RADIATION CENTER

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STATE
UNIVERSITY

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October 27, 1999

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

Reference: Oregon State University TRIGA Reactor (OSTR),
Docket No. 50-243, License No. R-106

In accordance with section 6.7.e of the OSTR Technical Specifications, we are hereby submitting the Annual Report of the Oregon State University Radiation Center and TRIGA Reactor for the period July 1, 1998 through June 30, 1999 Please note that we are also using this letter of transmittal to send copies of the current report to Mr. Al Adams, OSTR Senior Project Manager, USNRC, Washington, DC.

The 1998-99 Annual Report continues the pattern established over the past few years and includes information about the entire Radiation Center rather than concentrating primarily on the reactor. Because the report addresses a number of different interests, it is rather lengthy, but we have incorporated a short executive summary which highlights the Center's activities and accomplishments over the past year.

A reading of the executive summary will soon communicate the fact that the Radiation Center has maintained its high degree of productivity this past year. We hope that you will find the current report to be informative and interesting. Should there be any questions, please let me know.

Sincerely,

Stephen E Binney

Stephen E. Binney
Director

SEB:lmj-J:\ANNREPT\Letters 98-99\letter to NRC with AR
Enclosure

A020

PDRA DOCK

cc w/enclosure:

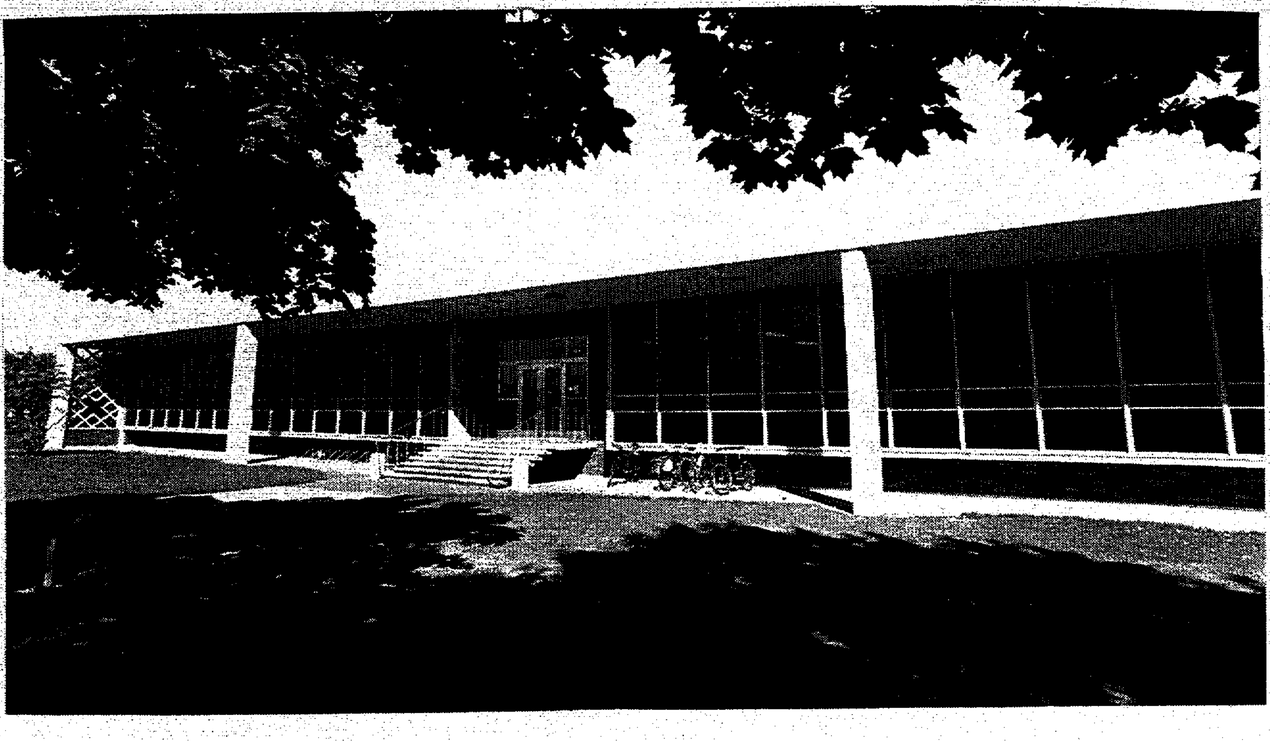
Mr. Al Adams, Jr., Senior Project Manager, USNRC, MS O11 B20, Washington, DC 20555-0001 (1 copy)
Mr. Craig Bassett, USNRC, 61 Forsyth St. SW, Ste. 23T85, Atlanta, GA 30303 (1 copy)
Mr. Ledyard Marsh, USNRC, MS O12 , Washington, DC 20555-0001 (1 copy)

cc w/out enclosure:

D. Stewart-Smith, Oregon Department of Energy
J. F. Higginbotham, Chairman, OSTR Reactor Operations Committee
A. D. Hall, OSTR Reactor Supervisor, OSU
S. R. Reese, OSTR Reactor Administrator, OSU
D. S. Pratt, Senior Health Physicist, OSU

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

July 1, 1998 - June 30, 1999



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

July 1, 1998 - June 30, 1999

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 Office of Energy, OOE Rule No. 345-030-010.

