office area for the student chapters of the American Nuclear Society and the Health Physics Society.

This reporting period saw further modifications to the Radiation Center's thermal hydraulics laboratory. This laboratory is being used by a member of the nuclear engineering faculty to accommodate a one-quarter scale model of the Westinghouse Electric Corporation AP600 reactor. The AP600 is a next-generation reactor which features simplicity, passive safety and standardization in its design. The multi-million dollar advanced plant experimental (APEX) facility was fully utilized by Westinghouse and the U. S. Nuclear Regulatory Commission during this reporting period to provide licensing data and to test safety systems in "beyond design basis" accidents. The fully scaled, integral model APEX facility uses electrical heating elements to simulate the fuel elements, operates at 450°F and 400 psia and responds at twice real time. It is the <u>only</u> facility of its type in the world and is owned by the U. S. Department of Energy, designed by Westinghouse, and operated by OSU.

2. Utilization

All of the laboratories and classrooms are used extensively during the academic year. For example, a listing of 76 courses accommodated at the Radiation Center during this reporting period along with their enrollments is given in Table III.E.1. Table III.A.1 gives a separate listing of the 29 classes specifically accommodated by the reactor during the reporting period.

Table III.E.1

Student Enrollment in Nuclear Engineering, Radiation Health Physics and Nuclear Science Courses Which Are Taught or Partially Taught at the Radiation Center

Course	Credit	Course Title	Number of Students			
			Fall 1994	Winter 1995	Spring 1995	Summer 1995
Nuclear Engineering Department Courses						
NE 111*	3	Introduction to Nuclear Engineering	22	--	--	--
NE 112	3	Introduction to Nuclear Engineering	--	20	--	--
NE 113*	3	Introduction to Nuclear Engineering	--	--	22	--
NE 231	3	Nuclear & Radiation Physics	19	--	--	--
RHP 231	3	Nuclear & Radiation Physics	7	--	--	--
NE 232	3	Nuclear & Radiation Physics	--	15	--	--
RHP 232	3	Nuclear & Radiation Physics	--	7	--	--
NE 233*	3	Nuclear Radiation Detection & Instrumentation	--	--	13	--
RHP 233*	3	Nuclear Radiation Detection & Instrumentation	--	--	9	--
NE 361	3	Nuclear Reactor Systems	--	7	--	--
NE 381	3	Principles of Radiation Safety	5	--	--	--
RHP 381	3	Principles of Radiation Safety	6	--	--	--
NE 406	1-16	Projects	1	--	--	--
NE 407	1	Nuclear Engineering Seminar	--	13	21	--
NE 414	3	Nuclear Rules & Regulations	--	--	18	--
RHP 414	3	Nuclear Rules & Regulations	--	--	8	--
NE 454	3	Nuclear Reactor Analysis	7	--	--	--
NE 455	3	Nuclear Reactor Analysis	--	7	--	--
NE 456	3	Nuclear Reactor Analysis	--	--	7	--
NE 457**	3	Nuclear Reactor Laboratory	--	--	7	--
NE 467	4	Nuclear Reactor Thermal Hydraulics	6	--	--	--
NE 471	3	Nuclear Power Systems Design	6	--	--	--
NE 472	3	Nuclear Power Systems Design	--	6	--	--
NE 473	3	Nuclear Reactor Design	--	--	6	--
NE 479**	1-4	Individual Design Project	1	4	5	--
RHP 480*	1-3	Field Practices in Radiation Protection	1	3	2	3
NE 484**	3	Applied Radiation Safety	7	--	--	--
RHP 484**	3	Applied Radiation Safety	3	--	--	--
NE 486	3	Radiation Dosimetry	--	--	7	--
RHP 486	3	Radiation Dosimetry	--	--	3	--
RHP 493	3	Non-Reactor Radiation Protection	--	--	3	--
NE 503**	1-16	Thesis	4	4	2	--
RHP 503**	1-16	Thesis	12	8	10	1

ST = Special Topics

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

Table III.E.1 (Continued)

Course	Credit	Course Title	Number of Students			
			Fall 1994	Winter 1995	Spring 1995	Summer 1995
NE 505	1-16	Reading & Conference	--	--	--	1
RHP 505	1-15	Reading & Conference	1	--	--	1
NE 506	1-16	Projects	1	--	--	1
RHP 506	1-16	Projects	1	--	--	--
NE 507	1	Seminar	--	1	2	--
RHP 510	1-12	Internship	--	1	--	--
NE 514	3	Nuclear Rules & Regulations	--	--	1	--
RHP 514	3	Nuclear Rules & Regulations	--	--	8	--
NE 526	3	Computational Methods for Nuclear Reactors	--	4	--	--
NE 537	3	Applications of Nuclear Techniques	--	4	--	--
RHP 537	3	Applications of Nuclear Techniques	--	7	--	--
NE 539	3	ST/Neutron Particle Physics	4	--	--	--
NE 549	3	ST/Low Level Waste Management	--	2	--	12
RHP 549	3	ST/Low Level Waste Management	--	11	--	--
NE 554	3	Advanced Nuclear Reactor Analysis	3	--	--	--
NE 555	3	Advanced Nuclear Reactor Analysis	--	1	--	--
NE 556	3	Advanced Nuclear Reactor Analysis	--	--	2	--
NE 557**	3	Advanced Nuclear Reactor Lab	--	--	1	--
NE 567	3	Advanced Nuclear Reactor Thermal Hydraulics	3	--	--	--
NE 571	3	Advanced Nuclear Power Systems Design	4	--	--	--
NE 572	3	Advanced Nuclear Power Systems Design	--	3	--	--
NE 573	3	Advanced Nuclear Power Systems Design	--	--	4	--
RHP 580*	1-3	Field Practices in Radiation Protection	1	--	2	2
RHP 584**	3	Applied Radiation Safety	6	--	--	--
NE 585	3	Environmental Aspects of Nuclear Systems	--	5	--	--
RHP 585	3	Environmental Aspects of Nuclear Systems	--	14	--	--
RHP 586	3	Advanced Radiation Dosimetry	--	--	6	--
RHP 589	3	ST/Environmental Pathways and Risk Assessment	13	--	--	--
RHP 593	3	Non-Reactor Radiation Protection	--	--	8	--
NE 601	1-16	Research	1	--	--	--
NE 603*	1-16	Thesis (Nuclear Engineering)	4	5	4	1
NE 605	1-16	Reading and Conference	--	--	4	--
NE 607	1	Nuclear Engineering Seminar	--	1	1	--
NE 655	3	Advanced Particle Physics for Reactors	--	--	2	--
NE 667	3	Advanced Thermal Hydraulics	--	--	4	--

ST = Special Topics

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

Table III.E.1 (Continued)

Course	Credit	Course Title	Number of Students			
			Fall 1994	Winter 1995	Spring 1995	Summer 1995
Chemistry Courses						
CH 219*	2	General Chemistry Lab	61	--	--	--
CH 222*	5	General Chemistry (Science Majors)	--	427	--	--
CH 418*	3	Nuclear Chemistry	3	--	--	--
CH 462*	3	Experimental Chemistry II Laboratory	--	15	--	--
CH 503*	1-16	Thesis (Chemistry)	2	2	2	--
CH 518*	3	Advanced Nuclear Chemistry	2	--	--	--
Other Courses						
ENGR 119*	1	Hands-On Engineering	21	--	--	--
GEO 300*	3	Environmental Conservation	--	--	2	--

NOTE: This table does not include the thesis courses from other OSU departments (see Table VI.C.2).

ST = Special Topics

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

F. Instrument Repair and Calibration Facility

1. Description

The Radiation Center has a facility for the repair and calibration of essentially all types of radiation monitoring instrumentation. This includes instruments for the detection and measurement of alpha, beta, gamma and neutron radiation, and encompasses both high range instruments for measuring intense radiation fields and low range instruments used to measure environmental levels of radioactivity. The Center's instrument calibration capability is described more completely in Section VI.C.7 of this report.

2. Utilization

The Center's instrument repair and calibration facility is used regularly throughout each year and is absolutely essential to the continued operation of the many different programs carried out at the Center. In addition, the absence of any comparable facility in the state has led to a greatly expanded instrument calibration program for the Center, including calibration of essentially all radiation detection instruments used by state and federal agencies in the state of Oregon. This includes instruments used on the OSU campus, plus instruments from the Oregon Health Division's Radiation Protection Services, the Oregon Department of Energy, the Oregon Public Utilities Commission, the Oregon Health Sciences University, the Army Corps of Engineers, and the U. S. Environmental Protection Agency. Additional information regarding instrument repair and calibration efforts, is given in Tables VI.C.4, VI.C.5, and VI.C.6.

G. Libraries

1. Description

The Radiation Center has libraries containing significant collections of texts, research reports, and videotapes relating to nuclear science, nuclear engineering, and radiation protection.

The Radiation Center is also a regular recipient of a great variety of publications from commercial publishers in the nuclear field, from many of the professional nuclear societies, from the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission and other federal agencies. Therefore, Center libraries maintain a current collection of leading research and regulatory documentation in the nuclear area. In addition, the Center has a collection over 50 sets of nuclear power reactor safety analysis and environmental reports specifically prepared by utilities for their facilities.

The Center maintains an up-to-date set of reports from such organizations as the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, and the International Commission on Radiological Units. Sets of the current U.S. Code of Federal Regulations for the U.S. Nuclear Regulatory Commission, the U.S. Department of Transportation and other appropriate federal agencies, plus regulations of various state regulatory agencies are also available at the Center.

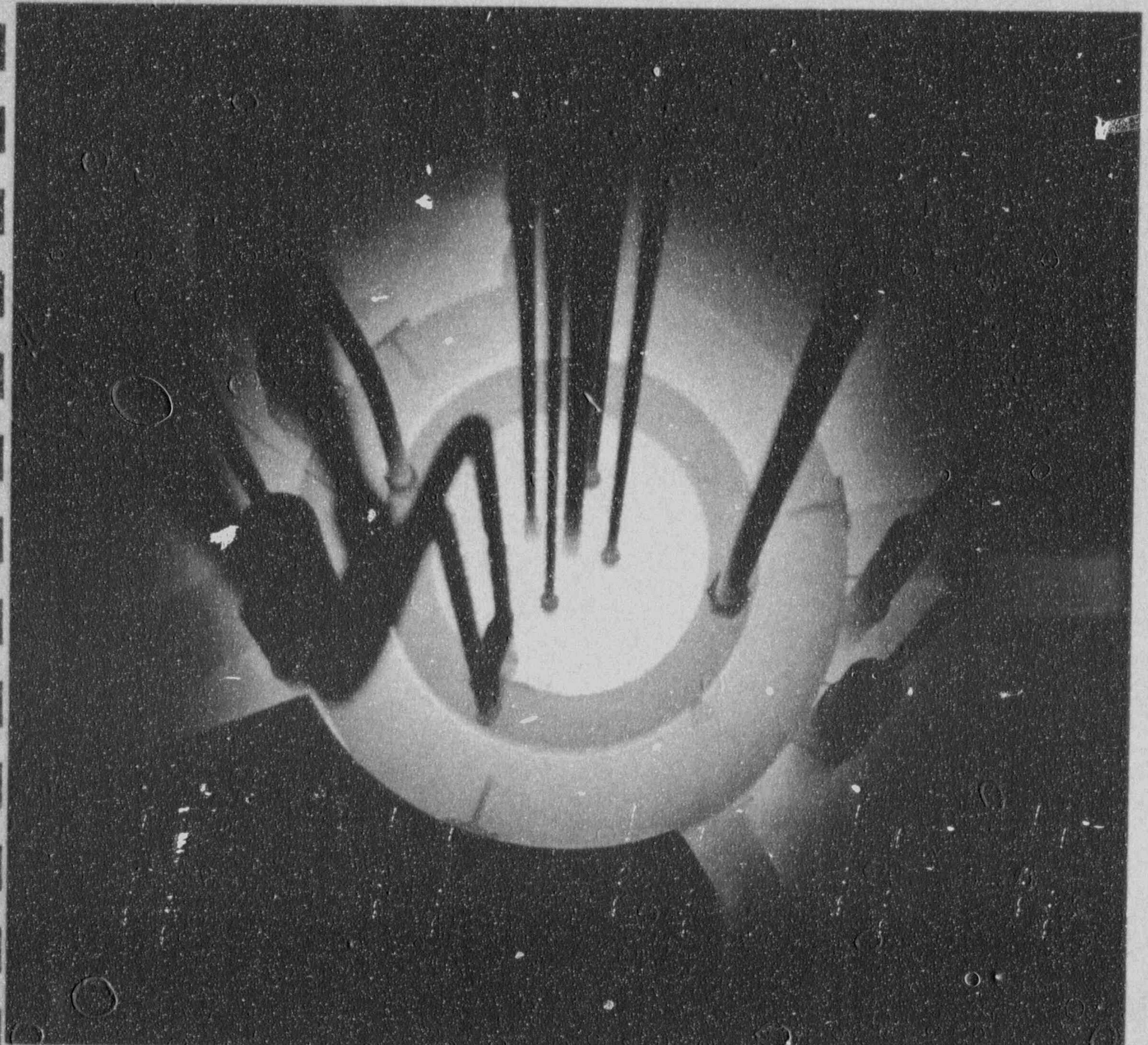
The Radiation Center videotape library has over one hundred tapes on nuclear engineering, radiation protection and radiological emergency response. In addition, the Radiation Center uses videotapes for most of the technical orientations which are required for personnel working with radiation and radioactive materials. These tapes are produced, recorded and edited by Radiation Center staff, using the Center's videotape equipment and the facilities of the OSU Communication Media Center.

2. Utilization

Radiation Center libraries are used mainly to provide reference material on an as-needed basis; however, they receive extensive use during the academic year. In addition, the orientation videotapes are used intensively during the beginning of each term, and periodically thereafter.

PART IV

REACTOR



PART IV

REACTOR

PART IV
REACTOR

A. Operating Statistics

For the current reporting period, the operating statistics for the OSTR remained steady as shown in this section. Operating data by individual category are given in Table IV.A.1 and annual energy production is plotted in Figure IV.A.1. Table IV.A.2 is included mainly for reference and summarizes the operating statistics for the original 20% enriched fuel.

The thermal energy generated in the reactor during this reporting period was 46.6 megawatt days (MWD). The cumulative thermal energy generated by the FLIP core now totals 702.7 MWD from August 1, 1976 through June 30, 1995. Reactor use time averaged approximately 87% of the normal nine-hour, five-day per week schedule. Tables IV.A.3 through IV.A.5 detail the operating statistics applicable to this reporting period.

No fuel elements were removed or added during the reporting period. The reactor core excess reactivity has increased slightly (~7¢) over this reporting period. This slight increase is due to the erbium poison being burned up at a faster rate than the fuel.

Table IV.A.1

OSTR Operating Statistics (Using the FLIP Fuel Core)

Operational Data for FLIP Core	August 1, 1976 Through June 30, 1977(1)	July 1, 1977 Through June 30, 1978	July 1, 1978 Through June 30, 1979	July 1, 1979 Through June 30, 1980	July 1, 1980 Through June 30, 1981	July 1, 1981 Through June 30, 1982	July 1, 1982 Through June 30, 1983	July 1, 1983 Through June 30, 1984
Operating Hours (critical)	875	819	458	875	1255	1192	1095	1205
Megawatt Hours	451	496	255	571	1005	999	931	943
Megawatt Days	19.0	20.6	10.6	23.8	41.9	41.6	38.8	39.3
Grams ^{235}U Used	24.0	25.9	13.4	29.8	52.5	52.4	48.6	49.3
Hours at Full Power (1 MW)	401	481	218	552	998	973	890	929
Numbers of Fuel Elements Added or Removed (-)	85	0	2	0	0	1	0	0
Number of Irradiation Requests	44	375	329	372	348	408	396	469

(1) The reactor was shutdown on July 26, 1976 for one month in order to completely refuel the reactor with a new FLIP fuel core.

Table IV.A.1 (continued)

OSTR Operating Statistics (Using the FLIP Fuel Core)

Operational Data for FLIP Core	July 1, 1984 Through June 30, 1985	July 1, 1985 Through June 30, 1986	July 1, 1986 Through June 30, 1987	July 1, 1987 Through June 30, 1988	July 1, 1988 Through June 30, 1989	July 1, 1989 Through June 30, 1990	July 1, 1990 Through June 30, 1991	July 1, 1991 Through June 30, 1992
Operating Hours (critical)	1205	1208	1172	1352	1170	1136	1094	1158
Megawatt Hours	946	1042	993	1001	1025	1013	928	1002
Megawatt Days	39.4	43.4	41.4	41.7	42.7	42.2	38.6	41.8
Grams ^{235}U Used	49.5	54.4	51.9	52.3	53.6	53.0	48.5	52.4
Hours at Full Power (1 MW)	904	1024	980	987	1021	1009	909	992
Numbers of Fuel Elements Added or Removed (-)	0	0	0(1)	-2(2)	0	-1, +1(3)	-1(4)	0(5)
Number of Irradiation Requests	407	403	387	373	290	301	286	297

(1) No fuel elements were added, but one fueled follower control rod was replaced.

(2) Two fuel elements were removed due to cladding deformation.

(3) One fuel element removed due to cladding deformation and one new fuel element added.

(4) One fuel element removed for core excess adjustment.

(5) No fuel elements were added, but the instrumented fuel element was replaced.

Table IV.A.1 (continued)

OSTR Operating Statistics (Using the FLIP Fuel Core)

Operational Data for FLIP Core	July 1, 1992 Through June 30, 1993	July 1, 1993 Through June 30, 1994	July 1, 1994 Through June 30, 1995	July 1, 1995 Through June 30, 1996	July 1, 1996 Through June 30, 1997	July 1, 1997 Through June 30, 1998	July 1, 1998 Through June 30, 1999	July 1, 1999 Through June 30, 2000
Operating Hours (critical)	1180	1248	1262					
Megawatt Hours	1026	1122	1117					
Megawatt Days	42.7	46.7	46.6					
Grams ^{235}U Used	53.6	58.6	58.4					
Hours at Full Power (1 MW)	1000	1109	1110					
Numbers of Fuel Elements Added or Removed (-)	0	0	0					
Number of Irradiation Requests	329	303	324					

Table IV.A.2

OSTR Operating Statistics with the Original (20% Enriched) Standard TRIGA Fuel Core

Operational Data for 20% Enriched Core	Mar 8, 67 Through Jun 30, 68 (1)	Jul 1, 68 Through Jun 30, 69	Jul 1, 69 Through Mar 31, 70 (2)	Apr 1, 70 Through Mar 31, 71 (3)	Apr 1, 71 Through Mar 31, 72	Apr 1, 72 Through Mar 31, 73	Apr 1, 73 Through Mar 31, 74	Apr 1, 74 Through Mar 31, 75	Apr 1, 75 Through Mar 31, 76	Apr 1, 76 Through Jul 26, 76 (4)	TOTAL: March 67 Through July 76
Operating Hours (critical)	904	810	567	855	598	954	705	563	794	353	6903
Megawatt Hours	117.2	102.5	138.1	223.8	195.1	497.8	335.9	321.5	408.0	213.0	2553.0
Megawatt Days	4.9	4.3	5.8	9.3	8.1	20.7	14.1	13.4	17.0	9.0	106.4
Grams ^{235}U Used	5.1	5.4	7.2	11.7	10.2	26.0	17.6	16.8	21.4	10.7	133.0
Hours at Full Power (250 kW)	429	369	58	---	---	---	---	---	---	---	856
Hours at Full Power (1 MW)	---	---	20	23	100	401	200	291	460	205	1700
Number of Fuel Elements Added to Core	70 (Initial)	2	13	1	1	1	2	2	2	0	94
Number of Irradiation Requests	429	433	391	528	347	550	452	396	357	217	4100
Number of Pulses	202	236	299	102	98	249	109	183	43	39	1560

(1) Reactor went critical on March 8, 1967 (70 element core; 250 kW). Note: This period length is 1.33 years as initial criticality occurred in March of 1967.

(2) Reactor shut down August 22, 1969 for one month for upgrading to 1 MW (did not upgrade cooling system). Note: This period length is only 0.75 years as there was a change in the reporting period from July-June to April-March.

(3) Reactor shut down June 1, 1971 for one month for cooling system upgrading.

(4) Reactor shut down July 26, 1976 for one month for refueling reactor with a new full FLIP fuel core. Note: This period length is 0.33 years.

Table IV.A.3

Present OSTR Operating Statistics

Operational Data for FLIP Core	Annual Values	Cumulative Values for FLIP Core
MWH of energy produced	1,117	16,866
MWD of energy produced	46.6	702.7
Grams ^{235}U used	58.4	882.2
Number of fuel elements added to (+) or removed from (-) the core	0	82 + 3 FFCR(1)
Number of pulses	40	1,241
Hours reactor critical	1,262	21,224
Hours at full power (1 MW)	1,110	16,487
Number of startup and shutdown checks	256	4,790
Number of irradiation requests processed(2)	324	6,840
Number of samples irradiated	4,148	79,269

(1) Fuel Follower Control Rod. These numbers represent the core loading at the end of this reporting period.

(2) Each irradiation request could authorize from 1 to 120 samples. The number of samples per irradiation request averaged 12.8 during the current reporting period.

Table IV.A.4

OSTR Use Time in Terms of Specific Use Categories

OSTR Use Category	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
Teaching (departmental and others)(1)	523	6,016
OSU research(2)	172	7,448
Off-campus research(2)	1,366	8,403
Forensic services	33	209(3)
Reactor preclude time	796	13,682
Facility time(4)	255	6,495
Visitor demonstration(5)	8	287
Total reactor use time	3,153	42,540

(1) See Tables III.A.2 and III.E.1 for teaching statistics.

(2) See Table III.A.3 for research statistics.

(3) Prior to the 1981-1982 reporting period, forensic services were grouped under another use category and the cumulative hours have been compiled beginning with the 1981-1982 report.

(4) The time OSTR spent operating to meet NRC facility license requirements.

(5) This is the time that the reactor was used specifically for visitor open-house (demonstration) events. The remainder of the visitors viewed the reactor during times when the reactor was being operated for regularly scheduled research and teaching.

Table IV.A.5

OSTR Multiple Use Time(1)

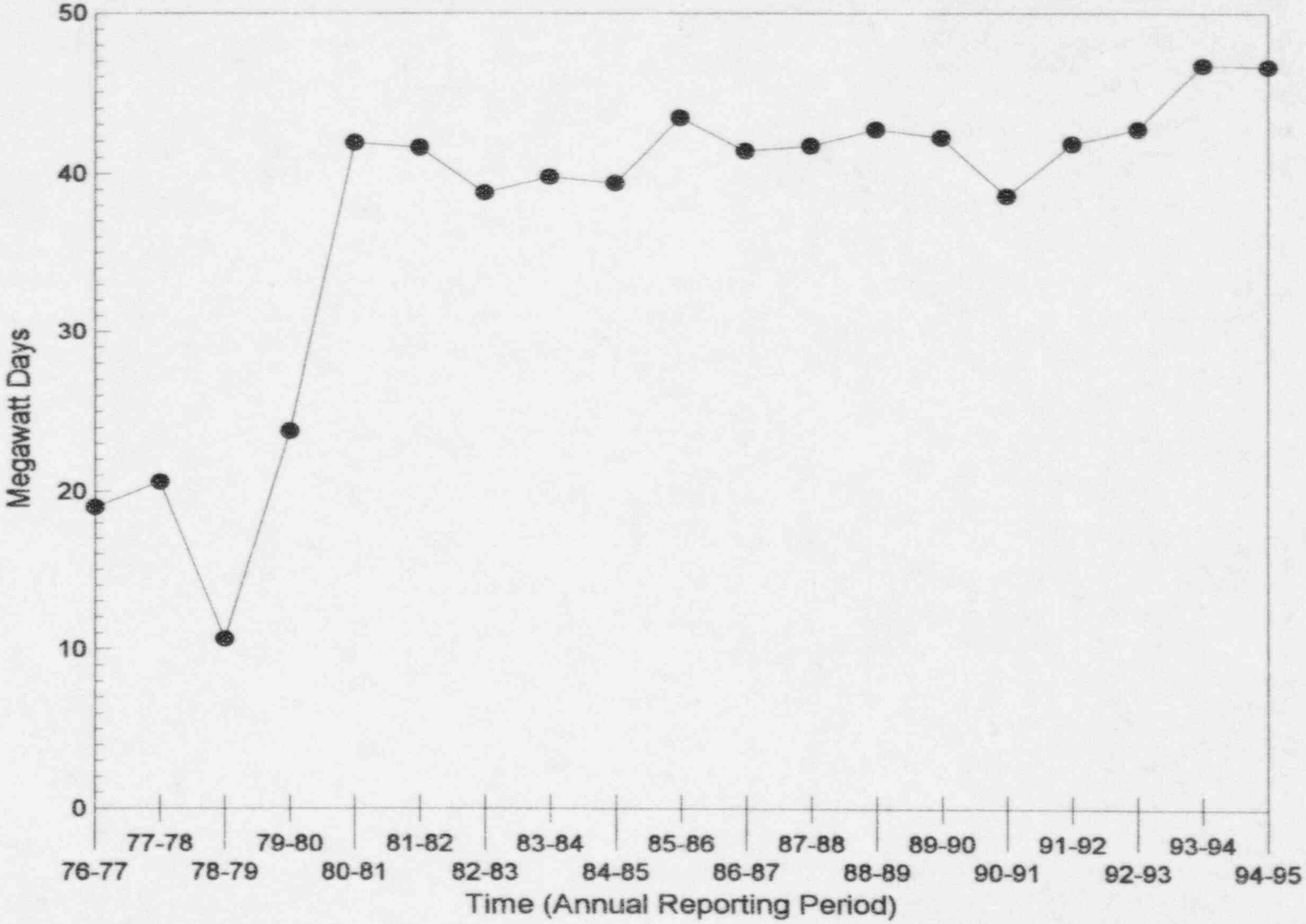
Number of Users	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
Two	345	2,464
Three	74	761
Four	54	284
Five	6	61
Six	1	32.5
Seven	0	10
Total multiple use time	480(2)	3,602.5(3)

(1) Multiple use time is that time when two or more irradiation requests are being concurrently fulfilled by operation of the reactor.

(2) This represents 38% of the total hours the reactor was critical during this reporting period.

(3) This represents 17% of the total hours the reactor was critical since startup with FLIP fuel in August of 1976.

Figure IV.A.1 OSTR Annual Energy Production Vs. Time (Annual Reporting Period)



B. Experiments Performed

1. Approved Experiments

During the current reporting period there were eight approved reactor experiments available for use in reactor-related programs. The following list of reactor experiments identifies the eight approved experiments. Missing numbers signify reactor experiments which are in the inactive file and are not currently being used. These are listed in the next section.

A-1	Normal TRIGA Operation (No Sample Irradiation).
B-3	Irradiation of Materials in the Standard OSTR Irradiation Facilities.
B-11	Irradiation of Materials Involving Specific Quantities of Uranium and Thorium in the Standard OSTR Irradiation Facilities.
B-12	Exploratory Experiments.
B-23	Studies Using TRIGA Thermal Column.
B-29	Reactivity Worth of Fuel.
B-30	NAA of Jet, Diesel, and Furnace Fuels.
B-31	TRIGA Flux Mapping.

Of the approved experiments on the active list, four were used during the reporting period. A tabulation of information relating to reactor experiment use is given in Table IV.B.1, and includes a listing of the experiments which were used, how often each was used, and the general purpose of the use.

Table IV.B.1

Use of OSTR Reactor Experiments[(1)]

Reactor Experiment Number[(2)]	Research	Teaching	Forensic	Facility Time[(3)]	TOTAL
A-1	3	46	0	63	112
B-3	160	25	19	N/A	204
B-11	6	0	0	N/A	6
B-12	2	0	0	N/A	2
TOTAL	171	71	19	63	324

(1) This table displays the number of times reactor experiments were used for a particular purpose.

(2) The following tabulation gives the number of each reactor experiment used and its corresponding title:

A-1	Normal TRIGA Operation
B-3	Irradiation of Materials in the Standard OSTR Irradiation Facilities
B-11	Irradiation of Materials Involving Specific Quantities of Uranium and Thorium in the Standard OSTR Irradiation Facilities
B-12	Exploratory Experiments

(3) The time OSTR spent operating to meet NRC facility license requirements.

2. Inactive Experiments

Presently, 29 experiments are in the inactive file. This consists of experiments which have been performed in the past and may be reactivated. Many of these experiments are now performed under the more general experiments listed in the previous section. The following list identifies these 29 inactive experiments.

A-2	Measurement of Reactor Power Level via Mn Activation.
A-3	Measurement of Cd Ratios for Mn, In, and Au in Rotating Rack.
A-4	Neutron Flux Measurements in TRIGA.
A-5	Copper Wire Irradiation.
A-6	In-core Irradiation of LiF Crystals.
A-7	Investigation of TRIGA's Reactor Bath Water Temperature Coefficient and High Power Level Power Fluctuation.
B-1	Activation Analysis of Stone Meteorites, Other Meteorites, and Terrestrial Rocks.
B-2	Measurements of Cd Ratios of Mn, In, and Au in Thermal Column.
B-4	Flux Mapping.
B-5	In-core Irradiation of Foils for Neutron Spectral Measurements.
B-6	Measurements of Neutron Spectra in External Irradiation Facilities.
B-7	Measurements of Gamma Doses in External Irradiation Facilities.
B-8	Isotope Production.
B-9	Neutron Radiography.
B-10	Neutron Diffraction.
B-13	This experiment number was changed to A-7.
B-14	Detection of Chemically Bound Neutrons.
B-15	This experiment number was changed to C-1.
B-16	Production and Preparation of ^{18}F.

B-17	Fission Fragment Gamma Ray Angular Correlations.
B-18	A Study of Delayed Status (n, γ) Produced Nuclei.
B-19	Instrument Timing via Light Triggering.
B-20	Sinusoidal Pile Oscillator.
B-21	Beam Port #3 Neutron Radiography Facility.
B-22	Water Flow Measurements Through TRIGA Core.
B-24	General Neutron Radiography.
B-25	Neutron Flux Monitors.
B-26	Fast Neutron Spectrum Generator.
B-27	Neutron Flux Determination Adjacent to the OSTR Core.
B-28	Gamma Scan of Sodium (TED) Capsule.
C-1	PuO_2 Transient Experiment.

C. Unplanned Shutdowns

There were ten unplanned reactor scrams during the current reporting period. A scram occurs when the rods drop in as a result of an automatic trip or as a result of the operator pushing the manual trip button. Table IV.C.1 contains a summary of the unplanned scrams including a brief description of the cause of each.

Table IV.C.1

Unplanned Reactor Shutdowns and Scrams

Type of Event	Number of Occurrences	Cause of Event
Safety Channel Power Scram	2	Failure of the low voltage power supply in the safety channel system. The power supply was repaired. (This did not involve an actual over power situation.)
Manual Scram	1	Linear channel behaving abnormally. The operator observed an overly conservative indication of full power by the linear channel. A 14V DC zener diode was replaced to correct the problem.
Safety Channel Power Scram	1	Operator was in the process of shutting the reactor down. Instead of pushing the "down" button for the control rod, he inadvertantly pushed the "up" button. The safety channel scrammed the reactor at its trip point of 1.06 MW.
Manual Scram	1	Commercial power failure. Commercial power was restored in about eight minutes and reactor operation was resumed.
Safety Channel Power Scram	1	The scram set point on the safety channel (106%) was reached while balancing rods at 1MW with a cadmium experimental facility located in-core. The flux perturbation caused by the in-core experiment resulted in lower readings on the linear and % power channels relative to the reading on the safety channel.
Manual Scram	1	Failure of the safety rod magnet down switch. The operator received an erroneous rod "down" light while operating at full power. The switch was replaced. (Full mechanical operability of the control rod was never lost.)
Manual Scram	1	Stack monitor filter failure alarm. The expired filter was replaced and reactor operation was resumed.
Manual Scram	2	Regulating rod upper limit switch malfunction. The regulating rod "up" button light failed to extinguish after lowering the rod from its full out position. The switch was repaired.

D. Changes to the OSTR Facility, to Reactor Procedures, and to Reactor Experiments Performed Pursuant to 10 CFR 50.59

The information contained in this section of the report provides a summary of the changes performed during the reporting period under the provisions of 10 CFR 50.59. For each item listed, we have included a brief description of the action taken and a summary of the applicable safety evaluation. **Although it may not be specifically stated in each of the following safety evaluations, all actions taken under 10 CFR 50.59 were implemented only after it was established by the OSTR Reactor Operations Committee (ROC) that the proposed activity did not require a change in the facility's Technical Specifications and did not introduce or create an unreviewed safety question as defined in 10 CFR 50.59(a)(2).**

1. 10 CFR 50.59 Changes to the Reactor Facility

There were four changes to the reactor facility during the reporting period.

a. UPGRADE OF THE PERCENT POWER CHANNEL, PULSING CHANNEL AND THE FUEL ELEMENT TEMPERATURE TEST CIRCUIT

(1) Description

The U. S. Department of Energy University Research Reactor Instrumentation Grant program for 1993 provided the funds to perform an upgrade of certain electronics in the OSTR console. In particular, the existing percent power channel, the pulsing channel (nv circuit) and the fuel element (FE) temperature test circuits were upgraded.

Percent Power and Pulsing Channels

The percent power channel and the pulsing channel (nv circuit) were replaced by a power range monitor (PRM), which is a modern equivalent of the two channels it replaces. The new PRM equipment was manufactured by Gamma-Metrics.

High Voltage Power Supply

The high voltage power supply for the uncompensated ion chamber (UIC) was replaced by a modern equivalent power supply in the new PRM.

Computer Data Acquisition System (CDAS)

The computer data acquisition system (CDAS) was modified to bypass the existing amplifier and use the 10 volt full scale output available from the power range monitor.

Fuel Element Temperature Test Circuit

The fuel element temperature test circuit was modified to eliminate the use of a D-cell battery and a voltage divider to provide a test input signal to the digital thermometer. In lieu of the existing circuit, a more reliable 6.8 VDC regulated voltage from the bulk temperature thermometer was used to provide a step ramp input for the fuel element temperature thermometer.

(2) Safety Evaluation

A safety evaluation of the upgrade of the console electronics consisted of a detailed review which determined that the changes did not constitute an unreviewed safety question or require changes in the OSTR Technical Specifications.

Percent Power and Pulsing Channels

The changes to the percent power and pulsing channels contribute to increased reliability and service life of the system by replacing old components with new ones. These changes enhance the ability of the systems to perform their intended safety functions and decrease the probability of equipment malfunction. Should failure occur in any component in the new PRM, the result is the prevention of reactor operation or a scram if the reactor is already operating. In addition, the margin of safety is actually increased with the modification because under the old design, reactor power was not monitored for the time between when the reactor is switched from steady state operation to pulse operation and the reactivity insertion is made. In the new configuration, the percent power channel is active during this interval because it is no longer switched out of the circuit. Another advantage the new PRM brings is the ability to test the pulsing channel as a part of the normal startup checks. This is a further enhancement to the margin of safety. Thus, the changes to the percent power and pulsing channels do not constitute an unreviewed safety question.

High Voltage Power Supply

The change to the high voltage power supply for the percent power channel contributed to increased reliability and service life for the components of the system thus decreasing the probability of equipment failure. The new system enhances the safety function of the high voltage power supply system through the introduction of a limit on the loading of the high voltage monitor signal to 60% of the unloaded signal compared to the previous 0%. This ensures compliance with the Technical Specification requirement for a high voltage scram at 25% of the nominal operating voltage. The change gives an increased margin of safety and does not introduce an unreviewed safety question.

Computer Data Acquisition System (CDAS)

The computer data acquisition system serves no safety function. It simply monitors the indicated reactor power signal. The minor modification of bypassing the existing CDAS amplifier does not prohibit the control systems of the console from performing their intended safety functions. OSTROP 6 requires a safety evaluation of the procedural changes to OSTROP 26, entitled " Procedures for the Use of External Monitoring and Recording Devices." Bypassing the amplifier required that changes be made to this procedure but the procedural changes did not cause an increase in the possibility for the CDAS to interfere with the control functions within the console. Hence, these changes do not introduce an unreviewed safety question.

Fuel Element Temperature Test Circuit

The change to the fuel element temperature test circuit made the test circuit less likely to fail and easier to operate. Even if the new circuit should fail, the fuel element temperature monitoring system will not be prohibited from monitoring the proper reactor fuel temperature and it will thus continue performing its safety function. The change did not introduce an unreviewed safety question.

b. REPLACEMENT OF THE SELECTOR SWITCH FOR THE FUEL ELEMENT TEMPERATURE SAFETY CHANNEL

(1) Description

The purpose of the fuel element temperature safety channel is to monitor the temperature of the fuel and if it exceeds 510°C then initiate a reactor scram. Should this ever occur, the Technical Specifications require that an evaluation be conducted to determine whether the fuel element temperature safety limit of 1150°C for FLIP fuel or 1000°C for standard TRIGA fuel was exceeded.

A review of the current system revealed that a different switch design would allow the fuel element temperature safety channel to perform the above function under a wider range of possible conditions. With the new switch, if any channel other than one of those connected to an operating thermocouple (1, 2 or 3) is selected, then the rod withdrawal prohibit is actuated thus preventing reactor operation. In the future should any one of the three thermocouples fail, a jumper in the new switch could be removed to ensure that the rod withdrawal prohibit is activated if that channel is selected. The new switch circuit also ensures a clear separation of the 115 VAC scram bus from the thermocouple circuit.

(2) Safety Evaluation

The new switch does not change the connection between the thermocouple and the scram system, so the fuel element temperature safety channel will continue to perform its intended function. The installation of the new switch improves the overall safety of the reactor by ensuring that the fuel temperature scram is operable whenever the reactor is not secured.

c. INSTALLATION OF A 10 MΩ RESISTOR IN THE PULSE MONITORING CIRCUIT OF THE POWER RANGE MONITOR

(1) Description

After installation of the new power range monitor system, the peak power display indicated a value of approximately 1.3% when the channel was in the low gain mode. When the mode switch was placed in the PULSE LOW position, the channel was put in the high gain mode and the display read zero. The source of this noise signal was the 115 VAC percent power and non-operation scram circuits.

Consultation with GAMMA-METRICS, the manufacturer of the power range monitor, revealed that the channel uses the dual bistable trip unit to switch the pulsing amplifier from a voltage follower (Gain = 1) in the PULSE HIGH mode to a non-inverting amplifier with a gain of four in the PULSE LOW mode. The result is an open line from the amplifier to the bistable on the backplane of the module. The open line acts as an antenna picking up noise from the 115 VAC percent power and non-operation scram circuits.

GAMMA-METRICS agreed that a solution was to install a 10 MΩ resistor in the circuit to bleed off the noise pickup. The modification should have resulted in a 0.1% change in the pulse power and energy readings.

(2) Safety Evaluation

The installation of the 10 MΩ resistor did not effect the operability of the pulse monitoring channels except that a system measurement error which was introduced by the noise signal should have been eliminated. Since the channel served only a monitoring function, failure of the resistor would not result in an increased safety concern.

d. MODIFICATION OF THE PULSE MONITORING CIRCUIT OF THE POWER RANGE MONITOR

(1) Description

The installation of the 10MΩ resistor in the pulse monitoring circuit of the power range monitor, which was approved by the Reactor Operations Committee, failed to remove the approximately 1.3% baseline reading on the peak power display when the channel was in the low gain mode. Subsequent investigation revealed that the actual source of the erroneous reading was noise pickup from the 115 VAC percent power scram loop which is on one side of the dual bistable card and the energized reed relay of the dual bistable circuit on the other side of the card.

To correct the problem, an existing 3.32 KΩ resistor was moved to the amplifier side of the relay and the bistable logic was reversed so that the relay is energized in the PULSE LOW mode but is tied to common so that noise is not developed. In PULSE HIGH mode, the relay is de-energized so the open line is not subjected to noise buildup.

To achieve the change in the bistable logic the following changes were made. The #2 bistable was changed to trip on a positive decreasing input. To ensure the X4 gain LED on the front panel is ON when the relay is energized, the circuit trace from R35 to CR3 was cut and a jumper installed from R35 to JP6 pin 3.

Before declaring the system operational again, checks of the power range monitor were performed to assure normal operation of all channels.

(2) Safety Evaluation

The modification did not effect the operability of the pulse monitoring channels except that a system measurement error introduced by the noise signal was eliminated. Since the channel serves only a monitoring function, possible failure of the redesigned circuit would not result in an increased safety concern.

2. 10 CFR 50.59 Changes to Reactor Procedures

There were four changes to reactor procedures which were reviewed, approved and performed under the provisions of 10 CFR 50.59 during the reporting period.

a. REVISIONS TO THE REACTOR OPERATIONS COMMITTEE CHARTER

(1) Description

On an annual basis, a standing Reactor Operations Committee (ROC) subcommittee reviews the Committee's charter. The 1994 review indicated that several changes were needed to keep the charter current. These changes only clarified activities already specified in the current charter. None of the changes involved major changes in ROC operating policies.

The changes to the ROC charter included several very minor editorial clarifications which were of no significance from a safety standpoint. All of the changes are listed in the safety evaluation. Additions are shown in italics, deletions are lined through.

(2) Safety Evaluation

The last sentence of Section II.5 of page 2 was changed to read: "Any such actions taken by an ROC subcommittee will be reviewed by the full ROC at the next regular*ly scheduled* meeting."

Section III.1.d, page 3 was changed to read: "An audit of operating procedures (OSTROPs). *The ROC reviews each OSTROP annually on a rotating basis, i.e., a certain fraction of the OSTROPs are reviewed each quarter."*

The second item d of Section III.1, page 3 was changed to read: "Radiation surveys (including routine surveys such as daily, weekly and monthly; special surveys; *radioactive material* receipt surveys; and environmental monitoring surveys)."

Section III.1.f of page 3 was changed to read: "The Radiation Center Health Physics Procedure *(RCHPPs)*. The ROC reviews the RCHPPs annually on a rotating basis, i.e., a certain fraction of the RCHPPs are reviewed each quarter. However, during the interim period, the Senior Health Physicist has the authority to review and revise RCHPPs as necessary without ROC approval."

Section III.1, page 3 was changed to allow for unique identification of specific sentences or paragraphs within this section. Hence the second group of letters from a through d were changed to f through I and the third group of letters from a through g were changed to j through p.

In Section III.2.a of page 4, the word "regularly" was inserted between next and scheduled.

Based on the nature and scope of the changes described above, it is evident that the changes were editorial. In cases where the changes added or deleted statements, the changes arose from the need to ensure that the current version of the charter is consistent with and responsive to the requirements of the OSTR license and technical specifications, and reflects the operating policies of the ROC. None of these changes have a negative safety impact and they should be beneficial to safety since they eliminate confusion or misunderstandings.

b. REVISIONS TO THE RADIATION CENTER AND OSTR EMERGENCY RESPONSE PLAN

(1) Description

As a result of the annual review of the Radiation Center and OSTR Emergency Response Plan a number of changes were made to the plan. The implementation of the new radiation protection regulations (10 CFR 20) necessitated the revision of the references to this document and the completion of the APEX facility added the need to address the new emergency conditions this facility imposes on the Radiation Center.

(2) Safety Evaluation

The implementation of the new 10 CFR 20 changed the paragraph numbers which identify the requirements for reporting of emergencies. These changes in no way decreased the effectiveness of the plan.

The completion of the APEX facility added another area at the Radiation Center which could require response in the event of an emergency. The changes made to the plan in recognition of this possibility did not decrease the effectiveness of the plan.

The other changes reflected the changing nature of the use in some areas of the Radiation Center, to accommodate changes in staff and to correct grammatical errors. All of these changes increased the plan's effectiveness by making it more accurate and easier to read. Special note is made that with the promotion of the reactor operator to the position of Reactor Supervisor, the OSU Campus Radiation Safety Officer replaced the reactor operator position in the line of succession to the Senior Health Physicist (page 3-8, section 3.3.2). Since the RSO is knowledgeable in radiation protection issues, participates in all appropriate Radiation Center training programs and is a very familiar with the facility, this change did not decrease the effectiveness of the plan.

The technical specifications require that a continuous air monitor which monitors for particulate radioactivity be operable in the reactor facility during operation. The particular instrument used to satisfy this requirement has the capability to monitor for both gaseous and particulate radioactivity. However, the backup instrument does not have gaseous monitoring capability. Thus the statement in the plan which is specific to the primary instrument was changed to require only particulate monitoring capability. Due to the added redundancy in monitoring capability, this change increased the effectiveness of the plan.

The changes described above were reviewed and approved by the Reactor Operations Committee (ROC) prior to being implemented. ROC approval included a review of this evaluation and the Committee's conclusion that the changes did not require a change in the OSTR Technical Specifications and did not constitute an unreviewed safety question as defined in 10 CFR 50.59(a)(2). This evaluation also included a review of applicable radiation protection aspects and was found to be consistent with the Radiation Center's commitment to ALARA.

c. MINOR CHANGES TO OSTROP 18.0, PROCEDURES FOR THE APPROVAL AND USE OF REACTOR EXPERIMENTS

(1) Description

During a review of OSTROP 18.0, Procedures for the Approval and Use of Reactor Experiments, a number of minor items were identified as needing either updating or revising. The items are listed below.

In Section 18.1.e, page 18.1, the first line was changed to read "To become an approved Program Director, individuals must apply to the Radiation Safety Committee." The second sentence referring to obtaining the blank forms was deleted.

In Section 18.1.f, page 18.2, the first sentence was changed to finish with the wording "... must apply to the Radiation Safety Committee." The second sentence referring to obtaining blank forms was deleted. The last sentence was revised to read "The completed amendment request MUST be sent to the Senior Health Physicist ...". And the following sentence is added to the end of the paragraph: "The Senior Health Physicist will retain copies of all amendment applications."

In Section 18.7.f, page 18.8a, a fourth category was added to the list of situations where a Radiation Safety Office approval number is not required. Hence change the wording of the NOTE to end with "... an approval number; 3) experimenters not part of OSU and not working under an OSU Radioisotope Use Authorization; and 4) reactor operation under experiment A1."

In Section 18.7.g, page 18.8a, the first sentence was changed to begin with the words "The licensed experimenter or in the absence of the licensed experimenter, the Radiation Center Senior Health Physicist, ..."

The page numbers of OSTROP 18.0 were revised to be sequential and this eliminated page 18.8a.

The irradiation request forms were replaced with copies of the current versions.

(2) Safety Evaluation

The deletion of the Radiation Safety Committee (RSC) Forms 102 and 105 do not diminish the ability of the Radiation Safety Office to collect the necessary information to perform an adequate safety analysis.

Experiment A1 by definition means that the reactor is simply being operated and that no samples are being irradiated in any reactor facility. Since there is no production of radioisotopes for the purpose of use or storage on the OSU Broadscope License, then there is no need to have an approval number for every operation under Experiment A1. Hence, eliminating the need for an approval number under this condition has no safety implications.

The requirement that only the licensed experimenter can sign for an irradiation request is overly restrictive. Before signing for an absent experimenter, the Radiation Center Senior Health Physicist must ensure that each request is made with the full knowledge and understanding of the licensed experimenter and that the request is covered by the applicable OSU authorization. The Senior Health Physicist still has veto authority over all requests for irradiation services and hence the ability to perform an appropriate safety review is unaffected by the proposed change to the procedure.

d. MINOR CHANGES TO OSTROP 6.0, ADMINISTRATIVE AND PERSONNEL PROCEDURES AND OSTROP 12.0, CONTROL ROD MAINTENANCE, REMOVAL AND REPLACEMENT PROCEDURES

(1) Description

During a review of OSTROP 6.0, Administrative and Personnel Procedures and OSTROP 12.0, Control Rod Maintenance, Removal and Replacement Procedures a number of minor items were identified as needing either updating or revising. The items are listed below.

OSTROP 6.0

The following approval pages were updated to include the new members of the committee.

ROC 50.59 review, page IV.6.31
ROC ROCAS review, page IV.6.34
Information Bulletin, page IV.6.35

The approval paragraphs were changed to read as follows:

"**APPROVALS**

The changes described above were reviewed and approved by the Reactor Operations Committee (ROC) prior to being implemented. ROC approval included a review of this evaluation and the Committee's conclusion that the change does not require a change in the OSTR Technical Specifications and does not constitute an unreviewed safety question as defined in 10 CFR 50.59(a)(2). This evaluation also included a review of applicable radiation protection aspects and was found to be consistent with the Radiation Center's commitment to ALARA.

The following signatures indicate review and approval by the Reactor Operations Committee and review by licensed operators. If any ROC member does not completely concur with or understand the proposed change then that member should hold this form unsigned and notify the ROC Chairman. The matter will then be discussed at the next meeting of the Committee. If any individual ROC member is unable to sign the sheet due to absence or illness this will be so noted."

OSTROP 12.0

In the General Information section, the first sentence was changed to read "The control rods and their drives are described in Vol. #1 of the Training Manual."

(2) Safety Evaluation

There is no safety implication from the change in the membership of the committee. The change to the approval form ensures proper review of safety issues and that all members of the committee are given a chance to review any proposed changes.

The rephrasing of the approval paragraph more clearly defines the authority of the ROC to make the change and emphasizes the Committee's commitment to the ALARA philosophy. There is no safety implication from this change.

The change to identify Volume #1 of the Training Manual more clearly identifies the document which describes the control rod drive system. There is no safety implication from this change.

3. 10 CFR 50.59 Changes to Reactor Experiments

There were no changes to reactor experiments during this reporting period.

E. Surveillance and Maintenance

1. Non-Routine Maintenance

Aug. 3, 1994	Repaired the safety percent power channel low voltage power supply.
Aug. 4, 1994	Repaired a broken turret solder joint on the console range switch.
Aug. 12, 1994	Replaced the northeast reactor tank underwater light.
Aug. 26, 1994	Replaced a 14V DC zener diode in the reactor linear channel.
Sept. 6, 1994	Replaced the safety rod scram switch with a new spare.
Sept. 16, 1994	Replaced the analog meter in the gas channel of the reactor top continuous air monitor.
Nov. 14, 1994	Repaired the reactor console power recorder with a new linear power slidewire potentiometer, two brass chart drive gears, and a new drive belt for the platen.
Dec. 7, 1994	Performed a recalibration of the stack monitor flow rate after installation of new seals on the unit.
Dec. 13, 1994	Installed all new physical security motion detectors.
Dec. 30, 1994 to Jan. 3, 1995	Performed a console upgrade that replaced the % power channel and the pulsing channel with a GAMMA-METRICS pulsing/power range monitor. In addition, the fuel element temperature test circuit was modified.
Feb. 1, 1995	Replaced the safety rod's magnet down switch.
Feb. 28, 1995	Installed two new batteries in the emergency power system.
Mar. 8, 1995	Performed modification of the pulse monitoring circuit of the power range monitor.
Mar. 9, 1995	Replaced the selector switch for the fuel element temperature safety channel.
Mar. 10, 1995	Completed removal of sludge buildup in the holdup tank.
Apr. 6, 1995	Inspected and performed maintenance on the chemical injection pump in the reactor secondary cooling system.

Apr. 10, 1995	Repaired the upper limit switch of the regulating rod.
Apr. 18, 1995	Repaired the pre-heat coil in the reactor building ventilation system.
May 4, 1995	Replaced the diaphragms of both the pre-heat and the re-heat steam valves in the reactor building ventilation system.
May 19, 1995	Readjusted the bistable trip point on the power range monitor that initiates both peak power and pulse energy measurements in pulse mode.
June 21, 1995	Replaced the building public address (PA) amplifier.
June 28, 1995	Changed the belt on the D100 hood fan.