Edited by:

S. E. Binney, Director

With contributions from:

K. M. Brock, Health Physicist
R. D. Normandin, Assistant Health Physicist
M. R. Conrady, Analytical Support Manager
J. M. Stueve, Office Coordinator
S. E. Binney, Director
A. D. Hall, Reactor Supervisor
S. R. Reese, Reactor Administrator
L. M. James, Office Specialist
R. A. Keen, Office Coordinator
D. S. Pratt, Senior Health Physicist
L. J. Robinson, Word Processor
S. P. Smith, Scientific Instrument Technician
E. G. Schütfort, Project Manager
D. L. Snow, Office Specialist
S. C. Campbell, Business Manager
G. M. Wachs, Senior Reactor Operator

Submitted by:

S. E. Binney
Director, Radiation Center

Radiation Center
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October 1999

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

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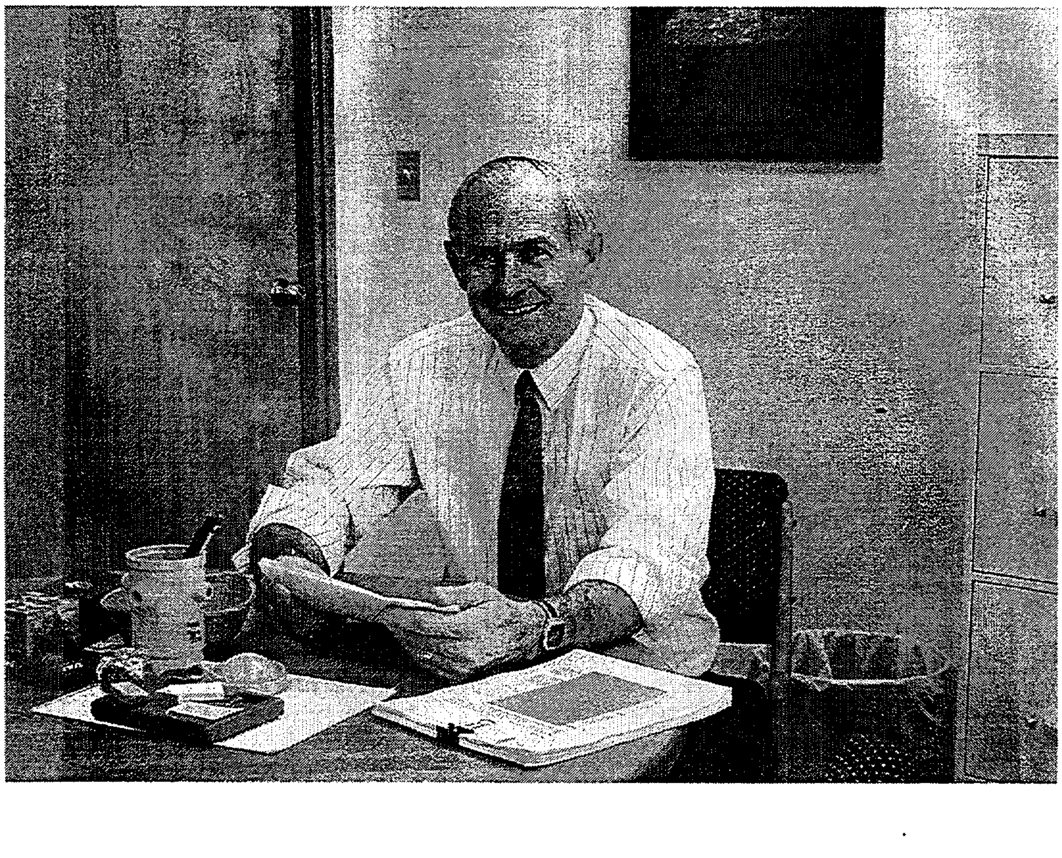
Part I

OVERVIEW



Part I

OVERVIEW

A. Acknowledgments

Many individuals and organizations help the Radiation Center succeed, and in recognition of this, the staff of the Oregon State University (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; to those who provided our funding, particularly the U. S. Department of Energy (USDOE) and the state of Oregon; to our regulators; to the researchers, the students, and others who used the Radiation Center facilities; to OSU Facilities Services; and to OSU Security Services and the Oregon State Police. We most earnestly say, "Thank you."

The Center would not be able to accomplish all that is shown in this report without the diligent efforts of all of its staff who have all worked hard. It is to their credit that we have managed to improve our level and quality of service. To each one,"Thank you."

Putting this report together each year is a major effort for several people. Only those who have been involved can fully understand what a great job Linda James has done in the data-gathering, organization, and keyboarding of this Annual Report. Thanks, Linda!

B. Executive Summary

The data from this reporting year show that the use of the Radiation Center and OSTR has still increased, despite being "maxed" out in many areas. This increase has been achieved by greater efficiencies. A good illustration of this is in reactor use hours. The reactor was busy an average of 40 hours per week. Additional users were accommodated by increasing the number of people who were simultaneously using the different reactor facilities. This year there were two or more users on the reactor for a total of 486 hours.

The Radiation Center supported 96 different courses this year, mostly in the Department of Nuclear Engineering. About one-third of these courses involved the OSTR. The number of OSTR hours used for academic courses and training was 1,114, while 1,561 hours were used for research projects. Seventy percent of the OSTR research hours were in support of off-campus research projects, which reflects the increasing wider use of the OSTR nationally and internationally. The number of samples irradiated in the reactor during this reporting period was 3,632. Funded OSTR use hours comprised 93% of the research use. This is consistent with the move to a more full cost recovery basis for services provided by the Center.

The OSTR continues to be the facility of choice for many of the $^{39}Ar/^{40}Ar$ geochronology laboratories around the world.

Personnel at the Radiation Center conducted 125 tours of the facility, accommodating 1,326 visitors. The visitors included elementary, middle school, high school, and college students; relatives and friends; faculty; current and prospective clients; national laboratory and industrial scientists and engineers; and state, federal and international officials. The Radiation Center is a significant positive attraction on campus because visitors almost always go away with a good impression of the facility and of Oregon State University.

Research projects of personnel housed in the Radiation Center totaled approximately $1.25 million for this year.

The Radiation Center projects database initiated a few years ago continues to provide a useful way of tracking the many different aspects of work at the facility. The number of projects supported this year was 126. Reactor projects comprised 69% of all projects. The contracts supporting these research projects totaled approximately $3,000,000. This year the Radiation Center provided service to 55 research faculty and 93 students (for a total of 471 uses of Center facilities) from 51 different institutions, 63% of which were from other states and 14% of which were from outside the U. S. and Canada. So while the Center's primary mission is local, it is also a facility with a national and international clientele.

With the closing of the State of Oregon's environmental radiological monitoring laboratory in Portland, the Radiation Center is essentially now the only place in the state where radiological monitoring can be performed.

The Radiation Center web site provides an easy way for potential users to evaluate the Center's facilities and capabilities as well as to apply for a project and check use charges. The address is: http://www.ne.orst.edu/facilities/radiation_center.

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, 1998 through June 30, 1999. 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, 1999. 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 Office 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 University System, and many other colleges and universities throughout the nation and the world. 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 Office, the OSU Institute of Nuclear Science and Engineering, and for the OSU nuclear chemistry, radiation chemistry, geochemistry 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; a ^{60}Co gamma irradiator; a large 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 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 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.

Also housed in the Radiation Center is the Advanced Thermal Hydraulics Research Laboratory, which is used for state-of-the-art two-phase flow experiments.

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, radiation effects on biological systems, radiation dosimetry, environmental radioactivity, 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.

E. Summary of Environmental and Radiation Protection Data

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

a.	Total estimated quantity of radioactivity released (to the sanitary sewer)(1) (2)	≤LLD (95%) of 6.12 x 10^{-5} Ci
b.	Detectable radionuclides in the liquid waste	N/A
c.	Estimated average concentration of released radioactive material at the point of release	≤LLD (95%) of 8.33 x 10^{-6} µCi/ml
d.	Percent of applicable monthly average concentration for released liquid radioactive material at the point of release	N/A
e.	Total volume of liquid effluent released, including diluent(3)	3,886 gallons

2. Liquid Waste Generated and Transferred (See Table V.B.1.b)

a.	Volume of liquid waste packaged(4)	32 gallons
b.	Detectable radionuclides in the waste	^{24}Na, ^{46}Sc, ^{47}Sc, ^{60}Co
c.	Total quantity of radioactivity in the waste	7.0 x 10^{-5} Ci

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

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

(3) 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.

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

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

a.	Total estimated quantity of radioactivity released	5.13 Ci
b.	Detectable radionuclides in the gaseous waste(1)	^{41}Ar ($t_{\frac{1}{2}}$ = 1.83 hr)
c.	Estimated average atmospheric diluted concentration of ^{41}Ar at the point of release	3.3 x 10^{-8} µCi/ml
d.	Percent of applicable monthly average concentration for diluted concentration of ^{41}Ar at the point of release	0.9%
e.	Total estimated release of radioactivity in particulate form with half lives greater than 8 days(2)	None

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

a.	Total amount of solid waste packaged and disposed of	30 ft^3
b.	Detectable radionuclides in the solid waste	^{3}H, ^{24}Na, ^{46}Sc, ^{47}Sc, ^{51}Cr, ^{56}Mn, ^{59}Fe, ^{60}Co, ^{86}Rb, ^{90}Sr, ^{122}Sb, ^{124}Sb, ^{131}I, ^{133}I, ^{139}Ba, ^{140}Ba, ^{210}Bi
c.	Total radioactivity in the solid waste	3.0 x 10^{-3} Ci

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(1) Routine gamma spectroscopy analysis of the gaseous radioactivity in the stack discharge indicated that it was virtually all ^{41}Ar.