2. Routine Surveillance and Maintenance

The OSTR has an extensive routine surveillance and maintenance (S&M) program. Examples of typical S&M checklists are presented in Figures IV.E.1 through IV.E.4. Items marked with an asterisk (*) are required by the OSTR Technical Specifications.

F. Reportable Occurrences

There were no reportable occurrences during the reporting period.

Figure IV.E.1

Monthly Surveillance and Maintenance (Sample Form)

OSTROP 13

SURVEILLANCE & MAINTENANCE FOR THE MONTH OF ______

SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
* 1 FUNCTIONAL CHECK OF REACTOR WATER LEVEL ALARMS AND GREEN LIGHT ALARM	MAXIMUM MOVEMENT ± 3 INCHES	UP: ______ inches DN: ______ inches ANN: ______ GREEN LIGHT: ______				
2 MEASUREMENT OF THE REACTOR PRIMARY WATER pH	MIN: 5 MAX: 8.5					
3 MEASUREMENT OF THE BULK SHIELD TANK WATER pH	MIN: 5 MAX: 8.5					
4 EMERGENCY POWER SYSTEM BATTERY CHECKS	LIQUID: -1" DN					
INVERTER	S.G.: >1.250					
	FUNCTIONAL CHECK					
GENERATOR	S.G.: >1.250					
	VOLTS ≥ 12.6V DC					
5 EVACUATION HORN & P.A. EMERGENCY SYSTEM BATTERY CHECKS	LIQUID: FULL					
	S.G.: >1.250					
	VOLTS ≥ 12.6V DC					
	CORR: NONE					
6 INSPECTION OF THE BRUSHES ON THE PNEUMATIC TRANSFER SYSTEM BLOWER MOTOR	CHANGE WHEN 1/4" LEFT					
7 GREEN LIGHT BULB REPLACEMENT	75 WATT					
8 CHANGE LAZY SUSAN FILTER	FILTER CHANGED					
9 LUBRICATE THE TRIGA TUBE LOADING TOOL (REEL)	USE GUN OIL	NEED OIL? ____				
10 REACTOR TOP CAM OIL LEVEL CHECK	OSTROP 13.10	NEED OIL? ____				
11 PROPANE TANK LIQUID LEVEL CHECK (% FULL)	>50%					
*12 BULK WATER TEMPERATURE ALARM CHECK	FUNCTIONAL					
13 PRIMARY PUMP BEARINGS OIL LEVEL CHECK	OSTROP 13.13	NEED OIL? ____				

* License Requirement.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date completed last month plus six weeks.

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Figure IV.E.2

Quarterly Surveillance and Maintenance (Sample Form)

OSTROP 14 SURVEILLANCE & MAINTENANCE FOR THE QUARTER OF ______/______/______

SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
* 1 REACTOR OPERATION COMMITTEE (ROC) AUDIT OF REACTOR OPERATIONS FOR ____/____/____ QUARTER	QUARTERLY					
* 2 QUARTERLY ROC MEETING	QUARTERLY					
‡ 3 FUEL ELEMENT RADIATION LEVEL MEASUREMENTS IN WATER	≥23 R/hr @ 2' IN WATER					
4 INSPECTION OF THE SOLENOID VALVES IN THE PNEUMATIC TRANSFER SYSTEM	FUNCTIONAL					
5 PNEUMATIC TRANSFER SYSTEM INSERTION TIME CHECK	≤6 SECONDS					
6 ROTATING RACK CHECK FOR UNKNOWN SAMPLES	RACK SHOULD BE EMPTY					
7 FUNCTIONAL CHECK OF EMERGENCY LIGHTS (SEE CHECKSHEET)	FUNCTIONAL					
8 WATER MONITOR ALARM CHECK	FUNCTIONAL					
9 STACK MONITOR CHECKS (OIL DRIVE MOTORS, H.V. READINGS)	MOTORS OILED					
	PART: 1150 V ±50	VOLTS				
	GAS: 900 V ±50	VOLTS				
10						
11 ARM SYSTEM ALARM CHECKS	FUNCTIONAL					
12 OPERATOR LOG	a) ≥4 hours: at console (RO) or as Rx. Sup. (SRO) b) Complete Operating Exercise	a) TIME	b) OPERATING EXERCISE			

11 ARM SYSTEM ALARM CHECKS

CHAN	1	2	3	4	5	6	7	8	9	10	11	12
A/D												
LIGHT												
PANEL												
ANN												

12 OPERATOR LOG

NAME	a) TIME	b) OPERATING EXERCISE			

* License Requirement ‡ Physical Security Plan Requirement

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date completed last quarter plus four months.

Figure IV.E.2 (Continued)

Quarterly Surveillance and Maintenance (Sample Form)

OSTROP 14 (CONTINUED)

SURVEILLANCE & MAINTENANCE FOR THE <u>QUARTER</u> OF ________/________/________ 19____

SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
13 CHECK FILTER TAPE SPEED ON STACK MONITOR	1"/HR ± 0.2					
14 INCORPORATE 50.59 & ROCAS INTO DOCUMENTATION	QUARTERLY					
15						
16 FUNCTIONAL CHECK OF EVACUATION ALARMS	ALL FUNCTIONAL					
*17 SUBMISSION OF SAFEGUARDS LOG BY P.S.O. FOR ____/____/____ QUARTER	SUBMIT IF NEW ENTRIES					
18 STACK MONITOR ALARM CIRCUIT CHECKS	ALARM ON CONTACT					
19 ALARM TESTING OF VITAL AREA DOUBLE DOORS	FUNCTIONAL					

* License Requirement.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date completed last quarter plus four months.

Figure IV.E.3

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15 **SEMI-ANNUAL SURVEILLANCE AND MAINTENANCE FOR** ____________________

SURVEILLANCE & MAINTENANCE TO BE PERFORMED							LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
*1	FUNCTIONAL CHECKS OF REACTOR INTERLOCKS	a) NEUTRON SOURCE COUNT RATE INTERLOCK					NO WITHDRAW	a1				
							≥5 cps	a2				
		b) TRANSIENT ROD AIR INTERLOCK					NO PULSE	b				
		c) PULSE PROHIBIT ABOVE 1 kW					≥1 kW	c				
		d) TWO ROD WITHDRAWAL PROHIBIT					1 only	d				
		e) PULSE MODE ROD MOVEMENT INTERLOCK					NO MOVEMENT	e				
		f) MAXIMUM PULSE REACTIVITY INSERTION LIMIT					≤ $2.50	f				
		g) PULSE INTERLOCK ON RANGE SWITCH					NO PULSE	g				
*2	SAFETY CIRCUIT TEST	PERIOD SCRAM					≥3 sec					
*3	CONTROL ROD WITHDRAWAL, INSERTION & SCRAM TIMES		TRANS	SAFE	SHIM	REG						
		a) SCRAM					≤2 sec	a				
		b) WITHDRAWAL					≤50 sec	b				
		c) INSERTION					≤50 sec	c				
*4	PULSE COMPARISON (PREVIOUS PULSE):	PULSE # ________ $ ____________ ____________ MW ____________ °C					≤20% CHANGE	PULSE # ____ $ ________ ________ MW ________ °C				
*5	REACTOR BAY VENTILATION SYSTEM SHUTDOWN TEST						DAMPERS CLOSE IN ≤5 SECONDS	4TH FLOOR ____ 1ST FLOOR ____				
*6	CALIBRATION OF THE FUEL ELEMENT TEMPERATURE CHANNEL						±2°C					
*7	MATERIALS BALANCE REPORT/FUEL MANAGEMENT						REPORTS DONE/ - EVEN BURNUP		APRIL 15 OCTOBER 15	APRIL 30 OCTOBER 30		
*8	CLEANING & LUBRICATION OF TRANSIENT ROD CARRIER INTERNAL BARREL						3-IN-1 or GUN OIL	CLEANED ____ OILED ______				
*9	LUBRICATION OF BALL-NUT DRIVE ON TRANSIENT ROD CARRIER						3-IN-1 or GUN OIL	MOLY KOTE ____ OILED ______				
10	LUBRICATION OF THE ROTATING RACK BEARINGS						10 W OIL	OILED _____				
11	CONSOLE CHECK LIST (OSTROP 15.11)						OSTROP 15.11					
12	CONSTANT AIR MONITOR RECORDER MAINTENANCE											

* License Requirements.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date last time plus 7½ months.

Figure IV.E.3 (Continued)

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15 (continued)

SEMI-ANNUAL SURVEILLANCE AND MAINTENANCE FOR ____________________

SURVEILLANCE & MAINTENANCE TO BE PERFORMED			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
12	CONSTANT AIR MONITOR RECORDER MAINTENANCE							
13	Deleted							
14	STANDARD CONTROL ROD MOTOR CHECKS			OILED _____				
15	Deleted							
16	ION CHAMBER RESISTANCE MEASUREMENTS WITH MEGGAR INDUCED VOLTAGE	A. SAFETY CHANNEL	NONE (Info Only)					
		B. % POWER CHANNEL	NONE (Info Only)					
17	FISSION CHAMBER RESISTANCE CALCULATION $R = \frac{800V}{\Delta I}$	@ 100 V. I = ________ AMPS @ 900 V. I = ________ AMPS ΔI = ________ AMPS R = ________ Ω	NONE (Info Only)					
18	FUNCTIONAL CHECK OF HOLDUP TANK WATER LEVEL ALARMS		OSTROP 15.18	HIGH _____ FULL _____ GREEN LIGHT _____				

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* License Requirements.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date last time plus 7½ months.

Figure IV.E.4

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16.0 — ANNUAL Surveillance and Maintenance for the Year ________ — Page 1

SURVEILLANCE AND MAINTENANCE TO BE PERFORMED			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
*1	BIENNIAL INSPECTION OF CONTROL RODS:	a) FFCRS	OSTROP 12.0					
		b) TRANS						
*2	ANNUAL REPORT (DUE JUNE 30 + 75 DAYS)		NOV 1		OCT 1	NOV 1		
*3	CONTROL ROD CALIBRATION:	a) SAFE	OSTROP 9.0					
		b) SHIM						
		c) REG						
		d) TRANS						
*4	REACTOR POWER CALIBRATION		OSTROP 8.0					
*5	CALIBRATION OF REACTOR TANK WATER TEMPERATURE METERS		OSTROP 16.5					
*6	CONTINUOUS AIR MONITOR CALIBRATION:	a) Particulate Monitor	RCHPP 18.0					
		b) Gas Monitor						
*7	STACK MONITOR CALIBRATION:	a) Particulate Monitor	RCHPP 18 & 26					
		b) Gas Monitor						
*8	AREA RADIATION MONITOR CALIBRATION		RCHPP 18.0					
*9	WATER MONITOR CALIBRATION		RCHPP 18.0					
10	REACTOR TANK AND CORE COMPONENT INSPECTION		NO POWDERY WHITE SPOTS					
*11	SNM PHYSICAL INVENTORY		OSTROP 20.0					
*12	EMERGENCY RESPONSE PLAN DRILL							
*13	STANDARD CONTROL ROD DRIVE INSPECTION		OSTROP 16.13					
*14	OSU POLICE AND SECURITY RETRAINING							
*15	50.59 REPORT		NOV 15		OCT 15	NOV 15		
*16	INTRUSION ALARM RESPONSE DRILL (OSU POLICE AND SECURITY)		RESPONSE ≤5 MIN					

* License Requirements.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date completed last year plus 15 months. For biennial license requirements, it is equal to the date completed last time plus 2½ years.

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Figure IV.E.4 (Continued)

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16.0 (continued) | ANNUAL Surveillance and Maintenance for the Year __________ | Page 2

	SURVEILLANCE AND MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
17	EMERGENCY POWER INVERTER TEST	OSTROP 22.0					
18	REPLACE P.A. & EVAC SYSTEM LEAD-ACID BATTERIES	EVERY 4 YEARS					

*19	REACTOR OPERATOR LICENSE CONDITIONS	ANNUAL				BIENNIAL		EVERY 6 YEARS				
		REQUALIFICATION				MEDICAL		NRC REQUAL EXAM		LICENSE		
		WRITTEN EXAMINATIONS		OPERATING TEST		DUE DATE	DATE COMPLETED	DUE DATE	DATE PASSED	APPLICATION		EXPIRATION DATE
	NAME	DUE DATE	DATE PASSED	DUE DATE	DATE PASSED					DUE DATE	DATE MAILED	

	SURVEILLANCE AND MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
20	FUEL ELEMENT INSPECTION FOR SELECTED ELEMENTS (B1, B2, B3, B5, B6, C3, C5, D5, D6)	PASS GO/NO GO TEST		Pulse # ________ Date ________	Pulse # ________ Date ________		
*21	DECOMMISSIONING COST UPDATE	N/A	N/A				
22	FUNCTIONAL TEST OF THE REACTOR WATER LOW LEVEL ALARM	MAXIMUM MOVEMENT ~3 INCHES	___INS ___ANN				

23	NAME	ANNUAL - CPR		EVERY 3 YEARS - FIRST AID	
		REMINDER DATE	EXPIRY DATE	REMINDER DATE	EXPIRY DATE

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* License Requirements.

** Date not to be exceeded is only applicable to marked (*) items. It is equal to the date completed last year plus 15 months. For biennial license requirements, it is equal to the date completed last time plus 2½ years.

PART V

PROTECTION

PART V

PROTECTION

PART V
PROTECTION

A. Introduction

This section of the report deals with the **radiation protection program** at the OSU Radiation Center. The purpose of this program is to ensure the safe use of radiation and radioactive material in the Center's teaching, research, and service activities, and in a similar manner to ensure the fulfillment of all regulatory requirements of the state of Oregon, the U.S. Nuclear Regulatory Commission, and other regulatory agencies. The comprehensive nature of the program is shown in Table V.A.1, which lists the program's major radiation protection requirements and the performance frequency for each item.

The radiation protection program is implemented by a staff consisting of a Senior Health Physicist, a Health Physicist, a Radiation Protection Technologist, and several part-time Health Physics Monitors (see Part II.F). Assistance is also provided by the reactor operations group, the neutron activation analysis group, the Scientific Instrument Technician, and the Radiation Center Director.

The data contained in the following sections have been prepared to comply with the current requirements of Nuclear Regulatory Commission (NRC) Facility License No. R-106 (Docket No. 50-243) and the Technical Specifications contained in that license. The material has also been prepared in compliance with Oregon Department of Energy Rule No. 345-30-010, which requires an annual report of environmental effects due to research reactor operations. A summary of required data for the OSTR is provided in Part I.E for quick reference.

Within the scope of Oregon State University's radiation protection program, it is standard operating policy to maintain all releases of radioactivity to the unrestricted environment and all exposures to radiation and radioactive materials at levels which are consistently "as low as reasonably achievable" (ALARA).

Table V.A.1

Radiation Protection Program Requirements and Frequencies

FREQUENCY	RADIATION PROTECTION REQUIREMENT
Daily/Weekly/Monthly	Perform routine area radiation/contamination monitoring.
Weekly	Perform gamma spectroscopy of the (OSTR) continuous air monitor particulate filter.
Monthly	Perform routine response checks of radiation monitoring instruments. Monitor radiation levels (μrem/hr) at the environmental monitoring stations. Collect and analyze TRIGA primary, secondary, and make-up water. Exchange personnel dosimeters and inside area monitoring dosimeters, and review exposure reports. Inspect laboratories. Check emergency safety equipment. Perform neutron generator contamination survey. Calculate previous month's gaseous effluent discharge.
As Required	Process and record solid waste and liquid effluent discharges. Prepare and record radioactive material shipments. Survey and record incoming radioactive materials receipts. Perform and record special radiation surveys. Perform thyroid and urinalysis bioassays. Conduct orientations and training. Issue radiation work permits and provide health physics coverage for maintenance operations.
Quarterly	Prepare, exchange and process environmental TLD packs. Collect and process environmental soil, water and vegetation samples. Conduct orientations for classes using radioactive materials. Collect and analyze sample from reactor stack effluent line. Exchange personnel dosimeters and inside area monitoring dosimeters, and review exposure reports.
Semi-Annual	Leak test and inventory sealed sources. Conduct floor survey of corridors and reactor bay. Calibrate portable radiation monitoring instruments and personnel pocket ion chambers. Inventory and inspect Radiation Center equipment located in the Corvallis Fire Department Haz/Mat van and at Good Samaritan Hospital.
Annual	Calibrate reactor stack effluent monitor, continuous air monitors, remote area radiation monitors, water monitor, and air samplers. Measure face air velocity in laboratory hoods and exchange dust-stop filters and HEPA filters as necessary. Inventory and inspect Radiation Center emergency equipment. Conduct facility radiation survey of the ^{60}Co irradiators and X-ray machine. Conduct personnel dosimeter training. Perform contamination smear survey of Radiation Center ventilation stacks. Update decommissioning logbook.

B. Environmental Releases

The annual reporting requirements in the OSTR Technical Specifications state that the licensee (OSU) shall include "a summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee, as measured at, or prior to, the point of such release or discharge." The liquid and gaseous effluents released, and the solid waste generated and transferred are discussed briefly below. Data regarding these effluents are also summarized in detail in the designated tables.

1. Liquid Effluents Released

a. Liquid Effluents Released

Oregon State University has implemented a policy to reduce the volume of radioactive liquid effluents to an absolute minimum. For example, water used during the ion exchanger resin change is now recycled as reactor makeup water. Waste water from Radiation Center laboratories and the OSTR is collected at a holdup tank prior to release to the sanitary sewer. Whenever possible, liquid effluent is analyzed for radioactivity content at the time it is released to the collection point. However, liquids are always analyzed for radioactivity before the holdup tank is discharged into the unrestricted area (the sanitary sewer system). For this reporting period, the Radiation Center and reactor made four liquid effluent release to the sanitary sewer. All Radiation Center and reactor facility liquid effluent data pertaining to these releases are contained in Table V.B.1.a.

b. Liquid Waste Generated and Transferred

Liquid waste generated from decontamination of TRIGA tubes and glassware and from laboratory experiments is transferred by the campus Radiation Safety Office to its waste processing facility. Aqueous wastes are absorbed and disposed of as radioactive solid waste. Liquid scintillation fluid is shipped off campus in bulk and in vials for disposal. The annual summary of liquid waste generated and transferred is contained in Table V.B.1.b.

Table V.B.1.a

Monthly Summary of Liquid Effluent Releases to the Sanitary Sewer(1,2)
(OSTR Contribution Shown in ( ) and Bold Print)

Date of Discharge (Month & Year)	Total Quantity of Radioactivity Released (Curies)	Detectable Radionuclides in the Waste	Specific Activity For Each Detectable Radionuclide in the Waste, Where the Release Concentration Was $>1 \times 10^{-7}$ μCi/cc (μCi/cc)	Total Quantity of Each Detectable Radionuclide Released in the Waste (Curies)	Average Concentration of Released Radioactive Material at the Point of Release (μCi/cc)	Percent of Applicable MPC for Released Radioactive Material (%)	Total Volume of Liquid Effluent Released Including Diluent(3) (gal)
July 94 **(No OSTR Contribution)**	$<4.65 \times 10^{-5}$(4)	None	Not Applicable	Not Applicable	<LLD (95%)(4) of 4.56×10^{-6}	Not Applicable	2693
January 95 **(No OSTR Contribution)**	$<4.80 \times 10^{-5}$(4)	None	Not Applicable	Not Applicable	<LLD (95%)(4) of 5.89×10^{-6}	Not Applicable	2153
February 95 **(No OSTR Contribution)**	$<4.12 \times 10^{-5}$(4)	None	Not Applicable	Not Applicable	<LLD (95%)(4) of 4.87×10^{-6}	Not Applicable	2232
March 95 **(No OSTR Contribution)**	$<2.39 \times 10^{-5}$(4)	None	Not Applicable	Not Applicable	<LLD (95%)(4) of 5.15×10^{-6}	Not Applicable	1223
Annual Total for Radiation Center **(No OSTR Contribution)**	$<1.60 \times 10^{-4}$ (4)	None	Not Applicable	Not Applicable	<LLD (95%)(4) of 4.91×10^{-6}	Not Applicable	8301(5)

(1) OSU has implemented a policy to reduce to the absolute minimum radioactive wastes disposed to the sanitary sewer. There were no liquid effluent releases during months not listed.

(2) The OSU operational policy is to subtract only detector background from our water analysis data and not background radioactivity in the Corvallis city water.

(3) The total volume of liquid effluent plus diluent does not take into consideration the additional mixing with the over 250,000 gallons per year of liquids and sewage normally discharged by the Radiation Center complex into the same sanitary sewer system.

(4) Less than the lower limit of detection at the 95% confidence level.

(5) The increased volume of liquid effluent released during this reporting period was due to cleaning and flushing of the holdup tank during the period from January to March 1995.

Table V.B.1.b

Annual Summary of Liquid Waste Generated and Transferred

Origin of Liquid Waste	Volume of Liquid Waste Packaged(1) (Cubic feet)	Detectable Radionuclides in the Waste	Total Quantity of Radioactivity in the Waste (Curies)	Dates of Waste Pickup for Transfer to the Waste Processing Facility	Dates of Shipment from Oregon State University(2)
TRIGA Reactor Facility	0.7 ft^3	Not Applicable	1.7×10^{-5}	6/13/95	Not Applicable
Radiation Center Laboratories	10.4 ft^3	^{40}K, ^{60}Co, ^{82}Br, ^{110m}Ag, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{235}U	4.6×10^{-6}	3/14/95	5/24/95
TOTAL	11.1 ft^3	See above	2.2×10^{-5}	---	---

(1) TRIGA and Radiation Center liquid waste is picked up by the Radiation Safety Office for transfer to its waste processing facility for final packaging.

(2) Liquid waste that has been absorbed is shipped as solid waste to Allied Ecology Services, Inc. Liquid scintillation waste is shipped to the Quadrex Corporation.

2. Airborne Effluents Released

Airborne effluents are discussed in terms of the gaseous component and the particulate component.

a. Gaseous Effluents

Gaseous effluents from the reactor facility are monitored by the reactor stack effluent monitor. Monitoring is continuous (i.e., prior to, during, and after reactor operations). It is normal for the reactor facility stack effluent monitor to begin operation as one of the first systems in the morning and to cease operation as one of the last systems at the end of the day. All gaseous effluent data for this reporting period are summarized in Table V.B.2.

b. Particulate Effluents

Particulate effluents from the reactor facility are also monitored by the reactor facility stack effluent monitor.

Evaluation of the detectable particulate radioactivity in the stack effluent confirmed its origin as naturally-occurring radon daughter products, within a range of approximately 1×10^{-9} μCi/cc to 3×10^{-11} μCi/cc. This particulate radioactivity is predominantly ^{214}Pb and ^{214}Bi, which is not associated with reactor operations.

There was no release of particulate effluents with a half-life greater than 8 days and therefore the reporting of the average concentration of radioactive particulates with half-lives greater than eight days is not applicable.

3. Solid Waste Released

Data for the radioactive material in the solid waste generated and transferred during this reporting period are summarized in Table V.B.3 for both the reactor facility and the Radiation Center. Solid radioactive waste is routinely transferred to the OSU Radiation Safety Office. Until this waste is disposed of by the Radiation Safety Office, it is held along with other campus radioactive waste on the University's state of Oregon radioactive materials license.

Table V.B.2

Monthly Summary of Gaseous Effluent Releases[1]

Date of Discharge (Month & year)	Total Estimated Radioactivity Released (Curies)	Total Estimated Quantity of Argon-41 Released[2] (Curies)	Estimated Average Atmospheric Diluted Concentration of Argon-41 at Point of Release (Reactor Stack) (μCi/ml)	Percent of the Applicable MPC for Diluted Concentration of Argon-41 at Point of Release (Reactor Stack) (%)
July 94	0.39	0.39	3.0×10^{-8}	0.7%
August 94	0.37	0.37	2.8×10^{-8}	0.7%
September 94	0.25	0.25	2.2×10^{-8}	0.5%
October 94	0.30	0.30	2.3×10^{-8}	0.6%
November 94	0.26	0.26	2.1×10^{-8}	0.5%
December 94	0.29	0.29	2.2×10^{-8}	0.6%
January 95	0.26	0.26	2.2×10^{-8}	0.6%
February 95	0.31	0.31	2.6×10^{-8}	0.7%
March 95	0.30	0.30	2.3×10^{-8}	0.6%
April 95	0.24	0.24	1.9×10^{-8}	0.5%
May 95	0.21	0.21	1.6×10^{-8}	0.4%
June 95	0.21	0.21	1.7×10^{-8}	0.4%
ANNUAL VALUE	3.4	3. 4	2.2×10^{-8}	0.6%

(1) Airborne effluents from the OSTR contained no detectable particulate radioactivity resulting from reactor operations, and there were no releases of any radioisotopes in airborne effluents in concentrations greater than 20% of the applicable effluent concentration. (20% is a value taken from the OSTR Technical Specifications.)

(2) Routine gamma spectroscopy analysis of the gaseous radioactivity in the OSTR stack discharge indicated the only detectable radionuclide was argon-41.

Table V.B.3

Annual Summary of Solid Waste Generated and Transferred

Origin of Solid Waste	Volume of Solid Waste Packaged[1] (Cubic Feet)	Detectable Radionuclides in the Waste	Total Quantity of Radioactivity in Solid Waste (Curies)	Dates of Waste Pickup for Transfer to the OSU Waste Processing Facility	Dates of Shipment from Oregon State University[2]
TRIGA Reactor Facility	20[3]	^{46}Sc, ^{54}Mn, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{132}Te	9.2×10^{-4}	8/3/94 1/20/95 3/7/95 4/6/95 6/13/95	8/17/94 11/9/94 2/14/95 5/24/95
Radiation Center Laboratories	26	^{14}C, ^{22}Na, ^{40}K, ^{45}Ca, ^{46}Sc, ^{59}Fe, ^{60}Co, ^{75}Sc, ^{82}Ba, ^{110m}Ag, ^{137}Cs, ^{141}Ce, ^{143}Ce, ^{152}Eu, ^{154}Eu, ^{210}Bi, ^{235}U	1.2×10^{-1}	8/3/94 1/20/95 3/7/95 4/6/95 6/13/95	8/17/94 11/9/94 2/14/95 5/24/95
TOTAL	46	See Above	1.2×10^{-1}	---	---

(1) TRIGA and Radiation Center laboratory waste is picked up by the Radiation Safety Office for transfer to its waste processing facility for final packaging.

(2) Solid radioactive waste is shipped to Allied Ecology Services, Inc.

(3) Includes 3 ft^3 of dewatered resin beads.

Solid radioactive waste is disposed of by the University Radiation Safety Office by transfer to the University's radioactive waste disposal vendor, Allied Ecology Services, Inc., for burial at its installation located near Richland, Washington.

C. Personnel Doses

The OSTR annual reporting requirements specify that the licensee shall present a summary of the radiation exposure received by facility personnel and visitors. For the purposes of this report, the summary includes all Radiation Center personnel who may have received exposure to radiation. These personnel have been categorized into six groups: facility operating personnel, key facility research personnel, facilities services maintenance personnel, students in laboratory classes, police and security personnel, and visitors.

Facility operating personnel include the reactor operations and health physics staff. The dosimeters used to monitor these individuals include monthly or quarterly X-ray, beta, and gamma [Xβ(G)] film badges, quarterly track-etch/albedo neutron dosimeters, either monthly or quarterly TLD (finger) extremity dosimeters, and pocket ion chambers.

Key facility research personnel consist of Radiation Center staff, faculty, and graduate students who perform research using the reactor, reactor-activated materials, or using other research facilities present at the Center. The individual dosimetry requirements for these personnel will vary with the type of research being conducted, but will generally include a monthly or quarterly Xβ(G) film badge and TLD (finger) extremity dosimeters. If the possibility of neutron exposure exists, researchers are also monitored with a track-etch/albedo neutron dosimeter.

Facilities Services maintenance personnel are normally issued a gamma sensitive pocket ion chamber as their basic monitoring device. A few Facilities Services personnel who routinely perform maintenance on mechanical or refrigeration equipment are issued a quarterly Xβ(G) film badge and other dosimeters as appropriate for the work being performed.

Students attending laboratory classes are issued quarterly Xβ(G) film badges, TLD (finger) extremity dosimeters, and track-etch/albedo or other neutron dosimeters, as appropriate.

Students or small groups of students who attend a one-time laboratory demonstration and do not handle radioactive materials are usually issued a gamma sensitive pocket ion chamber. These results are not included with the laboratory class students.

OSU police and security personnel are issued a quarterly Xβ(G) film badge to be used during their patrols of the Radiation Center and reactor facility.

Visitors, depending on the locations visited, may be issued a gamma sensitive pocket ion chamber. OSU Radiation Center policy does not normally allow people in the visitor category to become actively involved in the use or handling of radioactive materials.

An annual summary of the radiation doses received by each of the above six groups is shown in Table V.C.1. There were no personnel radiation exposures in excess of the limits in 10 CFR 20 or state of Oregon regulations during the reporting period.

Table V.C.1

Annual Summary of Personnel Radiation Doses Received

Personnel Group	Average Annual Dose[1]		Greatest Individual Dose[1]		Total Person-mrem For the Group[1]	
	Whole Body (mrem)	Extremities (mrem)	Whole Body (mrem)	Extremities (mrem)	Whole Body (mrem)	Extremities (mrem)
Facility Operating Personnel	5	53	75	340	75	850
Key Facility Research Personnel	0	3	0	50	0	80
Facilities Services Maintenance Personnel	<1	N/A	5	N/A	142	N/A
Laboratory Class Students	0	0	0	0	0	0
Campus Police and Security Personnel	0	N/A	0	N/A	0	N/A
Visitors	<1	N/A	20	N/A	1072	N/A

(1) "0" indicates that each of the beta-gamma dosimeters during the reporting period was less than the vendor's gamma dose reporting threshold of 10 mrem or that each of the neutron dosimeters was less than the vendor's threshold of 30 mrem, as applicable. "N/A" indicates that there was no extremity monitoring conducted or required for the group.

D. Facility Survey Data

The OSTR Technical Specifications require an annual summary of the radiation levels and levels of contamination observed during routine surveys performed at the facility. However, the Center's comprehensive area radiation monitoring program encompasses the Radiation Center as well as the OSTR, and therefore monitoring results for both facilities are reported.

1. Area Radiation Dosimeters

Area monitoring dosimeters capable of integrating the radiation dose are located at strategic positions throughout the reactor facility and Radiation Center. All of these dosimeters contain at least a standard personnel-type beta-gamma film pack. In addition, for key locations in the reactor facility and for certain Radiation Center laboratories a CR-39 plastic track-etch neutron detector has also been included in the monitoring package. Figure V.D.1 shows the locations of the dosimeters in the reactor building and Radiation Center.

The total dose equivalent recorded on the various reactor facility dosimeters is listed in Table V.D.1 and the total dose equivalent recorded on the Radiation Center area dosimeters is listed in Table V.D.2. Generally, the characters following the MRC (Monitor Radiation Center) designator show the room number or location.

Figure V.D.1

TRIGA Facility and Radiation Center Area Dosimeter Locations

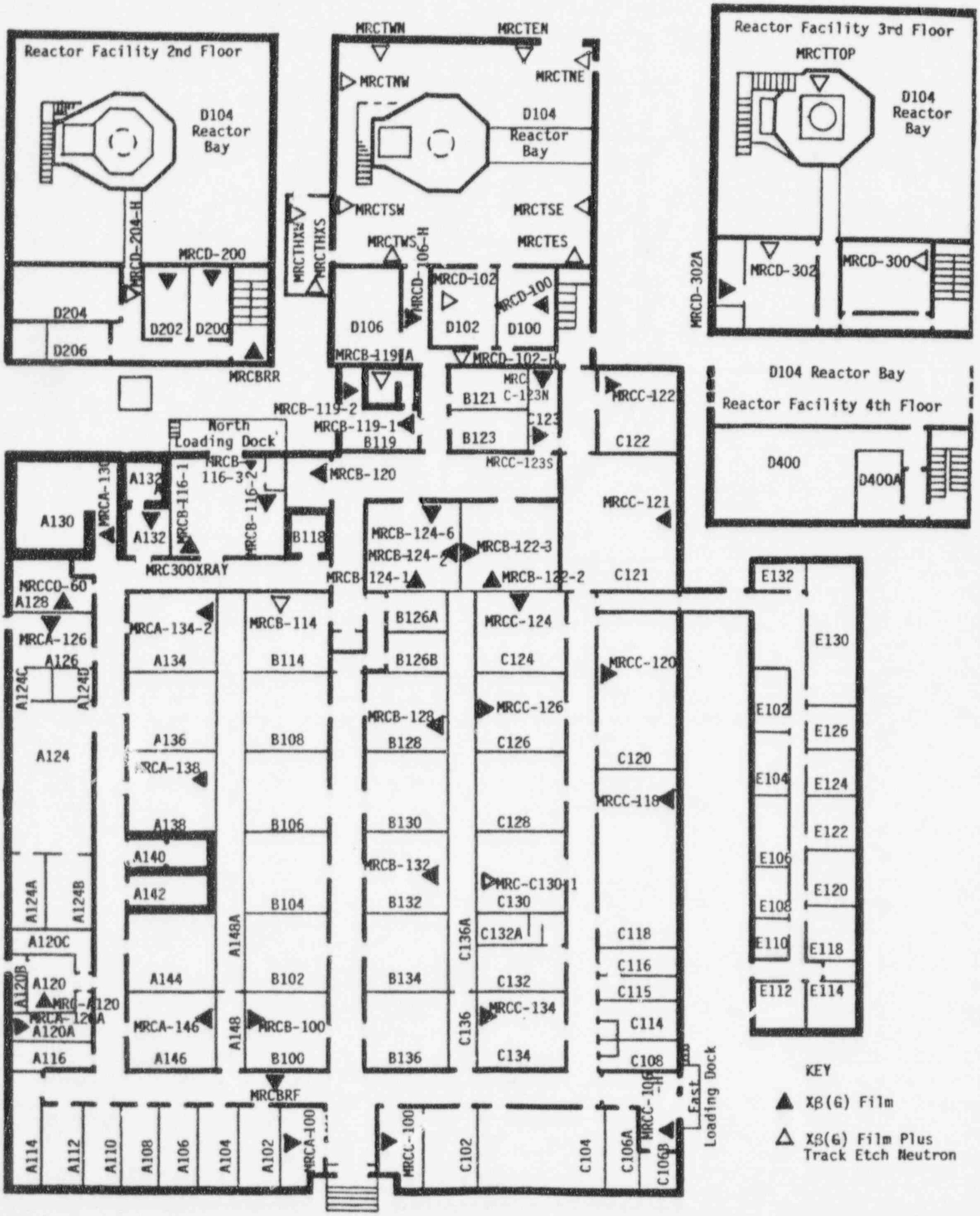


Table V.D.1

Total Dose Equivalent Recorded on Area Dosimeters Located Within the TRIGA Reactor Facility

Monitor I.D.	TRIGA Reactor Facility Location (See Figure V.D.1)	Total Recorded Dose Equivalent(1)(2)	
		xβ(G) (mrem)	Neutron (mrem)
MRCTNE	D104: North Badge East Wall	15	0
MRCTSE	D104: South Badge East Wall	0	0
MRCTSW	D104: South Badge West Wall	115	0
MRCTNW	D104: North Badge West Wall	0	0
MRCTWN	D104: West Badge North Wall	0	0
MRCTEN	D104: East Badge North Wall	465	0
MRCTES	D104: East Badge South Wall	1520	0
MRCTWS	D104: West Badge South Wall	730	0
MRCTTOP	D104: Reactor Top Badge	685	0
MRCTHXS	D104A: South Badge HX Room	925	0
MRCTHXW	D104A: West Badge HX Room	95	20
MRCD-302	D302: Reactor Control Room	335	0
MRCD-302A	D302A: Reactor Supervisor's Office	15(3)	N/A

(1) The total recorded dose equivalent values do not include natural background contribution and, except as noted, reflect the summation of the results of 12 monthly beta-gamma dosimeters or four quarterly fast neutron dosimeters for each location. A total dose equivalent of "0" indicates that each of the dosimeters during the reporting period was less than the vendor's gamma dose reporting threshold of 10 mrem or that each of the fast neutron dosimeters was less than the vendor's threshold of 50 to 100 mrem, as applicable. "N/A" indicates that there was no neutron monitor at that location.

(2) These dose equivalent values do not represent radiation exposure through an exterior wall directly into an unrestricted area.

(3) The total recorded dose equivalent reflects the summation of four quarterly beta-gamma dosimeters.

Table V.D.2

Total Dose Equivalent Recorded on Area Dosimeters Located Within the Radiation Center

Monitor I.D.	Radiation Center Facility Location (See Figure V.D.1)		Total Recorded Dose Equivalent(1)	
			xβ(G) (mrem)	Neutron (mrem)
MRCA100	A100:	Receptionist's Office	0(2)	N/A
MRCBRF	A102H:	Frt Personnel Dosimetry Stor. Rack	0(2)	N/A
MRCA120	A120:	Stock Room	0(2)	N/A
MRCA120A	A120A:	NAA Temporary Storage	95(2)	N/A
MRCA126	A126:	Campus RSO's Isotope Receiving Lab	220(2)	N/A
MRCCO-60	A128:	^{60}Co Irradiator Room	660(2)	N/A
MRCA130	A130:	Shielded Exposure Room	0(2)	N/A
MRC300XRAY	A132:	X-Ray Console Room	0(2)	N/A
MRCA134-2	A134:	NAA Research Office	200(2)	N/A
MRCA138	A138:	Health Physics Laboratory	0(2)	N/A
MRCA146	A146:	Gamma Analyzer Room (Storage Cave)	15(2)	N/A
MRCB100	B100:	Gamma Analyzer Room (Storage Cave)	115(2)	N/A
MRCB114	B114:	α Lab (^{226}Ra Storage Facility)	3590	20
MRCB116-1	B116:	Storage Rm (NAA Permanent Storage)	0(2)	N/A
MRCB116-2	B116:	Storage Rm (NAA Permanent Storage)	0(2)	N/A
MRCB116-3	B116:	Storage Rm (NAA Permanent Storage)	0(2)	N/A
MRCB119-1	B119:	Source Storage Room	20(2)	N/A
MRCB119-2	B119:	Source Storage Room	240(2)	N/A
MRCB119A	B119A:	Sealed Source Storage Room	10,050	2300
MRCB120	B120:	Instrument Calibration Facility	0(2)	N/A
MRCB122-2	B122:	Radioisotope Storage Hood	0(2)	N/A
MRCB122-3	B122:	Radioisotope Research Laboratory	0(2)	N/A
MRCB124-1	B124:	Radioisotope Research Lab (Hood)	50(2)	N/A
MRCB124-2	B124:	Radioisotope Research Laboratory	0(2)	N/A
MRCB124-6	B124:	Radioisotope Research Laboratory	0(2)	N/A
MRCB128	B128:	Instrument Repair Shop	0(2)	N/A
MRCB132	B132:	Radioisotope Research Laboratory	15(2)	N/A
MRCC100	C100:	Radiation Center Director's Office	0(2)	N/A
MRCC106-H	C106H:	East Loading Dock	0(2)	N/A
MRCC118	C118:	Radiochemistry Laboratory	0(2)	N/A
MRCC120	C120:	Student Counting Laboratory	0(2)	N/A
MRCC121	C121:	AP600 Facility	0(2)	N/A
MRCC122	C122:	AP600 Control Room	0(2)	N/A

See footnotes next page.

Table V.D.2 (continued)

Total Dose Equivalent Recorded on Area Dosimeters
Located Within the Radiation Center

Monitor I.D.	Radiation Center Facility Location (See Figure V.D.1)	Total Recorded Dose Equivalent[1]	
		$x\beta(G)$ (mrem)	Neutron (mrem)
MRCC123N	C123: Gamma Analyzer Room (Storage Cave)	85[2]	N/A
MRCC123S	C123: Gamma Analyzer Room	0[2]	N/A
MRCC124	C124: Student Computer Laboratory	0[2]	N/A
MRC126	C126: AP600 Office	0[2]	N/A
MRCC130-1	C130: Radioisotope Laboratory (Hood)	0[2]	N/A
MRCC134	C134: Gamma Analyzer Room (Storage Cave)	25	N/A
MRCD100	D100: Reactor Support Laboratory	75	N/A
MRCD102	D102: Pneumatic Transfer Terminal Lab	55	0
MRCD102-H	D102H: 1st Floor Corridor at D102	0	0
MRCD106-H	D106H: 1st Floor Corridor at D106	135[2]	N/A
MRCD200	D200: Reactor Administrators's Office	170[2]	N/A
MRCD202	D202: Senior Health Physicist's Office	105[2]	N/A
MRCBRR	D200H: Rear Personnel Dosimetry Storage Rack	0[2]	N/A
MRCD204-H	D204H: 2nd Floor Corridor at D204	0	0
MRCD300	D300: 3rd Floor Conference Room	15	0

(1) The total recorded dose equivalent values do not include natural background contribution and, except as noted, reflect the summation of the results of 12 monthly beta-gamma dosimeters or four quarterly fast neutron dosimeters for each location. A total dose equivalent of "0" indicates that each of the dosimeters during the reporting period was less than the vendor's gamma dose reporting threshold of 10 mrem or that each of the fast neutron dosimeters was less than the vendor's threshold of 50 to 100 mrem, as applicable. "N/A" indicates that there was no neutron monitor at that location.

(2) The total recorded dose equivalent reflects the summation of four quarterly beta-gamma dosimeters.

2. Routine Radiation and Contamination Surveys

The Center's program for routine radiation and contamination surveys consists of daily, weekly and monthly measurements throughout the TRIGA reactor facility and Radiation Center. The frequency of these surveys is based on the nature of the radiation work being carried out at a particular location or on other factors which indicate that surveillance over a specific area at a defined frequency is desirable.

The primary purpose of the routine radiation and contamination survey program is to assure regularly scheduled surveillance over selected work areas in the reactor facility and in the Radiation Center, in order to provide current and characteristic data on the status of radiological conditions. A second objective of the program is to assure frequent on-the-spot personal observations (along with recorded data), which will provide advance warning of needed corrections and thereby help to ensure the safe use and handling of radiation sources and radioactive materials. A third objective, which is really derived from successful execution of the first two objectives, is to gather and document information which will help to ensure that all phases of the operational and radiation protection programs are meeting the goal of keeping radiation doses to personnel and releases of radioactivity to the environment "as low as reasonably achievable" (ALARA).

The annual summary of radiation and contamination levels measured during routine facility surveys for the applicable reporting period is given in Table V.D.3.

Table V.D.3

Annual Summary of Radiation Levels and Contamination Levels Observed Within the Reactor Facility and Radiation Center During Routine Radiation Surveys

Accessible Location (See Figure V.D.1)	Whole Body Radiation Levels (mrem/h)		Contamination Levels[1] (dpm/100 cm^2)	
	Average	Maximum	Average	Maximum
TRIGA Reactor Facility:				
Reactor Top (D104)	1	120	<500[2]	14,875[2]
Reactor 2nd Deck Area (D104)	6	60	<500	<500
Reactor Bay SW (D104)	<1	7	<500[2]	2826[2]
Reactor Bay NW (D104)	<1	44	<500[2]	1650[2]
Reactor Bay NE (D104)	<1	80	<500[2]	2890[2]
Reactor Bay SE (D104)	<1	22	<500[2]	4565[2]
Class Experiments (D104,D302)	<1	80	<500[2]	3696[2]
Demineralizer Tank-- Outside Shielding (D104A)	<1	3	<500	<500
Particulate Filter-- Outside Shielding (D104A)	<1	3	<500	<500
Radiation Center:				
NAA Counting Rooms (A146,B100,C134)	<1	<1	<500	<500
Health Physics Laboratory (A138)	<1	1	<500	<500
^{60}Co Irradiator Room (A128)	<1	3	<500	<500
Radiation Research Labs (B114,B122,B124,B132)	<1	12	<500	<500
Radioactive Source Storage (B119A)	<1	24	<500	<500
Student Chemistry Laboratory (C118)	<1	47	<500	<500
Student Counting Laboratory (C120)	<1	<1	<500	<500
Operations Counting Room (C123)	<1	70	<500	<500
Pneumatic Transfer Laboratory (D102)	<1	70	<500	<500
TRIGA Tube Wash Room (D100)	<1	7	<500[2]	1380[2]

(1) <500 dpm/100 cm^2 = Less than the lower limit of detection for the portable survey instrument used.

(2) The contamination shown for this location assumes 100% smearing efficiency and was immediately removed. As a result, the average contamination level at this location during the reporting period was, for all practical purposes, <500 dpm per 100 cm^2.

E. Environmental Survey Data

The annual reporting requirements of the OSTR Technical Specifications include "an annual summary of environmental surveys performed outside the facility."

1. Gamma Radiation Monitoring

a. On-site Monitoring

Monitors used in the on-site gamma environmental radiation monitoring program at the Radiation Center consist of the reactor facility stack effluent monitor described in section V.B.2 and nine environmental monitoring stations. These stations consist of a polyethylene bottle placed inside a PVC tube attached to the reactor building perimeter fence at a height of four feet (see Figure V.E.1).

Each fence environmental station is equipped with an OSU supplied and processed TLD area monitor (normally three Harshaw ^{7}LiF TLD-700 chips per ^{7}Li monitor in a plastic "LEGO" mount). These monitors are exchanged and processed quarterly. The total number of TLD samples for the reporting period was 108 (9 stations x 3 chips per station per quarter x 4 quarters per year). A summary of this TLD data is shown in Table V.E.1.

Each fence environmental station also utilized a $CaSO_4$ TLD monitoring packet supplied and processed by Radiation Detection Company (R.D. Co.), Sunnyvale, California. Each R.D. Co. packet contained two $CaSO_4$ TLDs and was exchanged quarterly for a total of 72 samples during the reporting period (9 stations x 2 TLDs per station per quarter x 4 quarters per year). A summary of Radiation Detection Company's TLD data is also shown in Table V.E.1.

Monthly measurements of the direct gamma dose rate (μrem/h), were also made at each fence monitoring station. These measurements were made with a Bicron micro-rem per hour survey meter containing a 1" x 1" NaI detector.

Figure V.E.1

Area Radiation Monitor Locations for the TRIGA Reactor, and on the TRIGA Reactor Area Fence

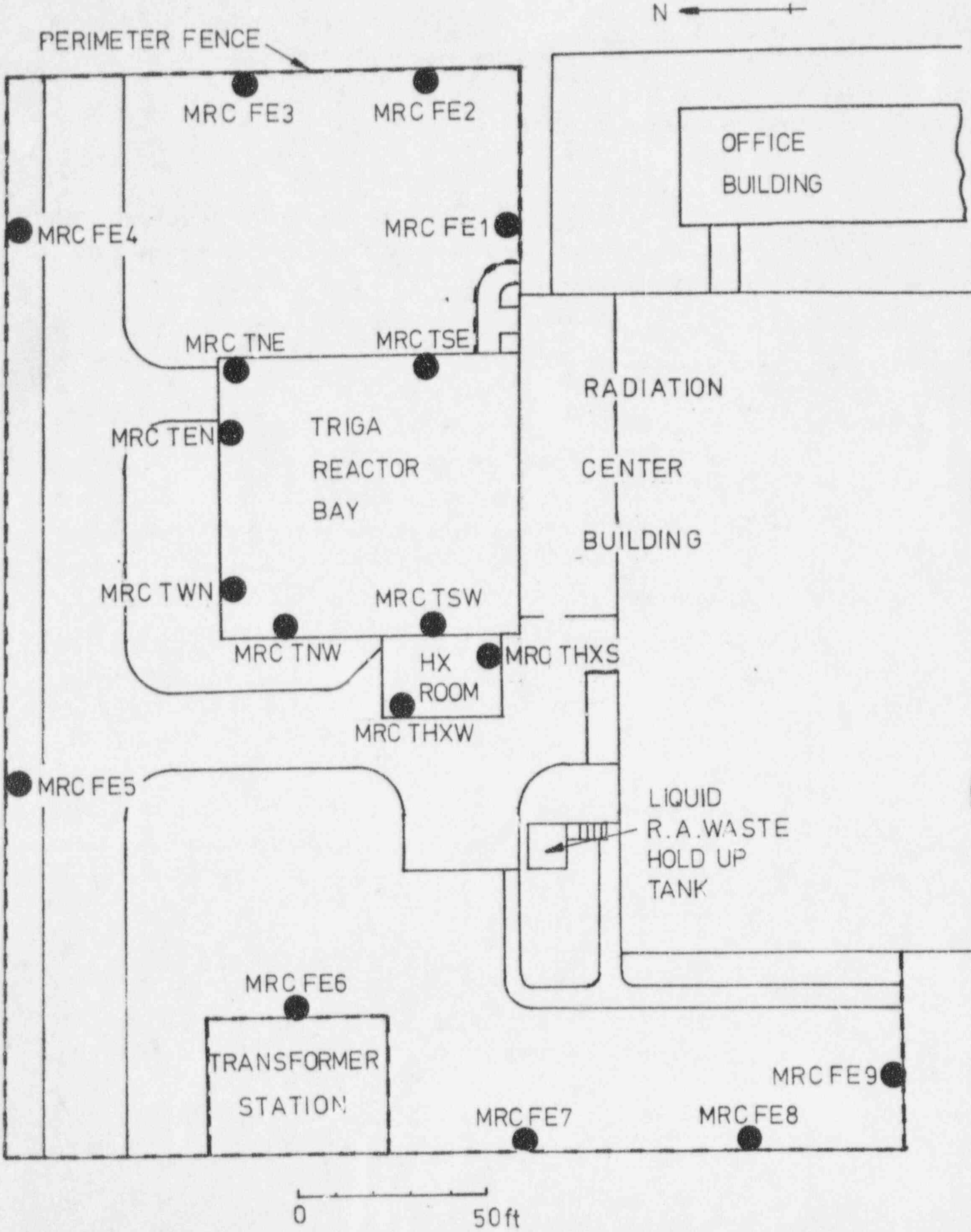


Table V.E.1

Total Dose Equivalent at the
TRIGA Reactor Facility Fence

Fence Environmental Monitoring Station (See Figure V.E.1)	Total Recorded Dose Equivalent Based on R.D. Co. TLDs(1) (mrem)	Total Recorded Dose Equivalent Based on OSU TLDs(2)(3) (mrem)	Total Calculated Dose Equivalent Based on the Annual Average μrem/h Dose Rate(3) (mrem)
MRCFE-1	102	66 ± 7	76 ± 11
MRCFE-2	104	66 ± 5	68 ± 8
MRCFE-3	106	70 ± 3	79 ± 10
MRCFE-4	107	72 ± 3	90 ± 11
MRCFE-5	94	66 ± 5	68 ± 8
MRCFE-6	98	63 ± 5	73 ± 13
MRCFE-7	98	59 ± 6	66 ± 9
MRCFE-8	96	58 ± 6	69 ± 7
MRCFE-9	92	54 ± 8	66 ± 6

(1) Radiation Detection Company (R.D. Co.) TLD totals include their annual natural background contribution of 75 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 54 mrem for the same period.

(2) OSU fence totals include a measured natural background contribution of 54 ± 4 mrem.

(3) ± values represent the standard deviation of the total value at the 95% confidence level.

A total of 108 μrem/h measurements were taken (9 stations per month x 12 months per year). The total calculated dose equivalent was determined by averaging the 12 separate μrem/h measurements and multiplying this average by 8760 hours per year. A summary of this data is shown in Table V.E.1.