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

5. Radiation Exposure Received by Personnel (See Table V.C.1)(1)

a. Facility Operating Personnel

		(mrem)
(1)	Average whole body	42
(2)	Average extremities	394
(3)	Maximum whole body	76
(4)	Maximum extremities	1409

b. Key Facility Research Personnel

(1)	Average whole body	21
(2)	Average extremities	4
(3)	Maximum whole body	40
(4)	Maximum extremities	29

c. Facilities Services Maintenance Personnel

(1)	Average whole body	14
(2)	Maximum whole body	18

d. Laboratory Class Students

(1)	Average whole body	12
(2)	Average extremities	8
(3)	Maximum whole body	25
(4)	Maximum extremities	51

e. Campus Police and Security Personnel

(1)	Average whole body	6
(2)	Maximum whole body	24

f. Visitors

(1)	Average whole body	<1
(2)	Maximum whole body	35

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(1) "ND" 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 (RDC 30 mrem, ICN 10 mrem), as applicable.

6. 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	132
(b)	Neutron dosimeter measurements	64

(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
	-- RDC/ICN TLD monitors	90
	-- Monthly µrem/h measurements	108
(b)	Offsite monitoring	
	-- OSU TLD monitors	264
	-- RDC/ICN TLD monitors	128
	-- Monthly µrem/h measurements	252

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

(a)	Soil samples	16
(b)	Water samples	12
(c)	Vegetation samples	56

F. History

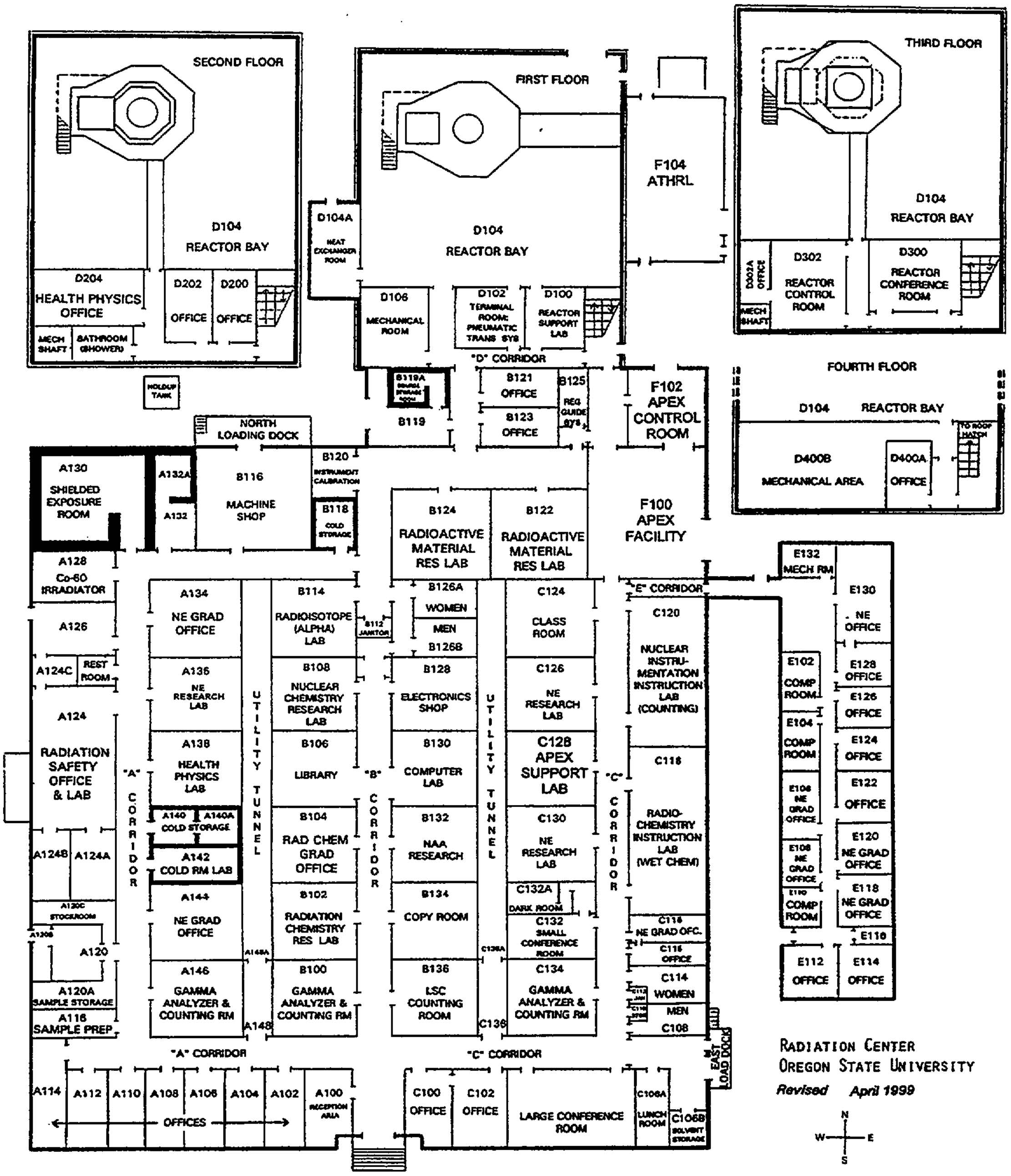
A brief chronology of the key dates and events in the history of the OSU Radiation Center and the TRIGA reactor is given below:

June 1964	Completion of the first phase of the Radiation Center, consisting of 32,397 square feet of office and laboratory space, under the direction of founding Director, C. H. Wang.
July 1964	Transfer of the 0.1 W AGN 201 reactor to the Radiation Center. This reactor was initially housed in the Department of Mechanical Engineering and first went critical in January, 1959.
October 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.
October 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.
September 1972	OSTR area fence installed.
December 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.
January 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.
December 1984	C. H. Wang retired as director. C. V. Smith became new director.
August 1986	Director C. V. Smith left to become Chancellor of the University of Wisconsin-Madison. A. G. Johnson became new Director.
December 1988	AGN-201 components transferred to Idaho State University for use in their AGN-201 reactor program.
December 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.
November 1992	Start of APEX plant construction.
June 1994	Retirement of Director A. G. Johnson. B. Dodd became new Director.
August 1994	APEX inauguration ceremony.
August 1995	Major external refurbishment: new roof, complete repaint, rebuilt parking lot, addition of landscaping and lighting.
March 1998	Start of ATHRL construction.
September 1998	B. Dodd left on a leave of absence to the International Atomic Energy Agency. S. E. Binney became new Director.
April 1999	Completion of ATHRL facility.

Figure I.D.1

Floor Plan of the Radiation Center



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 list 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. Professional and Research Faculty

Attfield, Martin P.
Faculty Research Associate
Chemistry

*Binney, Stephen E.
Director, Radiation Center (effective August 8, 1998)
Director, Institute of Nuclear Science and Engineering (effective August 8, 1998)
Chairman, OSTR Reactor Operations Committee (until August 7, 1998)
Nuclear Engineering and Radiation Health Physics

*Brock, Kathryn M.
Faculty Research Assistant
Health Physicist

*Conard, Bobbi L.
Senior Faculty Research Assistant
College of 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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* OSTR users for research and/or teaching.

Daniels, Malcolm
Professor Emeritus
Chemistry

*Dodd, Brian
Director, Radiation Center (until September 15, 1998)
Director, Institute of Nuclear Science and Engineering (until September 15, 1998)
Professor
Nuclear Engineering and Radiation Health Physics

Fekou-Youmbi, Valentin
Faculty Research Associate
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

Haggerty, Roy
Professor
Geosciences

Hart, Lucas P.
Faculty Research Associate
Chemistry

*Higginbotham, Jack F.
Reactor Administrator (until September 15, 1998)
Chairman, Reactor Operations Committee (effective September 16, 1998)
Associate Dean, Graduate School (effective July 6, 1998)
Professor
Nuclear Engineering and Radiation Health Physics

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

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* OSTR users for research and/or teaching.

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

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

Johnson, Richard A.
Adjunct Faculty
Nuclear Engineering

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

*Krane, Kenneth S.
Professor
Physics

Krebs, Rolf
Faculty Research Associate
Crop and Soil Science

Lafi, Abd Y.
Assistant Professor Senior Research
APEX Research Analyst
Nuclear Engineering

*Loveland, Walter D.
Professor
Chemistry

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

Mommer, Niels K.
Faculty Research Associate
Physics

---

* OSTR users for research and/or teaching.

Palmer, Todd S.
Assistant Professor
Nuclear Engineering

*Pastorek, Christine
Senior Instructor
Chemistry

Popovich, Milosh
Vice President Emeritus

*Prahl, Frederick G.
Professor
College of Oceanic and Atmospheric Sciences

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

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

Ringle, John C.
Professor Emeritus
Chairman, Reactor Operations Committee (August 8, 1998 - September 15, 1998)
Nuclear Engineering

Robinson, Alan H.
Department Head Emeritus
Nuclear Engineering

*Schmitt, Roman A.
Professor Emeritus
Chemistry

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

*Sparrow, Margaret
Senior Research Assistant
College of Oceanic and Atmospheric Sciences

---

* OSTR users for research and/or teaching.

*Sullivan, Barbara E.
Faculty Research Assistant
College of Oceanic and Atmospheric Sciences

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

Young, Roy A.
Professor Emeritus
Botany and Plant Pathology

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

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* OSTR users for research and/or teaching.

B. Visiting Scientists and Special Trainees

Name	*Field (Affiliation)*	*Advisor or Research Program Director*
Bissmarck, Frederick	Visiting Graduate Student Sweden	W. D. Loveland
Gallant, Aaron	Saturday Academy Mentorship Program Crescent Valley High School Corvallis, Oregon	W. D. Loveland
Lambert, Miriam	Undergraduate Student Physics Oregon State University	K. S. Krane
Menge, Duncan	Saturday Academy Mentorship Program Crescent Valley High School Corvallis, Oregon	W. D. Loveland
Parker, Michael	Health Physics Intern Public Health Undergraduate Student Oregon State University	K. M. Brock
*Shivers, Robert J.	Student Research Assistant Environmental Science Oregon State University	W. D. Loveland
Wallin, Petra	Visiting Undergraduate Student Chemistry Royal Institute of Technology, Sweden	W. D. Loveland

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* OSTR users for research and/or teaching.