From Table V.E.1 we have concluded that the doses recorded by the dosimeters on the TRIGA facility fence can be attributed to natural background radiation, which is about 110 mrem per year for Oregon (Refs. 1, 2).

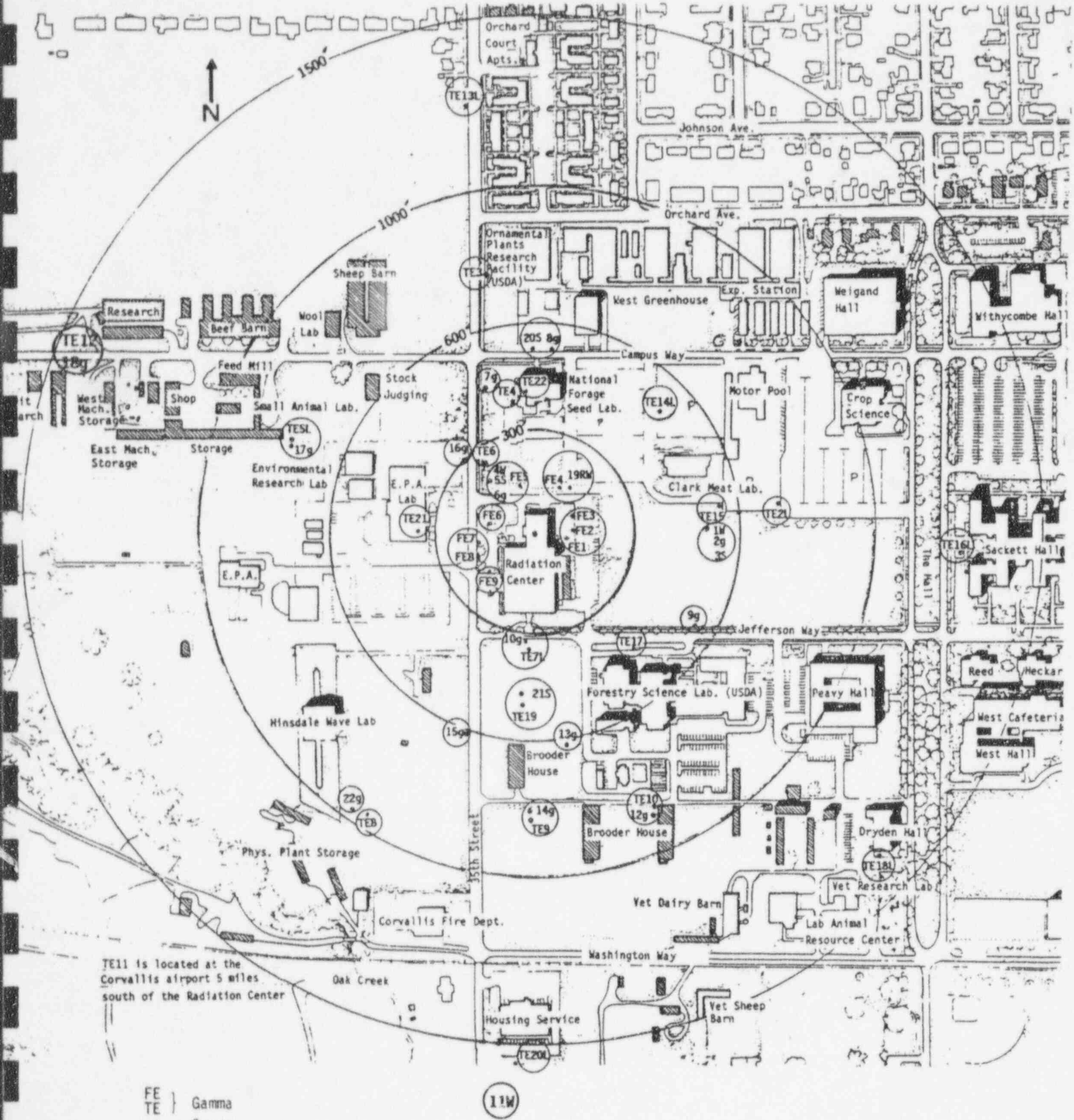
b. Off-site Monitoring

The off-site gamma environmental radiation monitoring program consists of twenty monitoring stations surrounding the Radiation Center (see Figure V.E.2) and one station located 5 miles to the south near the Corvallis Airport.

Each off-site radiation monitoring station is equipped with an OSU-supplied and processed TLD monitor. Each monitor consists of three (MRCTE-11 has six) Harshaw ^{7}LiF TLD-700 chips in a plastic "LEGO" mount. The mount is placed in a polyethylene bottle inside a PVC tube which is attached to the station's post about four feet above the ground (MRCTE 21 and MRCTE 22 are mounted on the roof of the EPA Lab. and National Forage Seed Lab., respectively). These monitors are exchanged and processed quarterly, and the total number of TLD samples during the current one-year reporting period was 264 (20 stations x 3 chips per station per quarter x 4 quarters per year plus 1 station x 6 chips per station per quarter x 4 quarters per year). A summary of the OSU off-site TLD data is provided in Table V.E.2. The total number of R. D. Co. TLD samples for the reporting period was 104 (13 stations x 2 TLDs per station per quarter x 4 quarters per year). A summary of Radiation Detection Company's TLD data for the off-site monitoring stations is also given in Table V.E.2.

Figure V.E.2

Monitoring Stations for the OSU TRIGA Reactor



FE TE	Gamma
g	Grass
S	Soil
W	Water
RW	Rainwater

SCALE: 0 100 200 300

Table V.E.2

Total Dose Equivalent at the Off-Site Gamma Radiation Monitoring Stations

Off-Site Radiation Monitoring Station(1) (See Figure V.E.2)	Total Recorded Dose Equivalent Based on R.D. Co. TLDs(2) (mrem)	Total Recorded Dose Equivalent Based on OSU TLDs(3)(4) (mrem)	Total Calculated Dose Equivalent Based on the Annual Average μrem/hr Exposure Rate(4) (mrem)
MRCTE-2L	---	55 ± 5	55 ± 7
MRCTE-3	101	65 ± 6	73 ± 9
MRCTE-4	91	58 ± 4	68 ± 8
MRCTE-5L	---	63 ± 5	70 ± 11
MRCTE-6	100	64 ± 3	75 ± 9
MRCTE-7L	---	54 ± 8	66 ± 7
MRCTE-8	106	62 ± 4	81 ± 15
MRCTE-9	102	56 ± 10	72 ± 8
MRCTE-10	91	54 ± 6	57 ± 7
MRCTE-11	91	53 ± 4	59 ± 10
MRCTE-12	104	65 ± 7	75 ± 11
MRCTE-13L	---	68 ± 5	68 ± 8
MRCTE-14L	---	54 ± 10	56 ± 7
MRCTE-15	94	65 ± 6	62 ± [illegible]
MRCTE-16L	---	68 ± 10	67 ± 9
MRCTE-17	92	63 ± 6	62 ± 9
MRCTE-18L	---	67 ± 4	72 ± 8
MRCTE-19	105	71 ± 4	75 ± 9
MRCTE-20L	---	64 ± 6	68 ± 7
MRCTE-21	74	46 ± 2	47 ± 9
MRCTE-22	81	53 ± 4	54 ± 9

(1) Monitoring stations coded with an "L" contained one standard OSU TLD pack only. Stations not coded with an "L" contained, in addition to the OSU TLD pack, one R.D. Co. TLD monitoring pack.

(2) Radiation Detection Company TLD totals include their annual natural background contribution of 75 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 54 mrem for the same period.

(3) OSU off-site totals include a measured natural background contribution of 54 ± 4 mrem.

(4) ± values represent the standard deviation of the total value at the 95% confidence level.

In a manner similar to that described for the on-site fence stations, monthly measurements of the direct gamma exposure rate in microroentgens per hour (µrem/h) are made at each of the twenty-one off-site radiation monitoring stations. As noted before, these measurements are made with a Bicron micro-rem per hour survey meter containing a 1" x 1" NaI detector. A total of 252 µrem/h measurements were made during the reporting period (21 stations per month x 12 months per year). The total dose equivalent for each station was determined by averaging the 12 separate µrem/h measurements and multiplying this average by 8760 hours per year. A summary of these data is given in Table V.E.2.

After a review of the data in Table V.E.2, we have concluded that, like the dosimeters on the TRIGA facility fence, all of the doses recorded by the off-site dosimeters can be attributed to natural background radiation, which is about 110 mrem per year for Oregon (Refs. 1, 2).

2. Soil, Water, and Vegetation Surveys

The soil, water and vegetation monitoring program consists of the collection and analysis of a limited number of samples in each category on a quarterly basis. The program monitors highly unlikely radioactive material releases from either the TRIGA reactor facility or the OSU Radiation Center, and also helps indicate the general trend of the radioactivity concentration in each of the various substances sampled. See Figure V.E.2 for the locations of the sampling stations for grass (G), soil (S), water (W) and rainwater (RW) samples. Most locations are within a 1000 foot radius of the reactor facility and the Radiation Center. In general, samples are collected over a local area having a radius of about ten feet at the positions indicated in Figure V.E.2.

There are a total of 22 quarterly sampling locations: four soil locations, four water locations (when water is available), and fourteen vegetation locations. The total number of samples possible during the reporting period is 88 (16 soil samples, 16 water samples, and 56 vegetation samples).

The annual average concentration of total net beta radioactivity (minus tritium) for samples collected at each environmental soil, water, and vegetation sampling location (sampling station) is listed in Table V.E.3. Calculation of the total net beta disintegration rate incorporates subtraction of only the counting system background from the gross beta counting rate, followed by application of an appropriate counting system efficiency.

The annual average concentrations were calculated using sample results which exceeded the lower limit of detection (LLD), except that sample results which were less than or equal to the LLD were averaged in at the corresponding LLD concentration. Table V.E.4 gives the average LLD concentration and the range of LLD values for each sample category for the current reporting period.

As used in this report, the LLD has been defined as the amount or concentration of radioactive material (in terms of μCi per unit volume or unit mass) in a representative sample, which has a 95% probability of being detected.

Identification of specific radionuclides is not routinely carried out as part of this monitoring program, but would be conducted if unusual radioactivity levels above natural background were detected. However, from Table V.E.3 it can be seen that the levels of radioactivity detected were consistent with naturally occurring radioactivity and comparable to values reported in previous years.

Table V.E.3

Annual Average Concentration of the Total Net Beta Radioactivity (Minus ^{3}H) for Environmental Soil, Water, and Vegetation Samples

Sample Location (See Figure V.E.2)	Sample Type	Annual Average Concentration of the Total Net Beta (Minus ^{3}H) Radioactivity(1)	Reporting Units
1-W	Water	(2)(3)$2.67 \times 10^{-8} \pm 8.26 \times 10^{-10}$	μCi/cc
4-W	Water	(2)(3)$2.67 \times 10^{-8} \pm 8.26 \times 10^{-10}$	μCi/cc
11-W	Water	(2)$2.67 \times 10^{-8} \pm 7.20 \times 10^{-10}$	μCi/cc
19-RW	Rainwater	(2)$2.69 \times 10^{-8} \pm 9.47 \times 10^{-10}$	μCi/cc
3-S	Soil	$7.64 \times 10^{-5} \pm 1.59 \times 10^{-5}$	μCi/gram of dry soil
5-S	Soil	$8.28 \times 10^{-5} \pm 1.61 \times 10^{-5}$	μCi/gram of dry soil
20-S	Soil	$1.01 \times 10^{-4} \pm 1.51 \times 10^{-5}$	μCi/gram of dry soil
21-S	Soil	$1.09 \times 10^{-4} \pm 1.65 \times 10^{-5}$	μCi/gram of dry soil
2-G	Grass	$1.68 \times 10^{-4} \pm 2.18 \times 10^{-5}$	μCi/gram of dry ash
6-G	Grass	$1.74 \times 10^{-4} \pm 2.04 \times 10^{-5}$	μCi/gram of dry ash
7-G	Grass	$2.58 \times 10^{-4} \pm 2.72 \times 10^{-5}$	μCi/gram of dry ash
8-G	Grass	$2.44 \times 10^{-4} \pm 2.56 \times 10^{-5}$	μCi/gram of dry ash
9-G	Grass	$3.79 \times 10^{-4} \pm 3.26 \times 10^{-5}$	μCi/gram of dry ash
10-G	Grass	$4.20 \times 10^{-4} \pm 3.64 \times 10^{-5}$	μCi/gram of dry ash
12-G	Grass	$4.10 \times 10^{-4} \pm 3.47 \times 10^{-5}$	μCi/gram of dry ash
13-G	Grass	$2.21 \times 10^{-4} \pm 2.27 \times 10^{-5}$	μCi/gram of dry ash
14-G	Grass	$1.39 \times 10^{-4} \pm 2.07 \times 10^{-5}$	μCi/gram of dry ash
15-G	Grass	$1.51 \times 10^{-4} \pm 2.15 \times 10^{-5}$	μCi/gram of dry ash
16-G	Grass	$2.42 \times 10^{-4} \pm 2.44 \times 10^{-5}$	μCi/gram of dry ash
17-G	Grass	$1.61 \times 10^{-4} \pm 1.74 \times 10^{-5}$	μCi/gram of dry ash
18-G	Grass	$1.92 \times 10^{-4} \pm 2.34 \times 10^{-5}$	μCi/gram of dry ash
22-G	Grass	$2.94 \times 10^{-4} \pm 2.94 \times 10^{-5}$	μCi/gram of dry ash

(1) ± values represent the standard deviation of the average value at the 95% confidence level.

(2) Less than lower limit of detection value shown.

(3) Based on three quarterly samples. Location was dry during one sampling period.

Table V.E.4

Average LLD Concentration and Range of LLD Values for Soil, Water and Vegetation Samples

Sample Type	Average LLD Value	Range of LLD Values	Reporting Units
Soil	2.20×10^{-5}	1.07×10^{-5} to 3.52×10^{-5}	μCi/gram of dry soil
Water	2.67×10^{-8}	2.63×10^{-8} to 2.73×10^{-8}	μCi/cc
Vegetation	3.06×10^{-5}	1.28×10^{-5} to 6.07×10^{-5}	μCi/gram of dry ash

F. Radioactive Material Shipments

A summary of the radioactive material shipments orginating from the TRIGA reactor facility, NRC license R-106, is shown in Table V.F.1. A similar summary for shipments originating from the Radiation Center's state of Oregon radioactive materials license ORE-0005-3 is shown in Table V.F.2. A summary of radioactive material shipments exported under Nuclear Regulatory Commission general license 10 CFR 110.23 is shown in Table V.F.3.

Table V.F.1

Annual Summary of Radioactive Material Shipments Originating From the TRIGA Reactor Facility's NRC License R-106

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Oceanography Corvallis, OR	5.7×10^{-4}	--	--	4	--	4
Berkeley Geochronology Center Berkeley, CA	5.7×10^{-4}	11	--	2	--	13
University of California Berkeley, CA	9.6×10^{-4}	--	--	6	--	6
Stanford University Stanford, CA	1.1×10^{-4}	5	--	4	--	9
Idaho State University Pocatello, ID	1.3×10^{-2}	--	--	16	--	16
University of Washington Seattle, WA	1.3×10^{-7}	1	--	--	--	1
University of California Santa Barbara, CA	3.6×10^{-5}	3	--	1	--	4
UCLA Center for Health Sciences Los Angeles, CA	2.9×10^{-4}	--	--	2	--	2
University of Wyoming Laramie, WY	4.3×10^{-5}	4	--	--	--	4
U.S. Bureau of Mines Salt Lake City, UT	1.2×10^{-3}	--	--	1	--	1
Auburn University Auburn, AL	6.3×10^{-6}	1	--	--	--	1
Western Carolina University Cullowhee, NC	1.3×10^{-6}	1	--	--	--	1
SUNY-Plattsburgh Plattsburgh, NY	1.3×10^{-7}	2	--	--	--	2
SUNY-Stony Brook Stony Brook, NY	2.0×10^{-6}	1	--	--	--	1
Rensselaer Polytechnic Institute Troy, NY	1.4×10^{-5}	4	--	--	--	4
TOTALS	1.7×10^{-2}	33	0	36	0	69

Table V.F.2

Annual Summary of Radioactive Material Shipments Originating From the Radiation Center's State of Oregon License ORE-0005-3

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Oceanography Corvallis, OR	1.4×10^{-9}	1	--	--	--	1
Lawrence Berkeley Lab Berkeley, CA	4.2×10^{-6}	1	--	--	--	1
UCLA Center for Health Sciences Los Angeles, CA	2.4×10^{-4}	--	--	1	--	1
Michigan State Univ. East Lansing, MI	1.9×10^{-5}	--	--	2	--	2
TOTALS	2.6×10^{-4}	2	0	3	0	5

Table V.F.3

Annual Summary of Radioactive Material Shipments Exported Under NRC General License 10 CFR 110.23

Shipped To	Total Activity (Curies)	Number of Shipments				
		Excepted Package	Type A Quantity			Total
			White I	Yellow II	Yellow III	
Vrije University Amsterdam, The Netherlands	1.3×10^{-3}	--	--	2	--	2
Scottish Universities Research and Reactor Center Scotland, UK	2.6×10^{-4}	--	--	1	--	1
University of Geneva Geneva, Switzerland	2.6×10^{-6}	--	--	1	--	1
FAPIG Radiation Research Yokosuka, Japan	9.8×10^{-8}	2	--	--	--	2
TOTALS	1.3×10^{-3}	2	0	4	0	6

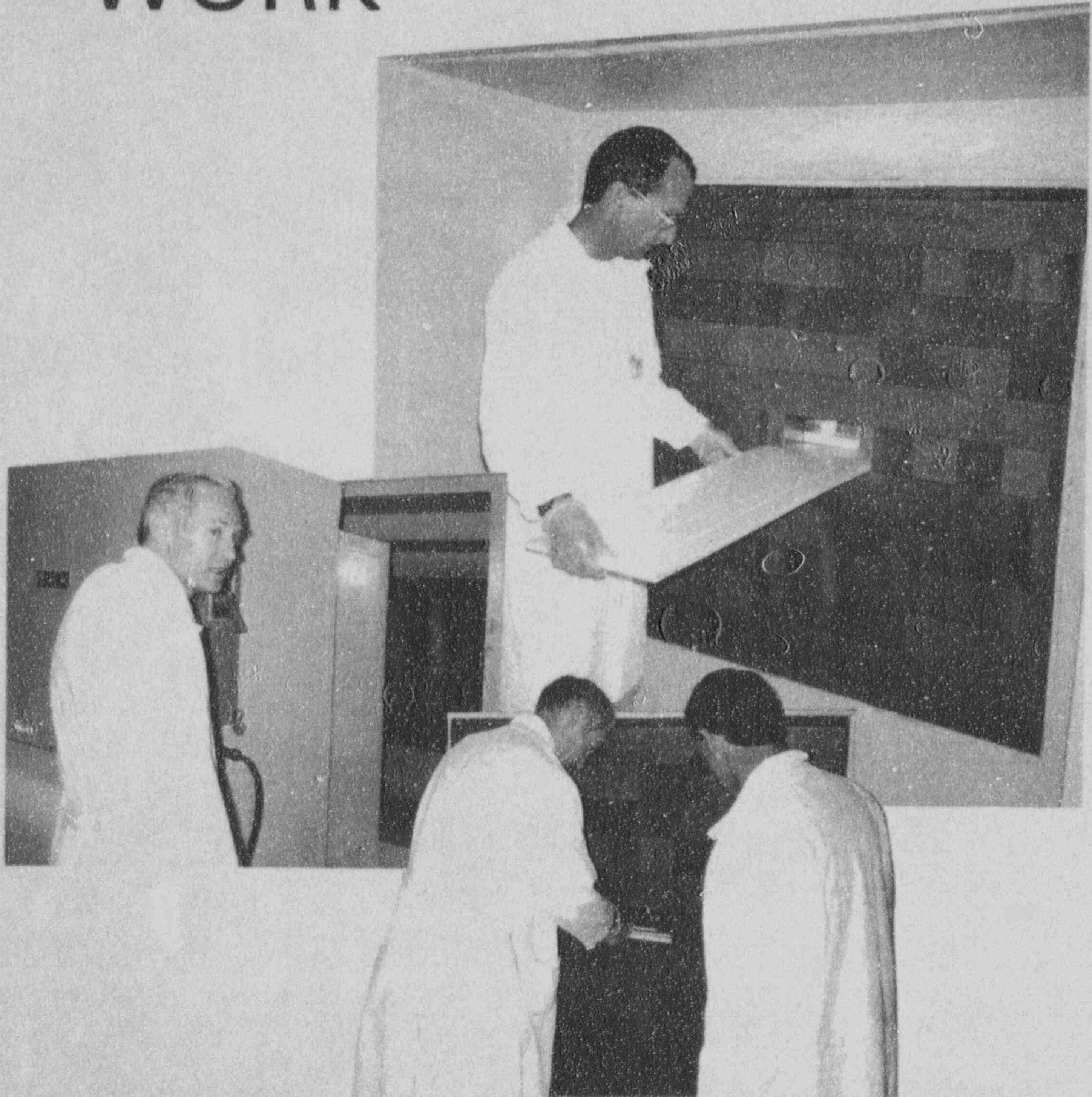
G. References

1. U.S. Environmental Protection Agency, "Estimates of Ionizing Radiation Doses in the United States, 1960-2000," ORP/CSD 72-1, Office of Radiation Programs, Rockville, Maryland (1972).

2. U.S. Environmental Protection Agency "Radiological Quality of the Environment in the United States, 1977," EPA 520/1-77-009, Office of Radiation Programs; Washington, D.C. 20460 (1977).

PART VI

WORK



PART VI

WORK

PART VI
WORK

A. Summary

The Radiation Center offers a large variety of resources for teaching, research and service related to radiation and radioactive materials. Some of these are discussed in detail in other parts of this report. The purpose of this part is to summarize the teaching, research and service efforts carried out during the current reporting period.

B. Teaching

The most important responsibility of the Radiation Center and reactor is to support OSU's academic programs. Implementation of this support occurs through direct involvement of the Center's staff and facilities in the teaching programs of various departments and through our participation in University research programs. For example, during the current reporting period, the Radiation Center accommodated 75 OSU academic classes involving a number of different academic departments. In addition, portions of classes from other Oregon universities were also supported by the Radiation Center. The OSU teaching programs (not including research) utilized 523 hours of reactor time. Tables III.A.1 and III.E.1 plus section VI.C.5 provide more detailed information on the use of the Radiation Center and reactor for instruction and training.

C. Research and Service

Almost all Radiation Center research and service work is tracked by means of a project system. When a request for facility use is received, a number is assigned to the project, a project sheet is generated, and the project is added to the database. The database includes such information as the project number, data about the person and institution requesting the work, a description of the project, Radiation Center resources needed, the Radiation Center project manager, estimated costs for the project, and the funding source.

Table VI.C.1 provides a summary of institutions and agencies which used the Radiation Center during this reporting period. This table also includes additional information about the number of academic personnel involved, the number of students involved and the number of uses logged for each organization. Details on graduate student research which used the Radiation Center are given in Table VI.C.2.

The major table in this section is Table VI.C.3. This table provides a listing of the research and service projects carried out during this reporting period and lists information relating to the personnel and institution involved, the type of project, and the funding agency. Projects which used the reactor are indicated by an asterisk.

In addition to identifying specific projects carried out during the current reporting period, Part VI also highlights major Radiation Center capabilities in research and service. These unique Center functions are described in sections VI.C.1 through VI.C.8.

Table VI.C.1

Institutions and Agencies Which Utilized the Radiation Center

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*Oregon State University[(1)] Corvallis, Oregon	45	31	26	210[(2)]
*U.S. Environmental Protection Agency Corvallis, Oregon	3	NA	NA	8
National Forage Seed Production Research Ctr Corvallis, Oregon	1	NA	NA	1
Corvallis Fire Department Corvallis, Oregon	1	NA	NA	5
*Alan Churchill Corvallis, Oregon	1	NA	NA	1
Good Samaritan Hospital Corvallis, Oregon	1	NA	NA	6
*Corvallis High School Corvallis, Oregon	1	1	1	1
Carden Academy Corvallis, Oregon	1	1	0	1
*Linn County Sheriff's Office Albany, Oregon	1	NA	NA	1
Oregon Department of Energy Salem, Oregon	2	NA	NA	7
*McNary High School Salem, Oregon	2	1	1	2
*Willamette University Salem, Oregon	3	2	1	4
U.S. Environmental Protection Agency Newport, Oregon	1	NA	NA	2
*Lincoln County Sheriff Newport, Oregon	1	NA	NA	2
*University of Oregon Eugene, Oregon	1	2	0	1
Molecular Probes Eugene, Oregon	1	NA	NA	28
Nancy Paulson Dayton, Oregon	1	NA	NA	1
*Oregon Health Sciences University Portland, Oregon	3	2	1	20

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(1) Use by Oregon State University does not include any teaching activities or classes accommodated by the Radiation Center.

(2) This number does not include ongoing projects being performed by residents of the Radiation Center such as the APEX project, Chemistry Department projects conducted by Dr. W. D. Loveland, or the bioremediation project being conducted by the College of Veterinary Medicine which involve daily use of Radiation Center facilities.

* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
Oregon State Health Division, Radiation Services Portland, Oregon	1	NA	NA	57
*Oregon Episcopal School Portland, Oregon	2	2	3	6
Army Corps of Engineers Portland, Oregon	1	NA	NA	2
*Oregon State Police Forensic Lab Portland, Oregon	1	NA	NA	1
*Portland Police Bureau Portland, Oregon	3	NA	NA	8
*Washington County Deputy District Attorney Hillsboro, Oregon	1	NA	NA	2
*Oregon State Police Bend, Oregon	1	NA	NA	1
MacSema Bend, Oregon	1	NA	NA	5
Roseburg Forest Products Roseburg, Oregon	1	NA	NA	1
Umpqua Research Company Myrtle Creek, Oregon	1	NA	NA	1
Altmont Elementary School Klamath Falls, Oregon	1	1	1	1
*University of Washington Seattle, Washington	3	2	1	3
*State Police Forensic Services Lab Ontario, Oregon	1	NA	NA	1
*College of the Siskiyous Weed, California	1	1	0	1
*California State University--Chico Chico, California	3	1	0	3
*Sonoma State University Rohnert Park, California	1	1	1	1
*Berkeley Geochronology Center Berkeley, California	1	1	0	22
*University of California--Berkeley Berkeley, California	2	2	1	6
*Stanford University Stanford, California	2	3	1	10
*Weltin, Van Dam and Flores Law Firm San Francisco, California	1	NA	NA	2
*University of California--Santa Cruz Santa Cruz, California	1	1	2	1

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* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*University of Idaho Moscow, Idaho	1	1	1	1
*Idaho State University Pocatello, Idaho	2	2	7	8
*University of Nevada--Reno Reno, Nevada	2	1	2	2
*U.S. Bureau of Mines Salt Lake City, Utah	1	NA	NA	1
*University of California--Santa Barbara Santa Barbara, California	1	1	1	4
*University of California--Los Angeles Los Angeles, California	4	3	1	7
GCP Technology Upland, California	1	NA	NA	4
*University of Wyoming Laramie, Wyoming	1	1	2	4
*University of Colorado Boulder, Colorado	3	3	1	5
*Eastern New Mexico University Portales, New Mexico	1	1	1	1
*Texas Tech University Lubbock, Texas	2	1	2	2
*Rice University Houston, Texas	2	2	1	2
*University of Wisconsin--Madison Madison, Wisconsin	2	1	0	2
*Southern Illinois University Carbondale, Illinois	1	1	1	1
*Indiana State University Terre Haute, Indiana	2	1	1	2
*Auburn University Auburn, Alabama	1	1	0	2
*College of Wooster Wooster, Ohio	1	2	1	1
*Clemson University Clemson, South Carolina	1	1	1	1
*University of North Carolina Chapel Hill, North Carolina	1	1	1	2
*Franklin & Marshall College Lancaster, Pennsylvania	2	1	2	2
*State University of New York Stony Brook, New York	1	1	1	1

* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*Rensselaer Polytechnic Institute Troy, New York	2	2	1	2
*City College of the City University of New York New York, New York	1	1	1	1
*Environmental Measurements Lab New York, New York	1	NA	NA	2
*State University of New York at Plattsburgh Plattsburgh, New York	1	1	2	2
*Johns Hopkins University Baltimore, Maryland	2	1	2	2
*Williams College Williamstown, Massachusetts	3	2	5	6
*Smith College Northampton, Masssachusetts	1	1	1	1
*George Washington University Washington, DC	1	1	2	2
*University of Florida Gainesville, Florida	2	2	4	2
*Kyoto Fission-Track Kyoto, Japan	1	NA	NA	3
*First Atomic Power Industrial Group--Japan Nagasaka, Yokosuka, Japan	1	NA	NA	1
*Scottish Universities Research & Reactor Centre Scotland, United Kingdom	1	1	0	4
*Vrije Universiteit Amsterdam Amsterdam, The Netherlands	1	1	0	1
*University of Geneva Geneva, Switzerland	1	1	0	2
TOTALS	152	95	85	622

* Project which involves the OSTR.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
OREGON STATE UNIVERSITY				
Al-Hussan, K.	PhD	Nuclear Engineering	Klein	Microdosimetry Anaysis and Calculations
Asghar, S.	MS	Nuclear Engineering	Reyes	A Study of Condensation Induced Water-Hammers in Passive Safety Systems
Bahmaid, M.	MS	Radiation Health	Higginbotham	Application of the Gamma Pathway Exemption Rule for Naturally Occuring Radioactive Materials in Industrial Waste
*Bae, J.	MS	Radiation Health	Higginbotham	Development of a Methodology to Accurately Inventory Activation Products
Betts, C.	PhD	Nuclear Engineering	Klein	Numerical Techniques for Coupled Neutronic/Thermal Hydraulic Nuclear Reactor Calculations
Baik, S.	PhD	Nuclear Engineering	Higginbotham	Not yet determined.
Brannan, C.	MS	Radiation Health	Higginbotham	Not yet determined.
Brock, T.	MS	Radiation Health	Higginbotham	Not yet determined.
Cantaloub, M.	MS	Radiation Health	Higginbotham	Analysis of Radioactive Material in Municipal Sewage
*Day, T.	PhD	Chemistry	Loveland	Measurement of Transferred Angular momentum and Polarization in the Reaction of 20-40 Mev/A ^{129}Xe With ^{238}U
DeKrey, G.	PhD	Toxicology	Kerkvliet	Investigation of the Mechanism of 3, 3′, 4, 4′, 5, 5′-Hexachlorobiphenyl-Induced Suppression of Cytotoxic T Lymphocite Activity in C57Bl/6 Mice: Endocrine and Cytokine Dysregulekion
Doucette, J.	PhD	Geosciences	Field	Petrochemical Study of the OK-Tedi Intrusive Complex, Papua New Guinea
*Dunn, J.	PhD	Chemistry	Loveland	Speciation of Plutonium in Aquatic Environmental Systems
*Eversmeyer, B.	PhD	Chem. Ocean.	Collier	Particle Chemistry of the Columbia River Estuary
Franz, S.	PhD	Nuclear Engineering	Reyes	Flow Instrumentation Development for the AP600 Reactor

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
Fundak, R.	MS	Nuclear Engineering	Higginbotham	Rapid Establishment of Emergency Areas as a Consequence of Large Scale Radioactive Material Releases from Fixed Nuclear Facilities
*Gallahan, W.	PhD	Oceanography	Duncan	Composition and Timing of Hydrothermal Circulation in Oceanic Crust: Evidence from the Troodos Ophiolite, Cyprus
Hassan, A.	MS	Chemistry	Gould	Biosynthesis of Mutant Metabolites
Hekkala, D.	MS	Radiation Health	Higley	A Methodology for Deriving Residual Contamination Levels in Soil at Remediated Hanford Sites
*Johnson, J.	MS	Radiation Health	Binney	Pituitary Tumor Therapy Using Boron Neutron Capture Therapy
*Johnson, J.	MS	Geosciences	Grunder	Geology and Petrology of the Duck Creek Butte Eruptive Center, High Lava Plains, Southeastern Oregon
*Kellar, M.	MS	Radiation Health	Dodd	Re-Evaluation of Dosimetry for Radiopharmaceuticals
Kim, Y.	MS	Civil Engineering	Semprini	Bioremediation of Chloroform Contamination
Kirchmeier, M.	MS	Chemistry	Gould	Biosynthesis of Mutant Metabolites
Lanoil, B.	PhD	Microbiology	Giovannoni	The Dynamics of Carbon Exchange in Coastal Vertically Stratified Bacterioplankton
Lee, H.	PhD	Nuclear Engineering	Klein	Development of An Advanced Computer Code for the Analysis of Multi-Phase Fluid Flow Phenomena
Lee, T.	PhD	Civil Engineering	Craig	In Vitro Anaerobic Trinitrotoluene (TNT) Degradation with Rumen Fluid and An Isolate, G.8.
Leon, L.	MS	Radiation Health	Higginbotham	State and Local Governments' Rights to Control Radioactive Material Transportation Through Their Borders
Lotrario, J.	MS	Environmental Engrg.	Craig	Nitro Group Reduction of five Aromatic Compounds by the Denitrifying Bacteria G.8.
Mankowski, M.	MS	Entomology	Morrell	Host Preference of Dampwood Termites on Western Wood Species
*Martin-Bandin, F.	MS	Radiation Health	Higginbotham	Real Time Measurement of High Energy Beta Particulates from Contaminated Soils

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
Miller, R.	MS	Radiation Health	Higginbotham	Not yet determined.
Nasir, A.	MS	Chemical Engineering	McGuire	Protein Mediated Displacement Using Radio Labelling
Naujok, M.	MS	Unknown	Gile	Effects of Elevated CO_2 on Soils
Pagh, R.	MS	Nuclear Engineering	Klein	Experimental Analysis of a Phase-Change Calibration Probe
Phillips, D.	MS	Microbiology	Bottomley	Isolation and Characterization of 2,4-D Degrading Bacteria from an Oregon Soil
Pimental, D.	MS	Nuclear Engineering	Reyes	Evaluation of the APEX Test Facility Break Flow
*Potter, N.	MS	Radiation Health	Higley	Calibration and Characterization of a TRIGA Beam Port Facility
Radley, J.	MS	Nuclear Engineering	Klein	RELAP5/MOD3 Analysis of a 1" cold Leg Break in the APEX Facility
Richardson, K.	MS	Radiation Health	Binney	Radioisotope Shielding Through Sand, Clay, and Low-Permeability Asphalt
Rynders, D.	MS	Radiation Health	Higginbotham	Not yet determined.
Saiyut, K.	MS	Radiation Health	Higginbotham	Not yet determined.
Shepherd, D.	PhD	Toxicology	Kerkvliet	Immunotoxicity of PCBs
*Shepherd, S.	PhD	Nuclear Engineering	Ringle	Chemonuclear Dissociation of Waste Materials
*Siadal, J.	MS	Radiation Health	Binney	Groundwater Leachability of Radioisotopes from Hanford Soil
*Sinton, C.	PhD	Oceanography	Duncan	The Caribbean Cretaceous Basalt Province: An Oceanic Plateau Formed by Mantle Plume Initiation
Stevens, O.	MS	Nuclear Engineering	Reyes	Evaluation of APEX Test Facility PRHR Heat Transfer
Stewart, D.	MS	Radiation Health	Dodd	Potential Doses to the Public from Dredged Columbia River Sediments
*Streck, M.	PhD	Geosciences	Grunder	Petrochemical Interpretation of the Rattlesnake Ash-Flow Tuff, Southeastern Oregon
Strom, D.	MS	Botany/Plant Pathology	Rivin	The Cloning of a Mutant Allele Causing Shootless Embryo Development in Maize

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* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
*Templeton, J.	PhD	Geosciences	Grunder	Chemical Zoning in Ash-Flow Tuffs from Nevada
Tiyapun, K.	MS	Radiation Health	Higginbotham	Not yet determined.
*Torne, E.	MS	Geosciences	Field	Geochemistry and Petrogenesis of Sphalerite from the San Vicente Deposit, Peru
*Vostmyer, C.	MS	Radiation Health	Binney	Neutron Beam Design Optimization for Boron Neutron Capture Therapy
Will, Y.	MS	Biochemistry	Craig	Test of an Isolate from Whole Rumen Fluid for Its Ability to Bioremediate Trinitrotoluene (TNT) Under Anaerobic Conditions
Wise, M.	PhD	Pharmacy/Biochemistry	Gerwick	Biosynthesis of Fatty Acids Metabolytes in Marine Algae
Wu, R.	MS	Radiation Health	Dodd	Determination of Total Effective Dose Equivalent from Columbia River Sediments
Zyromski, K.	PhD	Chemistry	Loveland	Fusion Enhancement Using Neutron-Rich Radioactive Beams
UNIVERSITY OF WASHINGTON				
Anders, N.	PhD	Geosciences	Nelson	Chemical and Isotope Systematics of the Tholerite to Alkalic Basalt Transition, Molokai and Waianai Volcanoes, Hawaii
UNIVERSITY OF CALIFORNIA -- BERKELEY				
*Mansouri, A.	PhD	Nuclear Engineering	Olander	Fission Product Diffusion in UO^{2+x}
UNIVERSITY OF IDAHO				
*Ricketts, A.	MS	Geology	Wood	Behavior of REE in Allanites in Casto Pluton, Central Idaho
IDAHO STATE UNIVERSITY				
*Cowatch, D.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 625
*Madden, D.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 625
*Meehan, C.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 625

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
*Reid, T.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 625
*Van Hoff, S.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 625
*Clovis, D.	MS	Geology	Hugues	INAA Studies for Geological Research -- Geology 615
*Glover, J.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 615
*Matarese, J.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 615
*McKnight, K.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 615
*Serrano, S.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 615
*Warren, I.	MS	Geology	Hughes	INAA Studies for Geological Research -- Geology 615
*Parker, J.	MS	Geology	Hughes	Field, Petrologic, and Geochemical Studies of the Tuff of Wooden Shoe Bute, Cassia County, Idaho
*Reed, M.	MS	Geology	Hughes	Stratigraphic Correlations and Characterization of Basalt Flows Beneath the Idaho Chemical Processing Plant, Idaho
*Watkins, A.	ME	Geology	Hughes	Geochemistry, Petrography and Stratigraphy of the Tuff of Steer Basin, Cassia County, Idaho
UNIVERSITY OF CALIFORNIA -- SANTA BARBARA				
*Calvert, A.	PhD.	Geological Sciences	Gans	Tectonic Studies in Eastern-Most Russia
UNIVERSITY OF CALIFORNIA -- LOS ANGELES				
*Castellana, B.	PhD	Earth & Space Science	Davidson	Surveys and Differences of Magmas from Avachinsley Volcano, Kamchatka, Russia
UNIVERSITY OF WYOMING				
*Strecker, U.	PhD	Geology & Geophysics	Steidtmann	Apatite Thermochronology of the Black Hills, South Dakota

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
UNIVERSITY OF COLORADO				
Shiroma, J.	MS	Geological Sciences	Stern	Genesis of Holocene Basaltic Centers Located Along the Liquine-Ofqui Fault, Southern Chile
*Verplanck, P.	PhD	Geological Sciences	Farmer	Petrogenesis of a Compositional Zoned, Epizonal Magma Body: A Detailed Geochemical Study of the Organ Needle Pluton, South-Central New Mexico
TEXAS TECH. UNIVERSITY				
*Johnson, K.	PhD	Geosciences	Barnes	Petrogenesis of the Tonalite-Trondhjemite Association, Cornucopia Stock, Eastern Oregon
*Schmidt, B.	PhD	Geosciences	Barnes	Petrology of the English Peak Intrusive Suite, Central Klamath Mountains, California
*Shannon, W.	PhD	Geosciences	Barnes	Petrogenesis of Middle Proterozoic Alkaline Granitic Rocks, Franklin Mountains, West Texas
RICE UNIVERSITY				
*Poole, A.	MA	Geology & Geophysics	Sisson	Implications of Triple Junction Migration on the Chugach Metamorphic Complex, Southeastern Alaska
INDIANA STATE UNIVERSITY				
*Li, X.	MA	Geology	de Silva	Petrogenesis of Lavas from Minor Centers in Peru
UNIVERSITY OF NORTH CAROLINA -- CHAPEL HILL				
*Waits, J.	MS	Geology	Glazner	Geochemical and Isotopic Variability of Xenolith Bearing Basalts in E. California
STATE UNIVERSITY OF NEW YORK -- STONY BROOK				
*Rasbury, T.	PhD	Earth & Space Sci.	Hansen	Uranium Concentrations in Sedimentary Rocks and Use in Age Dating

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
RENSSELAER POLYTECHNIC INSTITUTE				
*Zhang, Y.	MS	Geology	Miller	Thermal History of Sedimentary Basins
CITY COLLEGE OF NEW YORK				
*Chessman, S.	MS	Earth & Atmos. Sci.	Steiner	Meta-Diabasic Dikes Swarm Along Cameron's Line, New York City
STATE UNIVERSITY OF NEW YORK -- PLATTSBURGH				
*Mora, J.	PhD	Earth & Environ. Sci.	Roden-Tice	Analysis of S. Venezuelan Andes to Determine the Timing of Their Uplift
*Weber, J.	PhD	Earth & Environ. Sci.	Roden-Tice	Analysis of S. Venezuelan Andes to Determine the Timing of Their Uplift
JOHNS HOPKINS UNIVERSITY				
*McCormick, K.	MS	Geology	Marsh	Petrogenesis of Rhyolite on Rapa Nui (Easter Island), Chile
*Wheelock, M.	PhD	Earth & Planet. Science	Marsh	Not yet determined.
GEORGE WASHINGTON UNIVERSITY				
*W. Abbey	MS	Geology	Tollo	Geology and Emplacement History of the Polly Wright Cove Pluton, Blue Ridge Province, Virginia
*Ceci, V.	PhD	Geology	Tollo	Petrology of the Striped Rock Pluton, Blue Ridge Province, Virginia
KYOTO UNIVERSITY, JAPAN				
*Iwano, H.	PhD	Science	Danhara	Recognition of Track Registration Efficiency and Unetchable Track Range in Minerals
UNIVERSITY OF GENEVA, SWITZERLAND				
*Parlak, O.	MS	Geology	Singer	^{40}Ar/^{39}Ar Constraints on Timing of Emplacement of the Mersin Ophrolite, Turkey

* Thesis research which utilized the OSTR.

Table VI.C.3

Listing of Major Research and Service Projects Performed or in Progress at the Radiation Center and Their Funding Agencies

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
118	G. Larson M. Herley	National Park Service, OSU Cooperative Studies Unit	Crater Lake	Study of the primary production of phytoplankton in Crater Lake using ^{14}C labelled substances.	Forestry, OSU
*321	J. Steidtmann Strecker Murphy	Geology and Geophysics, University of Wyoming	Foreland Investigation	Fission track determination of the location of ^{235}U, ^{238}U and ^{232}Th in natural rocks and minerals.	University of Wyoming
*444	R. Duncan C. McElwee D. Desonie	Oceanography, OSU	^{40}Ar-^{39}Ar Dating	Production of ^{39}Ar from ^{39}K to measure radiometric ages on basaltic rocks from ocean basins.	Oceanography, OSU
480	B. Dodd J. Higginbotham	Radiation Center, OSU	RC Technical Support to Oregon DOE and Department of Human Resources	Technical support to the state of Oregon to assist in emergency preparedness for the PGE-TROJAN facility.	Radiation Center, OSU
481	L. Winans	Oregon Health Sciences University	Calibration of Radiation Survey Instruments	Survey instrument calibration for the Oregon Health Sciences University.	Oregon Health Sciences University
488	R. Farmer	Radiation Safety Office, OSU	Calibration of Portable Survey Instruments	Calibration of portable radiation survey instruments for radiation users on OSU campus.	Radiation Center, OSU
489	N. Goevelinger	Oregon State Health Division, Radiation Protection Services	Calibration of Radiation Protection Services Portable Survey Instruments	Calibration of portable radiation survey instruments for Oregon Radiation Protection Services.	Radiation Protection Services, OSHD
519	B. Livingstone J. Gile P. Monaco	USEPA, Corvallis	Instrument Calibration	Calibration of EPA portable radiation survey meters.	USEPA, Corvallis
*521	J. Vance	Geological Science, University of Washington	Fission Track Studies	Thermal column irradiation of zircon and other samples to induce fission tracks in catcher foils for dating.	Dept. of Geological Science, University of Washington
547	B. Boese	USEPA, Newport	Survey Instrument 2Calibration	Calibration of GM and other portable survey meters.	USEPA

* Project which involves the OSTR.

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
554	K. Niles D. Stewart-Smith	Oregon Department of Energy	Instrument Calibration for Oregon Department of Energy	Instrument calibration of survey meters for PUC truck inspectors.	Oregon Department of Energy
640	J. Higginbotham	Radiation Center, OSU	Investigation of the Response of Glass Calibration Capsules to High Energy Gamma Ray Irradiation	Determination of the dose response of glass personnel radiation dosimeters.	Radiation Center, OSU
664	M. Huntington	Good Samaritan Hospital, Special Imaging	Instrument Calibration, Radiation Survey Instruments	Calibration of radiation survey instruments.	Radiation Center, OSU
665	D. VanPelt	Corvallis Fire Department	Instrument Calibration, Radiation Survey Instruments	Calibration of radiation survey instruments.	Radiation Center, OSU
708	J. Reyes	Nuclear Engineering, OSU	AP600 Long Term Cooling Test	Fabrication and testing of a scale model of a section of the Westinghouse AP600 reactor cooling system.	Westinghouse
711	D. Mattson R. Baker	Veterinary Medicine, OSU	Diagnostic Biology	Sterilization of serum in ^{60}Co irradiator.	Veterinary Medicine, OSU
*722	R. Beard	U.S. Bureau of Mines--Salt Lake City, Utah	^{95}Zr Tracer Production	Production of ^{95}Zr by irradiation of ultra-pure Zr in the OSTR.	U.S. Bureau of Mines
724	J. Higginbotham J. Liedtke	Nuclear Engineering, OSU	Laboratory Preparedness for Radiological Emergency Response	Development of analysis procedures to ensure quick response to large-scale radiological emergencies.	Oregon Department of Energy
745	T. Clarke	University Hospital, Oregon Health Sciences University	Gamma Sterilization	Irradiation of various medicinals to OHSU-specified doses in ^{60}Co irradiator for the purpose of sterilization.	Radiation Center, OSU
*751	B. Albertson S. Binney S. Martsolf J. Johnson C. Vostmyer	Medicine/Endocrinology, Oregon Health Sciences University; Radiation Center, OSU	Pituitary Tumor Therapy Using Boron Neutron Capture Therapy	Irradiation of tissue samples containing ^{10}B compounds to enhance cell killing in B-loaded cells.	Oregon Health Sciences University
756	M. Craig S. Smith D. Wachenheim D. Bilich	Veterinary Medicine, OSU	Bacterial Incubation with ^{14}C-Trinitrotoluene	Incubation of bacteria in ^{14}C-labelled TNT with analysis and separation of metabolic products by liquid scintillation counting and other methods.	Veterinary Medicine, OSU

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
815	J. Morrell M. Mankowski C. Sexton	Forest Products, Entomology, OSU	Sterilization of Wood Samples for Fungal Evaluations	Sterilization of wood samples in ^{60}Co irradiator (Gammacell 220).	Forest Products, OSU
*838	M. Kasuya	Kyoto Fission-Track Co., Ltd., Japan	Fission Track Dating of Geologic Materials	Thermal column irradiation of geologic materials for fission track age dating.	Kyoto Fission-Track Co., Ltd.
842	P. Millard	Molecular Probes, Eugene, Oregon	Viability of Bacillus Subtillus Spores	^{60}Co irradiation of spore samples.	Molecular Probes
*846	H. Shioda	First Atomic Power Industrial Group (FAPIG), Japan	Irradiation and Analytical Support	Irradiation and analytical support for studies being carried out by FAPIG.	FAPIG, Japan
*866	D. Olander A. Mansouri	Nuclear Engineering, University of California--Berkeley	Fission Product Migration in UC$_2$ Disks	Irradiation of depleted UO$_2$ disks for evaluation of fission product migration.	Nuclear Engineering, University of California--Berkeley
*867	S. Shepherd J. Ringle	Nuclear Engineering, OSU	Chemonuclear Dissociation	Irradiation of chemicals in X-ray, ^{60}Co and reactor to induce breakdown of molecules.	Nuclear Engineering, OSU
*920	T. Becker	Berkeley Geochronology Center	Ar-Ar Dating	Production of ^{39}Ar from ^{39}K to determine ages in geologic materials.	Berkeley Geochronology Center
928	C. Palm	USEPA, Corvallis	Fate & Persistence of Transgenic Plant Protein in Soil	^{60}Co irradiation to sterilize soil samples.	Mantech Environmental
*930	M. McWilliams B. Hacker C. Gansecki	Geophysics, Stanford University	^{40}Ar/^{39}Ar Dating of Geologic Samples	Irradiation of mineral grain samples from specified tiles to allow ^{40}Ar/^{39}Ar dating.	Stanford University
931	N. Kerkvliet P. Lawrence	Agricultural Chemistry, OSU	Study Effects of TCDD on T-Cell Activation, Using T-h Cell Clones	^{60}Co irradiation of spleen cells from mice.	Agricultural Chemistry, OSU
*932	T. Dumitru	Geology, Stanford University	Fission Track Dating	Thermal column irradiation of geological samples for fission track age dating.	Geology, Stanford University

* Project which involves the OSTR.