C. OSU Graduate Students

Name	*Degree Program*	*Field*	*Advisor*
Al-Hussan, Khalid A.	PhD	Nuclear Engineering	A. C. Klein
Alves, Mauro A.	PhD	Physics	J. A. Gardner
Baik, Seung-Hyuk	PhD	Nuclear Engineering	J. F. Higginbotham
Bergman, Joshua J.	MS	Radiation Health Physics	S. E. Binney
Cantaloub, Michael G.	MS	Radiation Health Physics	J. F. Higginbotham
Ching, Brenton	MS	Nuclear Engineering	T. S. Palmer
Chinudomsub, Kittisak	MS	Radiation Health Physics	J. F. Higginbotham
Colpo, Sarah E.	MS	Nuclear Engineering	J. N. Reyes
*Crail, Scott A.	MS	Radiation Health Physics	J. F. Higginbotham
Crowley, Paul R.	MS	Radiation Health Physics	J. F. Higginbotham
Eccleston, Bradley R.	MS	Nuclear Engineering	T. S. Palmer
Ellis, Christopher P.	MS	Nuclear Engineering	J. N. Reyes
Emerald, Kezia G.	PhD	Chemistry	W. D. Loveland
Gulich, John C.	MS	Nuclear Engineering	T. S. Palmer
Jue, Tracy M.	MS	Radiation Health Physics	S. E. Binney
Keillor, Martin E.	PhD	Nuclear Engineering	S. E. Binney
Kim, Kang Seog	PhD	Nuclear Engineering	T. S. Palmer
Kovacich, Robert J.	PhD	Chemistry	W. D. Loveland
Kropp, Edward K.	MS	Radiation Health Physics	S. E. Binney
Lee, Hsing Hui	PhD	Nuclear Engineering	A. C. Klein
Marianno, Craig M.	PhD	Radiation Health Physics	K. A. Higley
McCreary, David M.	MS	Nuclear Engineering	Q. Wu
Menn, Scott A.	MS	Radiation Health Physics	K. A. Higley
Miller, Robert E.	MS	Radiation Health Physics	K. A. Higley
Moss, Stephen C.	MS	Radiation Health Physics	K. A. Higley
*Povetko, Oleg G.	PhD	Radiation Health Physics	K. A. Higley
Richardson, Eric L.	MS	Nuclear Engineering	T. S. Palmer
Rios, Maribel G.	MS	Physics	K. S. Krane
Rusher, Christopher D.	MS	Nuclear Engineering	J. N. Reyes
Saiyut, Kittiphong	PhD	Nuclear Engineering	J. F. Higginbotham
*Schütfort, Erwin G.	MS	Geosciences	C. Field
Schwab, Kristen E.	MS	Radiation Health Physics	K. A. Higley
Tang, Hong	PhD	Nuclear Engineering	Q. Wu
Tiyapun, Kanokrat	PhD	Radiation Health Physics	S. E. Binney
Walker, Matthew J.	MS	Radiation Health Physics	J. F. Higginbotham
Welter, Kent B.	PhD	Nuclear Engineering	T. S. Palmer
Zyromski, Kristiana E.	PhD	Chemistry	W. D. Loveland

D. Business, Administrative and Clerical Staff

Director, Radiation Center	*(to 9/15/98)* B. Dodd
Director, Radiation Center	*(from 9/16/98)* S. E. Binney
Acting Director	*(8/8/98 to 9/15/98)* S. E. Binney
Business Manager	S. C. Campbell
Office Manager	D. K. Dalton
Office Specialists	*(to 10/31/98)* D. C. West
	(from 12/1/98) D. L. Snow
	L. M. James
Custodian	E. Cimbri
Office Coordinator (Nuclear Engineering)	R. A. Keen
Word Processing Technician (Nuclear Engineering)	L. J. Robinson
Word Processing Technician (ATHRL – Nuclear Engineering)	T. L. Culver

E. Reactor Operations Staff

Principal Security Officer, Senior Reactor Operator	*(71/98 - 9/15/99)* B. Dodd
Principal Security Officer,	*(from 8/8/99)* S. E. Binney
Reactor Administrator, Senior Reactor Operator	*(to 9/15/99)* J. F. Higginbotham
Reactor Administrator	*(from 9/16/99)* S. R. Reese
Reactor Supervisor, Senior Reactor Operator	A. D. Hall
Senior Reactor Operator	S. P. Smith
	G. M. Wachs
Reactor Operator	S. A. Crail
	N. A. Carstens
Reactor Operator Trainee	*(9/16/98 through 6/28/99)* S. R. Reese

F. Radiation Protection Staff

Senior Health Physicist	D. S. Pratt
Health Physicist	K. M. Brock
Assistant Health Physicist	*(to 12/31/98)* D. R. Carver
	(from 3/1/99) R. D. Normandin
Health Physics Monitors (Students)	S. Beach
	J. Davidson
	M. Hackett
	C. Hepler
	K. Landry
	C. Marianno
	M. McClurg
	M. Young

G. Scientific Support Staff

Analytical Support Manager	M. R. Conrady
Projects Manager	E. G. Schütfort
Geochemist	S. Geiger
Neutron Activation Analysis Technicians (Students)	S. Antoine A. Ham M. Kapus K. Kincaid E. Rougeux
Scientific Instrument Technician	S. P. Smith
Nuclear Instrumentation Support	A. Ham K. Kincaid E. Rougeux

H. OSU Radiation Safety Office Staff

Radiation Safety Officer	R. H. Farmer
Assistant Radiation Safety Officers	D. L. Harlan (*to 9/15/98*) S. R. Reese (*from 3/1/99*) M. E. Bartlett
Office Manager	K. L. Miller
Lab Technician	(*to 7/31/98*) L. C. Meeks (*from 10/7/98*) P. A. Schoonover
Student Technicians	S. Menn B. Kowash

I. Committees

1. Reactor Operations Committee

Name	*Affiliation*
J. F. Higginbotham, Chair (*from 9/16/98*).	Graduate School, Nuclear Engineering
S. E. Binney	(*Chair to 8/7/98*) Radiation Center and Nuclear Engineering
B. Dodd	(*to 9/15/98)* Radiation Center and Nuclear Engineering
A. D. Hall	Radiation Center
A. C. Klein	Nuclear Engineering
M. E. Magaña	Electrical and Computer Engineering
D. S. Pratt	Radiation Center
W. J. Richards	McClellan Nuclear Radiation Center
J. C. Ringle	(*Chair 8/8/98 to 9/15/98*) Nuclear Engineering
W. H. Warnes	Mechanical Engineering
S. R. Reese	(*from 9/16/98)* Radiation Center and Nuclear Engineering

2. Radiation Safety Committee (OSU)

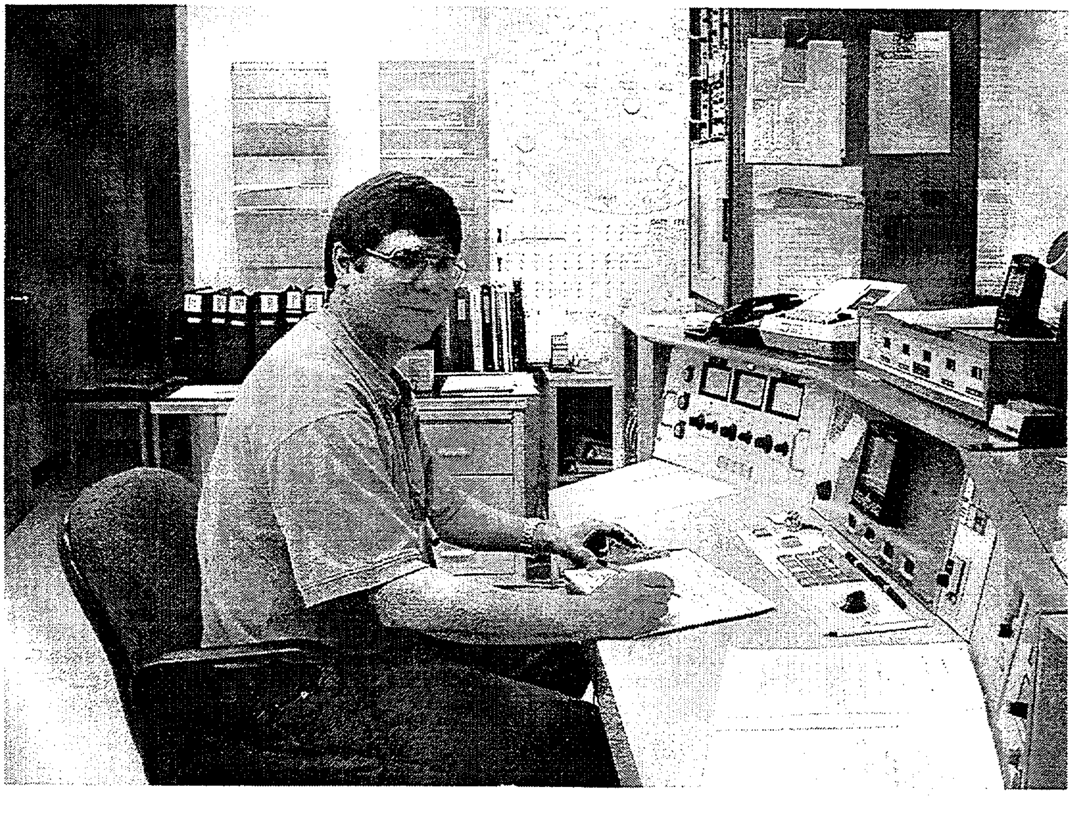
Name	*Affiliation*
T. Wolpert, Chair	Botany and Plant Pathology
J. Higginbotham, Vice Chair	Radiation Center and Nuclear Engineering
R. Collier	Oceanic and Atmospheric Sciences
T. Dreher	Agricultural Chemistry
R. Farmer, Secretary and RSO	Radiation Safety Office
B. Francis	Environmental Health and Safety
R. Specter	Vice President for Finance and Administration
M. Leid	Pharmacy
C. Snow	Exercise and Sport Science
J. Steiner	USDA-ARS/Crop and Soil Science
I. Wong	Biochemistry/Biophysics

3. Radiation Center Safety Committee

Name	*Affiliation*
W. D. Loveland, Chair	Chemistry
M. R. Conrady	Radiation Center
B. Dodd	*(through 9/15/98)* Radiation Center and Nuclear Engineering
J. F. Higginbotham	Radiation Center and Nuclear Engineering
D. S. Pratt	Radiation Center
D. R. Carver	*(to 12/31/98)* Radiation Center
J. T. Groome	Radiation Center
K. L. Miller	Radiation Safety

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 2500 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, an in-core irradiation tube, and a cadmium-lined in-core irradiation tube for experiments requiring a high energy neutron flux. The OSTR also has an Argon Irradiation Facility for the production of ^{41}Ar.