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*936	E. Torne C. Field	Geosciences, OSU	Geochemistry and Petrology of the San Vicente Rhythmite Deposit, Peru	Determination of major and trace element components of carbonate host rock and Zn-Pb ore-bands of the San Vicente Deposit, Peru.	Radiation Center, OSU (Unfunded Research)
*949	D. Miller C. Ravenhurst Y. Zhang	Earth and Environmental Sciences, Rensselaer Polytechnic Institute	Thermal History of Rocks	Study thermal history of rocks using the fission track analysis of apatite and zircons.	USDOE (Reactor Use Sharing)
*950	P. Mueller R. Moss C. Beauvais	Geology, University of Florida	Evolution of Middle to Early Archean Crust in the Beartooth Mountains	Senior student projects involving major, trace and isotopic data analysis.	USDOE (Reactor Use Sharing)
*960	R. Warner N. Kidd	Earth Sciences, Clemson University	Crystallization of Pyroxene and Spinel Group Minerals in Diabase Dikes	INAA of basaltic diabase samples for control of geochemistry of different dikes.	USDOE (Reactor Use Sharing)
*966	S. Hughes M. McCurry M. Reed J. Parker	Geology, Idaho State University	Instrumental Neutron Activation Analysis of Geologic Materials	INAA to support geochemical classes, and research conducted by graduate students and faculty at Idaho State University.	USDOE (Reactor Use Sharing)
*969	R. Fifarek P. Jones	Geology, Southern Illinois University	Quantitative Fluorescence, Cathodoluminescence, Chromiticity, and Trace Element Characteristics of Fluorite from the Cave-in-Rock District, Illinois	Investigation of the association of trace element contents in fluorite with color and fluorescent and cathodoluminescent response.	USDOE (Reactor Use Sharing)
*972	R. Wiebe S. Adams J. Lien	Geosciences, Franklin & Marshall College	Origin of Siluro-Devonian Plutonic and Volcanic Rocks on the Northern Coast of Maine	Study of plutonic rocks to understand petrogenic relations between associated mafic and silicic rocks.	USDOE (Reactor Use Sharing)
*973	R. Wobus J. Phipps W. Cunningham E. Fung	Geology, Williams College	Mapping and Sampling Paleozoic Metavolcanic Rocks Along the Main Coast East of Mt. Desert Island	Mapping and sampling Paleozoic metavolcanic rocks along the Maine Coast east of Mt. Desert Island to categorize magma source regions and tectonic environments at the time of volcanism.	USDOE (Reactor Use Sharing)
*974	D. McCreery	Willamette University	The Tell Nimrin Project	Analysis of soil and botanical samples from Jordan.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR.   INAA = Instrumental Neutron Activation Analysis   REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*975	R. Schweickert	Geological Sciences, University of Nevada--Reno	Geochemical Provenance Discrimination of Terranes in Western Nevada and the Northern Sierra Nevada of California	Comparison of the geochemistry and implied provenances of the Mesozoic sedimentary rocks from several adjacent terranes.	USDOE (Reactor Use Sharing)
*976	A. Skinner M. Rudolph	Chemistry, Williams College	Electron Spin Resonance Dating of Geological and Archaeological Materials	INAA of flint artifacts for electronic spin resonance dating.	USDOE (Reactor Use Sharing)
*977	T. Kato	Geosciences, California State University--Chico	Coarse Crystalline Blueschists from the Coastal Range of Central Chile	INAA of coarse crystalline blueschists to assess trace element content.	USDOE (Reactor Use Sharing)
*978	R. Duncan M. Pringle	Oceanic and Atmospheric Sciences, OSU; University of Amsterdam	^{40}Ar-^{39}Ar Dating	B-ring irradiation for production of ^{39}Ar from ^{39}K to determine radiometric ages of volcanic rocks from seafloor and continents.	Oceanic and Atmospheric Sciences, OSU
*980	R. Collier J. Dymond B. Conard	Oceanic and Atmospheric Sciences, OSU	Joint Global Ocean Flux Study	INAA of sediment trap materials from equatorial Pacific.	Oceanic and Atmospheric Sciences, OSU
983	J. McGuire A. Nasir	Bioresource Engineering, OSU	Liquid Scintillation Counting of ^{14}C	Instruction in liquid scintillation counting and assistance with sample counting.	Bioresource Engineering, OSU
*985	R. Schmitt Y.-G. Liu	Radiation Center, OSU	Petrogenesis of Yucca Mountain (Nevada) Travertines and Other Yucca Mountain Rocks, Soils, Sediments, Etc.	INAA of Yucca Mountain samples to test supergene or hypogene hypothesis.	Technology Resources Assessment Corporation, Boulder, CO
995	P. Bottomley T. Sawyer	Microbiology, OSU	Herbicide Mineralization in Agricultural Soils	^{60}Co soil sterilization.	Crop and Soil Science, OSU
998	C.-A. Huh	Oceanic and Atmospheric Sciences, OSU	Cesium-137 Determination in Dry Sediments	Assessment of ^{137}Cs concentrations in sediment samples.	Oceanic and Atmospheric Sciences, OSU
999	D. Shepherd N. Kerkvliet	Agricultural Chemistry, OSU	Immunotoxicity of PCBs	Use of antibodies to deplete immune cells; ^{60}Co irradiation of mice to suppress immune system.	Agricultural Chemistry, OSU

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1002	B. Singer	Mineralogy, University of Geneva	^{40}Ar/^{39}Ar Dating of Young Geological Materials	CLICIT irradiation of geological materials for ^{40}Ar/^{39}Ar dating.	University of Geneva
*1003	G. Hansen T. Rasbury	Earth and Space Sciences, State University of New York--Stony Brook	Fission Track Dating of Geological Materials	Fission track irradiations in the thermal column.	State University of New York--Stony Brook
*1004	S. Binney J. Siadal	Nuclear Engineering, OSU	Measurement of Vitrified Glass Leach Rates	Irradiation and counting of samples to determine radioisotopes present.	Nuclear Engineering, OSU
1006	S. Gould M. Kirchmeier A. Hassan	Chemistry, OSU	Biosysthesis of Mutant Metabolites	Liquid scintillation counting of ^{14}C labelled glucose samples.	Chemistry, OSU
*1010	A. Grunder J. Templeton	Geosciences, OSU	Chemical Zoning in Ash-Flow Tuffs from Nevada	Use of trace element signatures to document chemical zonation in zoned tuffs.	Radiation Center, OSU (Unfunded Research)
*1017	M. Streck	Radiation Center, OSU	A Glimpse into the Upper Crustal Structure of the Harney Basin, Eastern Oregon	Provenance study of lithic fragments from the Rattlesnake Tuff.	Radiation Center, OSU (Unfunded Research)
1018	L. Gashwiler	Occupational Health Laboratory, Portland	Calibration of Nuclear Instrumentation for the Oregon Occupational Health Laboratory	Calibration of radiation survey meters for the Oregon Occupational Health Laboratory.	Consumer & Business Services, Fiscal Section
*1019	R. Erickson T. Hartman	Geology, Sonoma State University	Rare Earth Correlation of Three Separate Metapelite Bodies in the Dose Cabezas Mountains, Arizona	Further analysis of phyllite samples for rare-earth concentrations to be plotted and correlated with field, petrographic and geochemical data.	USDOE (Reactor Use Sharing)
*1020	P. Gans A. Galvert	Geological Sciences, University of California--Santa Barbara	Tectonic Studies in Eastern-Most Russia	Irradiation for ^{40}Ar-^{39}Ar dating using the CLICIT or dummy fuel element.	University of California--Santa Barbara
*1021	T. Kato	Geosciences, California State University--Chico	Possible Local Origins for the Lovejoy Basalt in Northern California	INAA of basalt sample to determine petrogenesis of the basalt and implications for regional stratigraphic correlation.	USDOE (Reactor Use Sharing)

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1022	K. Hoernle H. Schmincke J. Gill	Earth Sciences, University of California--Santa Cruz	Iblean Hills and Island of Linosa (Sicily) Basalt Determinations	Determination of OIB, MORB, arc affinities, and trace element characteristics of basalt rock samples.	USDOE (Reactor Use Sharing)
*1023	E. Torne	Radiation Center, OSU	Calibration of New NBS-standard SRM 688 (Basalt) and SRM 278 (Obsidian; NIST-standard)	Determination of trace and major element components using INAA.	Radiation Center, OSU
1024	J. Trowbridge	MacSema, Bend, Oregon	Gamma Sensitivity of Memory Buttons	Gamma irradiation of memory buttons to determine the failure dose.	MacSema
1025	L. Semprini Y. Kim	Civil Engineering, OSU	Sterilization of Subsurface Soil	Soil sterilization in order to investigate the bioremediation of chloroform contamination.	Civil Engineering, OSU
*1026	B. Gerwick M. Wise	Pharmacy and Biochemistry, OSU	Determination of Metals in an Enzyme	INAA of 90 mg of an enzyme to determine if any metals are present.	Radiation Center, OSU (Unfunded Research)
*1027	P. Streb R. Beeson	Weltin, Van Dam and Flores, Law Firm	Forensic Comparison of Paint/Chips	INAA of paint and paint chips to determine if one vessel ran into another.	Weltin, Van Dam and Flores
1028	N. Paulson	private citizen	Consultation on Bioeffects of Radiation	Provide consultation on potential biological effects of childhood radiation exposure.	Radiation Center, OSU
1029	K. Niles	Oregon Department of Energy	Technical Assistance for Radiological Emergencies	Provide technical assistance to Oregon Department of Energy during the TRANSAX exercise.	Radiation Center, OSU
*1030	A. Glazner J. Waits	Geology, University of North Carolina	Geochemical and Isotopic Variability of Xenolith-Bearing Basalts in Eastern California	Detailed geochemical and isotopic study of two basalt vents in eastern California.	USDOE (Reactor Use Sharing)
*1031	C. Barnes K. Latter	Geosciences, Texas Tech University	Petrology of Crustal Xenoliths from Potrillo Maar, Northern Mexico	Study of the petrography, petrology, and elemental geochemistry of a suite of crustal xenoliths from Potrillo Maar volcano.	USDOE (Reactor Use Sharing)

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1033	W. Hirt	College of the Siskiyous	Compositional Zonation of the Mount Whitney Intrusive Suite, Eastern Sierra Nevada, California	Characterization of recently recognized mafic dike rocks to better determine the nature of internal zoning and the effects of aplite segregation in the middle (Paradise) pluton.	USDOE (Reactor Use Sharing)
*1034	M. Skewes	Geological Sciences, University of Colorado--Boulder	Geochemistry of Andean Igneous Rocks	Study of the chemistry and petrogenesis of Andean igneous rocks related to ore deposits.	USDOE (Reactor Use Sharing)
*1035	C. Stern	Geological Sciences, University of Colorado--Boulder	Chemical fingerprinting of Obsidian Artifacts from Patagonia	Determination of the chemical composition of rhyolite obsidian artifacts found in archaeological sites in Patagonia, South America.	USDOE (Reactor Use Sharing)
*1036	C. Barnes K. Johnson	Geosciences, Texas Tech University	Mesozoic Magmatism Associated with Terrane Accretion, Blue Mountains, Oregon	Characterization of the compositional nature of Mesozoic plutons to identify the tectonic processes by which accretion occurred.	USDOE (Reactor Use Sharing)
*1037	D. Smith	Geology, Trinity University	Petrology and Geochemistry of Proterozoic Granites, Llano Uplift, Texas	INAA to determine which petrologic processes were important in the origin and evolution of granitic magmas emplaced in the Llano Uplift.	USDOE (Reactor Use Sharing)
*1038	P. Mueller A. Heatherington G. Trude L. Horn K. D'Arcy	Geology, University of Florida	Precambrian Infrastructure of the Southern Appalachian Orogen (SAO)	Identification and characterization of Precambrian lithologic associations in the SAO to aid in reconstructing the origin and evolution of SAO exotic terranes.	USDOE (Reactor Use Sharing)
*1039	R. Wiebe S. Adams	Geosciences, Franklin and Marshall College	Co-mingling Between Different Silicic Magmas	Study of the geochemistry of shallow-level silicic plutonic rocks located in coastal Maine.	USDOE (Reactor Use Sharing)
*1040	S. Olsen	Geology and Geophysics, University of Wisconsin--Madison	A Preliminary Geochemical Study of Amitsog and Nuuk Gneisses, Southwest Greenland	Comparison of geochemical data from high grade gneisses from the two formations in the Nuuk area.	USDOE (Reactor Use Sharing)
*1041	M. Roden-Tice J. Mora J. Weber	Earth and Environmental Science, SUNY College at Plattsburgh	Fission-Track Thermochronologic Research	Determination of the location of ^{235}U and ^{238}U in natural rocks and minerals by using fission-tracks.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1042	J. Davidson B. Castellana	Earth and Space Sciences, University of California--Los Angeles	Temporal and Spatial Geochemical Variations Across the Damchatka Arc: An Evaluation of Mantle and Crustal Contributions to Arc Magmatism	Comparison of volcanic rocks of different ages to study changes in the compositions of magmas through time.	USDOE (Reactor Use Sharing)
*1043	D. Miller C. Ravenhurst Y. Zhang	Earth and Environmental Science, Rensselaer Polytechnic Institute	Thermal History of Rocks	Study of the thermal history of rocks using the fission track analysis of apatites and zircons.	USDOE (Reactor Use Sharing)
*1044	D. McCreery	Willamette University	Investigation of the Ancient Environment and Agricultural Practices in the Jordan Valley	INAA of ancient soil and botanical samples to reconstruct ancient trade patterns	USDOE (Reactor Use Sharing)
*1045	G. Farmer P. Verplanck	CIRES, University of Colorado--Boulder	Geochemistry of the Organ Needle Pluton	Identification of the processes responsible for the generation of zoned magma bodies as well as understanding how silicic magmas are formed.	USDOE (Reactor Use Sharing)
*1046	S. Hughes M. McCurry 7 grad students	Geology, Idaho State University	INAA of Geologic Materials	INAA of geologic materials for use in classes taught at Idaho State.	USDOE (Reactor Use Sharing)
*1047	T. Kato	Geosciences, California State University--Chico	The Distribution and Petrogenetic Relationships of Mid-Miocene Tholeiitic Basalts of Northern California	Investigation of the belief that Northern Sacramento Valley basalts are remnants of flows originating in western Nevada.	USDOE (Reactor Use Sharing)
*1048	R. Tollo W. Abbey S. Semick	Geology, George Washington University	Petrology and Geochemistry of Late Proterozoic Anorogenic Granitoids of the Central and Southern Blue Ridge Geologic Province	Geochemical analyses of granite samples to gain an understanding of the magmatic processes operative during the early states of continental extension and rifting.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR.

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1049	J. Steiner S. Chessman	Earth and Atmospheric Science, City College of New York	Newly Discovered Intrusive Dike Swarms Near Cameron's Line, New York City Water Tunnel Construction Site	Determination of the geochemistry of dike rocks and amphibolites in dike swarms in New York City.	USDOE (Reactor Use Sharing)
*1050	A. McBirney E. Sonnenthal	Geological Science, University of Oregon	Compilation and Analysis of Twenty-Five Years of Work on the Skaergaard Intrusion	Final analyses of Skaergaard Intrusion samples in order to fill gaps in data or investigate anomalies.	USDOE (Reactor Use Sharing)
*1051	W. Leeman	Geology and Geophysics, Rice University	Petrogenesis of Alkalic Basalts from the Eastern Snake River Plain	Evaluation of the origin and evolution of unusual basaltic lavas related to interaction of the Yellowstone hotspot with the North American tectonic plate using trace element data.	USDOE (Reactor Use Sharing)
*1052	S. de Silva	Geography and Geology, Indiana State University	The Origin and Significance of Silicic Magmas in the Central Andes	INAA of volcanic samples to gain understanding of the origin of magmas critical to models of magmagenesis.	USDOE (Reactor Use Sharing)
*1053	V. Sisson A. Poole	Geology and Geophysics, Rice University	Implications of Triple Junction Migration on the Chugach Metamorphic Complex, Southeastern Alaska	INAA of samples from the eastern end of the Chugach Metamorphic Complex to determine a more complete history of the complex.	USDOE (Reactor Use Sharing)
*1054	B. Epperson J. Garcia	Chemistry, McNary High School	Analysis of Heavy Metal Build-Up in Fireplace Ash from a Variety of Homes	Analysis of fireplace ash to determine buildup of heavy metal ions in different types of burnable fuel.	USDOE (Reactor Use Sharing)
*1055	R. Schweickert D. Davis L. Garside	Geological Sciences, University of Nevada--Reno	Geochemical Provenance Discrimination of Terranes in Western Nevada and the Northern Sierra Nevada of California	Comparison of the geochemistry and implied provenances of the Mesozoic sedimentary rocks.	USDOE (Reactor Use Sharing)
*1056	S. Wood A. Ricketts	Geology, University of Idaho	Behavior of REE in Allanites in Casto Pluton, Central Idaho	Characterization of the alteration products, if any, of the REE-Th bearing mineral allanite in the Eocene pink granite of the Casto Pluton, Central Idaho.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR.

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1057	B. Marsh K. McCormick	Earth and Planetary Sciences, Johns Hopkins University	The Petrogenesis of Rhyolite on Rapa Nui (Easter Island), Chile	Recognizing and understanding the process(es) by which oceanic islands produce rhyolitic material.	USDOE (Reactor Use Sharing)
*1058	S. de Silva X. Li	Geography and Geology, Indiana State University	Petrogenesis of Lavas from Minor Centers in Peru	INAA of andesite and basaltic andesite samples to understand the origin and evolution of the magmas beneath the arc in Peru.	USDOE (Reactor Use Sharing)
*1059	B. Nelson	Geological Sciences, University of Washington	Origin of Cenozoic Volcanism in the Chortis Block, Guatemala	INAA of granitic rock samples to determine the origins of Guatemalan granites.	USDOE (Reactor Use Sharing)
*1060	R. Varga L. Bettison-Varga D. Kreeger	Geology, The College of Wooster	Structural Development of Interference Accommodation Zones in Extensional Orogens	Geochemical study of volcanic rocks in a well-exposed interference accommodation zone in Arizona to delineate changes in magma source areas and depths as they might relate to the progress of extension.	USDOE (Reactor Use Sharing)
*1061	B. Marsh M. Wheelock	Earth and Planetary Science, Johns Hopkins University	Mechanisms for Chemical and Physical Differentiation in Basaltic Sills	Characterization of the physical mechanisms that produce chemical differentiation in thick basaltic sills.	USDOE (Reactor Use Sharing)
1062	J. Selby	Carden Academy	Atoms for 5-8 Grade Students	Presentation on the nature of atoms and fission and answer questions.	USDOE (Reactor Use Sharing)
*1063	R. Hemphil H. Gregory	Chemistry, Oregon Episcopal School	Heavy Metal Concentration in Hay	Determination of heavy metal concentrations hays for horse feed.	USDOF (Reactor Use Sharing)
*1064	D. Goodney S. Quiriconi	Willamette University	Utilization and Discrimination of Elements from Soil by Modern and Ancient Wheat and Barley	Analysis of the utilization of strontium and barium in modern wheat samples to help theorize on the archaeological mysteries of wheat.	USDOE (Reactor Use Sharing)
*1065	J. LeCavalier J. Mehr I. Chapman	Oregon Episcopal School	Analysis of Heavy Metals Found in the Soils and Waters of the Commassia Nature Preserve, West Linn, Oregon	Analysis of inflows, onsite, and outflow samples to determine heavy metals found in soils and waters of the Commassia Nature Preserve, West Linn, Oregon	USDOE (Reactor Use Sharing)

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1066	J. Constantopoulos L. Cherednik	Physical Sciences, Eastern New Mexico University	Petrology and Geochemistry of the Railroad Mountain Dike, Chaves County, New Mexico	Determination of the vertical and horizontal variation in mineralogy texture, and geochemistry.	USDOE (Reactor Use Sharing)
*1067	P. Canan H. Pratt	Physics, Corvallis High School	INAA of Nine Samples for Selenium	INAA of Raisins, Gin, Brewer's Yeast, Chicken, Liver, Selenium Capsules, Hair, and Fingernail Clippings for Selenium.	USDOE (Reactor Use Sharing)
*1068	R. Burger D. Kovaric	Geology, Smith College	Geochemistry of Archean Rocks from the Tobacco Root Mountains, Montana	Determination of trace and REE in amphibolites and gneisses from the Tobacco Root Mountains, Montana	USDOE (Reactor Use Sharing)
*1069	A. Skinner M. Rudolph A. Selder	Chemistry, Williams College	Using Electron Spin Resonance (ESR) to Date Flint Artifacts	Measurement of radiation damage in flint as a method of determining the age of archaeological materials.	USDOE (Reactor Use Sharing)
1071	S. Giovannoni B. Lanoil	Microbiology, OSU	The Dynamics of Carbon Exchange in Coastal Vertically Stratified Bacterioplankton Communities	Irradiation of DNA to 1 krad, 4 krad, 16 krad using the ^{60}Co irradiator.	USDOE (Reactor Use Sharing)
1072	S. Rasmussen	Army Corps of Engineers	Instrument Calibration	Calibration of radiation detection instruments.	Army Corps of Engineers
*1073	M. Pringle	Scottish Universities Research and Reactor Centre, Scotland, United Kingdom	^{40}Ar-^{39}Ar Dating of Rock Minerals	^{40}Ar-^{39}Ar dating of rock minerals.	Scottish Univ. Research and Reactor Centre
*1074	J. Vijbrans	Earth Sciences, Vrije Universiteit Amsterdam, The Netherlands	^{40}Ar-^{39}Ar Dating of Rock Minerals	^{40}Ar-^{39}Ar dating of rock minerals.	Vrije Universiteit, Amsterdam
*1075	M. Lederer	Nuclear Engineering, University of California , Berkeley Energy Institute	Activation Analysis Experiment for NE Class Lab at UC Berkeley	Irradiation of <0.5 g stainless steel sample for use in Radiation Measurements Lab.	Nuclear Engineering, UC Berkeley
*1076	J. O'Brien R. Steele	Office of the Sheriff, Lincoln County, Newport, Oregon	Processing of Gunshot Residue Kit for Case #94-3413	RNAA of gunshot residue kit to determine the presence of gunshot residue on suspect swabbings.	Lincoln County Sheriff's Office

* Project which involves the OSTR.

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1077	S. Taormina	Forensic Services Laboratory, Department of State Police	INAA of Lead Bullet Samples to Determine a Match with Shooting Suspect's Weapon	INAA of lead bullets to compare those recovered from crime scene with those in suspect's weapon and determine whether they match.	Grant County District Attorney
*1078	C. Field J. Doucette	Geosciences, OSU	INAA of Various Altered Igneous Rocks	Interpretation of hydrothermal and igneous processes regarding the solidification of magma and subsequent hydrothermal alteration.	Mine Geology, OK-Tedi Mining Ltd.
*1079	A. Churchill	private citizen	Refined PGE-soil from Benton County	Qualitative analysis of $IrCl_3$-compound that could be soil.	A. Churchill
*1080	J. Higginbotham F. Martin-Bandin	Radiation Health Physics, OSU	Determination of U and Th Concentrations in Layerite Sand	INAA of one layerite sample.	Radiation Center, OSU
1081	B. Epperson	Chemistry, McNary High School	Gamma Analysis of Fireplace Wood Ash	Gamma spectrometry of several wood ash samples to determine natural radioactive present.	Radiation Center, OSU
1082	J. Entry	Agronomy and Soils, Auburn University	Accumulation of ^{137}Cs and ^{90}Sr by Switch Grass	^{137}Cs counting on plants and soils.	Auburn University
1083	J. Steiner	National Forage Seed Production Research Center	Lotus Comiculotus Seed Irradiation	Irradiation of seeds with gamma radiation in an attempt to change yellow flower to white.	U.S. Department of Agriculture
*1084	J. Wasson	Institute of Geophysics and Planetary Physics, University of California--Los Angeles	Determination of Major, Minor and Trace Elements in Stony and Iron Meteorites by INAA	Irradiation and first count of meteoritic samples of IGPP/UCLA group.	Institute of Geophysics and Planetary Physics, UCLA
*1085	T. Beasley	Environmental Measurements Lab	Determinations of Stable Iodine in Kelp	Determination of the feasibility of assessing Russian pollution by the analysis of iodine in kelp.	Radiation Center, OSU (Unfunded Research)
*1086	J. Davidson B. Castellana	Earth and Space Sciences, University of California--Los Angeles	Temporal and Spatial Geochemical Variations Across the Damchatka Arc: An Evaluation of Mantle and Crustal Contributions to Arc Magmatism	Comparison of volcanic rocks of different ages to study changes in the compositions of magmas through time.	Earth and Space Sciences, UCLA

* Project which involves the OSTR.   INAA = Instrumental Neutron Activation Analysis   REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*1087	J. Bixby	Forensic Lab, Oregon Department of State Police	Department of State Police Forensic Laboratory Case #94L-7325	INAA of five lead bullet samples.	Multnomah County District Attorney
*1088	G. Clark K. Taylor	Portland Police Bureau	INAA of Seven Lead Bullets for Portland Police Bureau Case 94-10841	INAA of seven lead bullets to determine match between fired and unfired samples.	Portland Police Bureau
*1089	R. Ringsage	Oregon State Police	INAA of Three Lead Bullets for Oregon State Police Case 94P-566	INAA of three lead bullets.	Oregon State Police
*1090	B. Nelson N. Anders	Geology, University of Washington	Geochemical Evolution of East Molokai Volcano	INAA of samples from East Molokai volcano.	N. Anders
1091	B. Conard	Oceanic and Atmospheric Sciences, OSU	Arabian Sea Particle Flux Program	Determination of elemental content of particles collected on filters by in-situ large volume pump.	Radiation Center, OSU
1092	J. Higginbotham F. Martin-Bandin	Nuclear Engineering, OSU	Evaluation of the Response Characteristics of the Beta Scint Detector System	Evaluation of the Beta Scint detector system using mixed beta particle and gamma ray sources.	Radiation Center, OSU
*1093	P. Warren J. Wasson	Institute of Geophysics and Planetary Physics, University of California--Los Angeles	INAA of a Luna Meteorite	Determination of trace and minor element composition of a lunar meteorite.	IGPP, UCLA
*1094	J. Beilah	Portland Police Bureau	Analysis of Nine Lead Bullets for Case #93-67850	INAA of nine lead bullets in an attempt to correlate several drive-by shootings.	Portland Police Bureau
1095	W. Loveland G. Souliotis	Chemistry, OSU	^{198}Au Projectile Fragmentation in Intermediate Energy Nuclear Collisions	^{198}Au projectile fragmentation in intermediate energy nuclear collisions.	Radiation Center, OSU
*1096	W. Loveland J. Vlčáková	Chemistry, OSU	QSAR of Metal Chelates	Measurement of K_{ow} for a homologous series of metal chelates.	Radiation Center, OSU
1097	W. Loveland J. Dunn	Chemistry, OSU	Speciation of Pu in the Aquatic Environment	Measurement of the chemical speciation of Pu in fresh water.	Radiation Center, OSU
1098	W. Loveland L. Zyromski	Chemistry, OSU	Fusion Enhancements with n-rich Projectiles	Measurement of fusion enhancements with n-rich and radioactive projectiles.	Radiation Center, OSU

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
1099	W. Loveland T. Day	Chemistry, OSU	Angular Momentum Transfer in Xe-U Collisions	Measurement of transferred angular momentum and polarization in the reaction of 20-40 MeV/A ^{129}Xe with ^{238}U.	Radiation Center, OSU
1100	W. Loveland R. Yanez K. Aleklett et al.	Chemistry, OSU	Angular Momentum Transfer in O-Au Collisions	Measurement of angular transfer and polarization in intermediate energy O-Au collisions.	Radiation Center, OSU
1101	W. Loveland L. Zyromski N. Ham M. Andersson J. Vlčáková	Chemistry, OSU	Study of the Interaction of 29 MeV/A ^{208}Pb with ^{197}Au	Study of the interaction of 29 MeV/A ^{208}Pb with ^{197}Au.	Radiation Center, OSU
1102	W. Loveland	Chemistry, OSU	Synthesis of Element 110	Possible synthesis of Element 110 via the ^{209}Bi (^{59}Co, n) reaction.	Radiation Center, OSU
1106	E. Fredrickson	Roseburg Forest Products	Determination of the Effectiveness of Dy As An HerbicideTracer	Analysis of Dy-laced herbicide in cotton material placed in a sprayed field.	Roseburg Forest Products
*1107	A. Grunder J. Johnson	Geosciences, OSU	Petrogenic Evolution of Duck Creek Butte Eruption Center	Determination of major, minor, and trace elements in basaltic andesites.	Geosciences, OSU
1108	B. Michalek	Umpqua Research Co.	Sterilization of Activated Carbon Filter	Gamma irradiation of activated carbon filter for sterilization.	Umpqua Research Co.
*1109	M. Sparrow F. Prahl B. Eversmeyer	Oceanic and Atmospheric Sciences, OSU	Suspended Solid Description of Columbia River Particulate	INAA (Rabbits) of sediments on polycarbonate filters.	Oceanic and Atmospheric Sciences, OSU
*1110	R. Knapp	Washington County Deputy District Attorney	Case #94-21752	Gun-shot residue kit analysis.	Washington County Sheriff's Office
1111	G. Wilson	Altmont Elementary School	Radiation Effects on Bean Seeds	Irradiation of bean seeds to various doses to observe effects on growth.	Radiation Center, OSU

* Project which involves the OSTR.

INAA = Instrumental Neutron Activation Analysis

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
1112	L. Curtis Park	Fisheries and Wildlife, OSU	Correlation of Mercury Deposition with Sediment Core Age	^{137}Cs counting of sediment cores to try to determine their age.	Fisheries and Wildlife, OSU
*1113	S. Olsen	Geology and Geophysics, University of Wisconsin--Madison	Petrology of Migmatite from the Swiss Alps	INAA for REE to determine the petrology of migmatite from the Swiss Alps.	University of Wisconsin--Maditon
*1114	S. Binney	Nuclear Engineering, OSU	NAA of Mn in TLD-400s	Determination of Mn content in TLD-400s by NAA.	Radiation Center, OSU
1115	E. Link	GCP Technology	Investigation of Gamma Radiation Effects on Tourmaline	^{60}Co irradiation of tourmaline to various doses to examine radiation damage effects.	GCP Technology Systems
*1116	S. Binney J. Ringle	Nuclear Engineering, OSU	A Day with the Atoms	Provision of facilities (including reactor) for American Nuclear Society workshop.	American Nuclear Society
*1117	J. Liedtke	Radiation Center, OSU	Sc-Zn Interference Study	Determination of potential Zn-Sc interference in INAA of rock samples.	Radiation Center, OSU (Unfunded Research)
1118	G. Larson	Cooperative Park Studies Unit, OSU	Primary Phytoplankton Production Studies at Crater Lake	Evaluation of the primary production of phytoplankton in Crater Lake and lakes in Mount Rainier, Olympic and North Cascades National Parks using C-14 and liquid scintillation counting.	Resource Recreation, OSU
*1119	J. Salsbery	Linn County Sheriff's Office	Case No. 94-17596	INAA of two lead bullets for matching purposes.	Linn County Sheriff's Office
1120	C. Rivin K. Hardeman D. Strom L. Yoon	Botany and Plant Pathology, OSU	Clonal Analysis of Maize Meristem	Testing to determine if an isolated mutated gene is required for past embryonic meristem formation or function.	Botany, OSU
1121	M. Naujok	EPA ERL-C	Radon Monitoring of Soils	Use of logging radon monitor.	EPA
*1122	E. Herbert	Portland Police Bureau	Investigation of Loupe Homicide	INAA of five lead bullets for matching purposes.	Portland Police Bureau

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis REE = Rare Earth Elements

1. Neutron Activation Analysis

Neutron activation analysis (NAA) stands at the forefront of techniques for the quantitative multi-element analysis of major, minor, trace and rare elements. The principle involved in NAA consists of first irradiating a sample with neutrons in a nuclear reactor such as the OSTR to produce specific radionuclides. After the irradiation, the characteristic gamma rays emitted by the decaying radionuclides are quantitatively measured by suitable semiconductor radiation detectors, and the gamma rays detected at a particular energy are usually indicative of a specific radionuclide's presence. Data reduction of gamma ray spectra by means of a computer then yields the concentrations of various elements in samples being studied. With sequential instrumental NAA it is possible to measure quantitatively about 35 elements in small samples (5 to 100 mg), and for activatable elements, the lower limit of detection is on the order of parts per million, or parts per billion depending on the element.

The Radiation Center's NAA laboratory has analyzed for the major, minor, and trace element content in many thousands of samples covering essentially the complete spectrum of material types and involving virtually every scientific and technical field.

While some researchers perform their own sample counting on their own or on Radiation Center equipment, the Radiation Center provides a complete NAA service for researchers and others who may require it. This includes sample preparation, sequential irradiation and counting, and data reduction and analysis.

Data on NAA research and service performed during this reporting period are included in Table VI.C.3.

2. Forensic Studies

Neutron activation analysis can also be advantageously used in criminal investigations. The principle underlying such application usually involves matching trace element profiles in objects or substances by NAA. This in turn can help identify materials or products (e.g., identify the manufacturer of a given object), and in some cases can match bullets and other materials recovered from a victim to similar materials obtained from suspects. Materials which have been analyzed by the Radiation Center for forensic purposes include bullets, metals, paint, fuses, coats, glass, meat, and salts.

Forensic studies performed in this reporting period are included in the listings in Tables VI.C.1 and VI.C.3.

3. Irradiations

As described throughout this report, a major capability of the Radiation Center involves the irradiation of a large variety of substances with X-rays, gamma rays and neutrons. Detailed data on these irradiations and their use during this reporting period are included in Part III as well as in section C of this part.

4. Radiological Emergency Response Services

The Radiation Center has an emergency response team capable of responding to all types of radiological accidents. This team directly supports the City of Corvallis and Benton County emergency response organizations and medical facilities. In addition, most members of the team have been certified as Regional Radiological Technical Assistants (RRTAs). As a result, these individuals are authorized to provide assistance at the scene of any radiological incident anywhere in the state of Oregon on behalf of the Oregon Radiation Protection Services and the Oregon Department of Energy.

The Radiation Center maintains dedicated stocks of radiological emergency response equipment and instrumentation. These items are located at the Radiation Center, at the Good Samaritan hospital, and in the Linn/Benton Region 5 HAZMAT vehicle.

During the current reporting period, the Radiation Center emergency response team conducted several training sessions and exercises, but was not required to respond to any actual incidents.

In conjunction with the OSU Department of Nuclear Engineering, Radiation Center staff provide on-going support to the state of Oregon's emergency response plan for the Trojan Nuclear Power Plant. Although the reactor itself is now shut down, Trojan still must have an emergency plan for the fuel kept in the spent fuel storage ponds. About seven persons residing in the Radiation Center hold either primary, second shift or alternate positions in the Trojan Emergency Plan, and would work in the Emergency Operations Center in Salem, or in the Emergency Operations Facility at Trojan in the event of an incident.

During the past year, Radiation Center personnel attended training sessions, participated in drills and exercises, and provided advice relating to emergency response to a Trojan incident, but no one was required to respond to a real Trojan emergency.

5. Training and Instruction

In addition to the academic laboratory classes and courses discussed in Parts III.A.2, III.E and VI.B, and in addition to the routine training needed to meet the requirements of the OSTR emergency response plan, physical security plan and operator requalification program, the Radiation Center is also used for special training programs. Radiation Center staff are well experienced in conducting these special programs, and regularly offer training in areas such as research reactor operations, research reactor management, research reactor radiation protection, radiological emergency response, reactor behavior (for nuclear power plant operators), neutron activation analysis, nuclear chemistry and nuclear safety analysis.

Special training programs generally fall into one of several categories: visiting faculty and research scientists; International Atomic Energy Agency (IAEA) fellows; special short-term courses; or individual reactor operator or health physics training programs. During this reporting period there were five visiting scientists and special trainees. Two visiting scientists, one from Sweden and one from the Czech Republic, worked in the field of nuclear chemistry under the direction of Dr. Loveland. A visiting associate professor from Portland Community College worked extensively on neutron activation analysis with the Radiation Center's geochemist this past year. Finally, two high school students were mentored by Dr. Loveland as part of the Saturday Academy during this reporting period.

Two special one-week long training opportunities were provided at the Radiation Center during the summer. One was a workshop for high school science and social science teachers entitled "Hanford's Radioactive Waste: Technical and Social Issues." The other was the "HAZMAT Teams: Radiological Course." This is a development of the Regional Radiological Technical Assistant's summer school, which was first taught in 1985.

6. Radiation Protection Services

The primary purpose of the radiation protection program at the Radiation Center is to support the instruction and research conducted at the Center. However, due to the high quality of the program and the level of expertise and equipment available, the Radiation Center is also able to provide health physics services in support of the OSU Radiation Safety Office and to assist other state and federal agencies. The Radiation Center does not compete with private industry, but supplies health physics services which are not readily available elsewhere. In the case of support provided to state agencies, this definitely helps to optimize the utilization of state resources.

The Radiation Center is capable of providing health physics services in any of the areas which are discussed in Part V. These include personnel monitoring, radiation surveys, sealed source leak testing, packaging and shipment of radioactive materials, calibration and repair of radiation monitoring instruments (discussed in detail in Section VI.C.7), radioactive waste disposal, radioactive material hood flow surveys and radiation safety analysis and audits.

The Radiation Center also provides services and technical support as a backup radiation laboratory to the Oregon State Health Division (OSHD) laboratory in the event of a radiological emergency within the state of Oregon. In this role, the Radiation Center will provide gamma-ray spectroscopy analysis of water, soil, milk, food products, vegetation, and air samples collected by OSHD radiological response field teams. As part of the ongoing preparation for this emergency support the Radiation Center participates in inter-laboratory drills and cross-calibrations each year.

7. Radiological Instrument Repair and Calibration

While repair of nuclear instrumentation is a practical necessity, routine calibration of these instruments is a licensing and regulatory requirement which must be met. As a result, the Radiation Center operates a radiation instrument repair and calibration facility which can accommodate a wide variety of equipment.

The Center's scientific instrument repair facility performs maintenance and repair on all types of radiation detection and other nuclear instrumentation. Since the Radiation Center's own programs regularly utilize a wide range of nuclear instruments, components for most common repairs are often on hand and repair time is therefore minimized.

In addition to the instrument repair capability, the Radiation Center has a facility for calibrating essentially all types of radiation monitoring instruments. This includes typical portable monitoring instrumentation for the detection and measurement of alpha, beta, gamma and neutron radiation, as well as instruments designed for low-level environmental monitoring. Higher range instruments for use in radiation accident situations can also be calibrated in most cases. Instrument calibrations are performed using radiation sources certified by the National Institute of Standards and Technology (NIST) or traceable to NIST.

Table VI.C.4 is a summary of the instruments which were calibrated in support of the Radiation Center's instructional and research programs and the OSTR Emergency Plan while Table VI.C.5 shows instruments calibrated for other OSU departments and non-OSU agencies. Table VI.C.6 shows instruments repaired for non-Radiation Center departments and agencies. It should be noted that the

Radiation Center only calibrates and repairs instruments for local state and federal agencies.

8. Consultation

Radiation Center staff are able to provide consultation services in any of the areas discussed in this annual report, but in particular: research reactor operations and use, radiation protection, neutron activation analysis, neutron radiography, radiological emergency response and radiotracer methods.

Records are not normally kept of such consultations as they often take the form of telephone conversations with researchers encountering problems or planning the design of experiments. Many faculty members housed in the Radiation Center have on-going consulting functions with various agencies, in addition to sitting on numerous committees in advisory capacities.

Table VI.C.4

Summary of the Types of Radiological Instrumentation Calibrated to Support the OSU TRIGA Reactor and the Radiation Center

Type of Instrument	Number of Calibrations
Radiation Center Instruments	
GM Detectors	78
Ion Chambers	22
Alpha Detectors	4
Neutron Detectors	4
Micro-R Meters	8
Mini Detectors	8
Civil Defense Detectors	16
Personnel Ion Chambers	88
Support Agency Instruments	
Corvallis Fire Department	16
Good Samaritan Hospital (Corvallis, OR)	16
TOTAL	260

Table VI.C.5

Summary of Radiological Instrumentation Calibrated to Support Other OSU Departments and Other Agencies

Department/Agency	Number of Calibrations
OSU Departments	
Agricultural Chemistry	9
Animal Sciences	3
Biochemistry/Biophysics	8
Bioresources Engineering	1
Botany and Plant Pathology	7
Chemistry	3
Civil Engineering	1
Crop Science	2
Food Science and Technology	4
Forest Science	4
Microbiology	5
Oceanic and Atmospheric Sciences	1
Pharmacy	2
Physics	4
Radiation Safety Office	14
Veterinary Medicine	1
Zoology	3
Non-OSU Agencies	
U.S. Environmental Protection Agency	7
Oregon Department of Energy (Incl. HAZMAT Teams)	29
Oregon Department of Transportation	6
Oregon Health Sciences University	27
Oregon Public Utilities Commission	1
Oregon State Health Division	49
Good Samaritan Hospital	6
Corvallis Fire Department	5
Army Corps of Engineers	2
TOTAL	204

Table VI.C.6

Summary of Radiological Instrument Repair Activities for Non-Radiation Center Departments and Agencies

Date	Organization	Instrument	Calibrated?	Nature of Repair
8/8/94	Forest Science, OSU	Mini-Monitor 5-10E	Yes	Replace GM tube
12/2/94	Good Samaritan Hospital	Technical Associates TBM-15	Yes	Replace GM tube
2/23/95	Oregon Health Sciences University	Eberline SRM	No	Replace processor
3/1/95	Microbiology, OSU	Ludlum 3	Yes	Install new probe, build cable
3/2/95	Oregon Health Sciences University	Eberline PAC-4G	No	Set sensitivity, run plateau
3/9/95	Physics, OSU	Technical Associates PUG-1	Yes	Replace GM tube
3/9/95	Physics, OSU	Technical Associates PUG-1	Yes	Replace GM tube
4/3/95	Microbiology, OSU	Mini-Monitor 5-10E	No	Replace cord
5/1/95	Oregon State Health Division	Ludlum 12	Yes	Install new scale
5/8/95	Forest Science, OSU	Technical Associates PUG-1	Yes	Replace transistor
Total Number of Repairs			10	

PART VII

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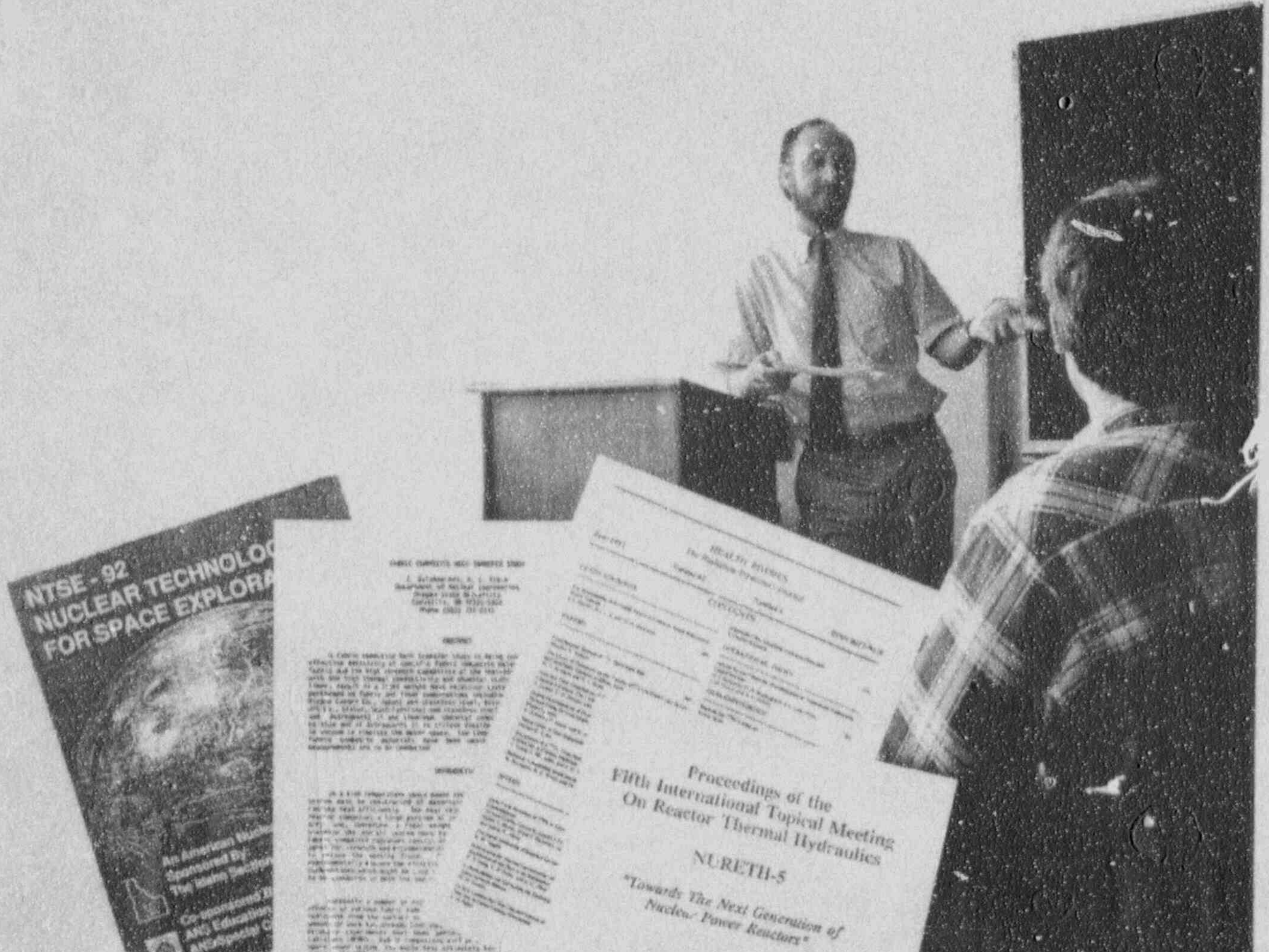

PART VII

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PART VII

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A. Publications in Print

Abdul-Hamid, S. A., and A. C. Klein (1994), "Monte Carlo Burnup Analysis Code Development and Application to an Incore Thermionic Space Nuclear Power System," *Proceedings of the 29th Intersociety Energy Conversion Engineering Conference*, p. 457-462.

Al-Soroudi, H. M., and A. C. Klein (1994), "Experimental Simulations and Heat Transfer Parameter Measurements of Film Condensation on a Rotating Flat Plate," *Experimental Thermal and Fluid Science*, in press.

Al-Kheliewi, A. S., and A. C. Klein (1994), "Modeling Transient Thermal-Hydraulic Behavior of a Thermionic Fuel Element for Space Nuclear Reactors," *Proceedings of the 29th Intersociety Energy Conversion Engineering Conference*, p. 499-504.

Al-Makhlafi, H., A. Nasir, J. McGuire, and M. A. Daeschel (1995), "Adhesion of Listeria Monocytogenes to Silica Surfaces After Sequential and Competitive Adsorption of Bovine Serum Albumin and β - Lactoglobulin," *Appl. Environ. Microbiol.*, 61:2013-2015.

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* Indicates OSTR use.

F. Public Relations

The continued interest of the general public in the TRIGA reactor is evident by the number of people who have toured the facility. In addition to many unscheduled visitors and interested individuals who stopped in without appointments because they were in the vicinity, a total of 88 scheduled tours including 1,307 people were given during this reporting period. See Table VII.F.1 for statistics on scheduled visitors.

Table VII.F.1

Summary of Visitors to the Radiation Center

Date	No. of Visitors	Name
July 5, 1994	6	Jennie Smith & Family
July 8, 1994	1	Cris S. Eberle (NE Faculty Candidate)
July 11, 1994	15	Teacher's Workshop on Radioactive Waste: Technical and Social Issues
July 13, 1994	21	Saturday Academy Student
July 19, 20, & 21, 1994	59	Adventures in Learning Students
July 22, 1994	1	Ed Coomes
July 26, 1994	2	Cynthia Studebaker & Sam Vendanayagam
July 27, 1994	1	Eric Fischer - SOAP Student
July 28, 1994	14	DAIDO Institute of Technology, Japan
July 29, 1994	3	Eric Anderson & family
August 2, 1994	2	English Language Institute
August 4, 1994	1	Tim Becker of Berkeley Geochronology Center
August 5, 1994	8	APEX Grand Opening & RC Tours
August 8, 1994	1	Todd S. Palmer (NE Faculty Candidate)
August 9, 1994	1	Dan Shryock, Editor, Corvallis Gazette Times
August 9, 1994	3	Greg, Clint, & Martha Waltz
August 10, 1994	2	Jay and John Hendricks
August 11, 1994	2	City Manager and Engineer, City of Corvallis
August 12, 1994	5	Jozef, Maria, and Eva Dopjera et al. of Slovakia
August 12, 1994	5	Lissa Zyromski & Guests
August 19, 1994	1	Don Russell of Cancer Research Institute
September 6, 1994	3	My-Lien Tran & Bill Martin
September 7, 1994	1	Robert W. Claussen, Sr.
September 7, 1994	5	Mark Small & Klein family
September 12, 1994	2	George A. Gaines & Ellen Chan from OSU Admissions

Table VII.F.1 (Continued)

Date	No. of Visitors	Name
September 12, 1994	2	Rebecca and Janey Powers
September 13, 1994	1	Page Zyromski
September 28, 1994	20	NE 111 Class
October 19, 1994	18	OPA (Office Personnel Association), OSU
October 21 and 24, 1994	20	NE 111 Class
October 25 and 27, 1994	61	Chem 219 Class
October 28, 1994	2	SPES (Italian AP600 Facility)
November 1, 1994	3	Navy ROTC - Capt. Rice, Capt. Stole, Lt. Watson
November 7, 1994	1	Dr. G. Brent Dalrymple, Dean, COAS
November 9, 1994	9	Alternate Energy Class - LBCC
November 9, 1994	1	Pat Welch, OSU Physics Dept.
November 18, 1994	5	Chem 418/518 Class
November 21, 1994	1	Tricia Lyons
November 23, 1994	3	Tasha Dunn, Rosie & Dave Kerr
November 29, 1994	21	Engr 119 Class
November 29, 1994	1	Teresa Tarbuck
November 30, 1994	1	Bob Harvey, RSO, SOSC
December 12, 1994	4	Stephen Frantz & Joshua Filner, Director & Assoc. Director, Reed College Reactor Facility
December 13, 1994	4	Doug Strain, Electro Scientific Industries; Molly Cook, OSU Devel. Office; John Matylonek, Engr. Librarian; Dr. Van Vechten, Engr.
December 14, 1994	4	Joe Coleman and family - Navy ROTC
December 29, 1994	1	OSU Affirmative Action Office
January 5, 1995	2	NRC
January 5, 12, 17 & February 2, 1995	15	Chemistry 462 Class
January 17, 1995	7	McNary High School Students
February 2, 1995	2	Oregon Episcopal School/ Hemphill-Gregory

Table VII.F.1 (Continued)

Date	No. of Visitors	Name
February 4, 1995	106	Dad's Weekend Open House
February 11, 1995	15	Beaver Open House
February 20, 1995	16	Corvallis HazMat Team
February 21, 1995	427	Chem 222 Class
February 22, 1995	2	Atsushi Mizuochi & Yoko Ishibashi
February 23, 1995	4	Guests from "Engineering Week"
March 3, 1995	2	Wilson and Kristen Parrish
March 7, 1995	19	Santiam Christian High School Physical Science Class (Freshmen)
March 8, 1995	3	Oregon Episcopal School Students
March 8, 1995	21	Coquille High School Physics Class
March 9, 1995	6	Corvallis Water Department
March 15, 1995	1	Maury Howard
March 16, 1995	1	Terry Lindsey, Oregon Health Division
March 30, 1995	4	OSU Geosciences
March 30, 1995	23	Our Lady of the Lake Students
April 7, 1995	18	SMILE Program Students
April 7, 1995	9	Battelle Staff Members
April 11, 1995	1	Dr. John M. Ryskamp, Idaho Nat'l Engr. Lab
April 14, 1995	2	Mr. and Mrs. Fernando Martin-Bandin
April 18, 1995	2	Willi Frisch, Nuclear Institute near Muchen
April 28, 1995	39	Wilson School's Fourth Grade Class
April 29, 1995	35	Teacher's Workshop: A Day with the Atoms
May 4, 1995	47	ANS Topical Meeting Group
May 5, 1995	1	Martin Becker, Oregon Graduate Institute
May 6, 1995	49	Mom's Weekend Open House
May 9, 1995	1	Craig Williamson,ORISE
May 16, 1995	20	New Student Programs

Table VII.F.1 (Continued)

Date	No. of Visitors	Name
May 16, 1995	1	Ray Fry, OHSU
May 24, 1995	19	National Assn. Of Foreign Student Affairs
May 30, 1995	11	Chinese Delegation
May 31, 1995	3	Rozalyn Patterson and family
June 1, 1995	2	GEO 300 Environmental Conservation
June 1, 1995	1	Don Palmrose
June 2, 1995	1	Tim Moody of Bechtel Hanford
June 7, 1995	2	Elam Mechley & John Strom
June 15, 1995	1	Lou Samprini, Civil Engineering
June 20, 1995	16	HazMat Response Teams Course
June 29, 1995	2	NRC Regulatory Division
TOTAL	1307	