The **pneumatic transfer facility** enables samples to be inserted and removed from the core in four to five 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. Rotation of the rack ensures that each sample will receive an identical irradiation.

The reactor's **thermal column** consists of a large stack of graphite blocks which slows down neutrons from the reactor core in order to increase thermal neutron activation of samples. Over 99% of the neutrons in the thermal column are thermal neutrons. 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. Another beam port contains the **Argon Irradiation Facility** for production of curie levels of ^{41}Ar. The other beam port is available for a variety of experiments.

If samples which are to be irradiated require a large neutron fluence, especially from higher energy neutrons, they 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. Similarly samples can be placed in the **in-core irradiation tube** which can be inserted in the same core location.

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 higher energy 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. It is the same as the in-core irradiation tube except for the presence of the cadmium lining.

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 40 hours during a typical work week.

a. Instruction

Instructional use of the reactor is twofold. First, it is used significantly for classes in Nuclear Engineering, Radiation Health Physics, 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 31 different OSU academic classes plus three other academic programs. In addition, portions of classes from other Oregon universities were also supported by the OSTR. The OSU teaching programs utilized 1,114 hours of reactor time. Tables III.A.1 and III.A.2, as well as Table III.D.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 commonly used experimental technique requiring reactor use is 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 purposes such as the ^{39}Ar/^{40}Ar ratio and fission track methods of age dating samples.

During this reporting period, the OSTR accommodated 77 funded and 8 unfunded research projects. 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 Table VI.C.1 OSTR use is indicated with an asterisk.

B. Analytical Equipment

1. Description

The Radiation Center has a large variety of radiation detection instrumentation. This equipment is upgraded as necessary, especially the gamma ray spectrometers with their associated computers and germanium detectors. Tables III.B.1 through III.B.4 provide a brief listing of laboratory counting devices present at the Center. Additional equipment for classroom use 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 may be made available on a loan basis to OSU researchers in other departments.

C. Radioisotope Irradiation Sources

1. Description

The Radiation Center is equipped with a 2,463 curie (as of 7/1/98) Gammacell 220 ^{60}Co irradiator (Fig. III.C.1), which is capable of delivering high doses of gamma radiation over a range of dose rates to a variety of materials.

Typically, the irradiator is 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, biological specimen, 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 radioactivity 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}Co irradiator. These projects included the irradiation of a variety of biological materials including different types of seeds. In addition, the irradiator was used for sterilization of several media and the evaluation of the radiation effects on different materials. Table III.C.1 provides use data for the Gammacell 220 irradiator.

D. Laboratories and Classrooms

1. Description

The Radiation Center is equipped with a number of different radioactive material laboratories designed to accommodate research projects and 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 UNIX 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 gamma spectrometry 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 35 and 18 students, respectively. 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 continued high utilization of the Radiation Center's thermal hydraulics laboratory. This laboratory is being used by a Nuclear Engineering faculty member 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 the U. S. Nuclear Regulatory Commission 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 *only* facility of its type in the world and is owned by the U. S. Department of Energy, designed by Westinghouse, and operated by OSU. In addition, a new building, the Advanced Thermal Hydraulics Research Laboratory (ATHRL), was constructed next to the Reactor Building in 1998. Two-phase flow experiments are conducted in the ATHRL.

2. Utilization

All of the laboratories and classrooms are used extensively during the academic year. For example, a listing of 96 courses accommodated at the Radiation Center during this reporting period along with their enrollments is given in Table III.D.1.

E. 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. It 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 the 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 and all other institutions in the Oregon University System, plus instruments from the Oregon Health Division's Radiation Protection Services, the Oregon Office 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.

F. Library

1. Description

The Radiation Center has a library 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, the Center library maintains a current collection of leading nuclear research and regulatory documentation. In addition, the Center has a collection over 50 sets of nuclear power reactor Safety Analysis Reports 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 topics. 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

The Radiation Center library is used mainly to provide reference material on an as-needed basis. It receives extensive use during the academic year. In addition, the orientation videotapes are used intensively during the beginning of each term and periodically thereafter.

Table III.A.1

OSU Courses Using the OSTR

Course Number	Course Name
NE 111	Introduction to Nuclear Engineering
NE 112	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 429	Nuclear Reactor Laboratory
NE 457	Nuclear Reactor Laboratory
RHP 480	Field Practices in Radiation Protection
NE 484	Applied Radiation Safety
RHP 484	Applied Radiation Safety
NE 486	Radiation Dosimetry
RHP 486	Radiation Dosimetry
RHP 488	Radioecology
NE 503	Thesis (Nuclear Engineering)
RHP 503	Thesis (Radiation Health Physics)
RHP 506	Projects
NE 559	Nuclear Reactor Laboratory
RHP 580	Advanced Field Practices in Radiation Protection
RHP 584	Advanced Applied Radiation Safety
RHP 586	Advanced Radiation Dosimetry
RHP 588	Advanced Radioecology
NE 603	Thesis (Nuclear Engineering)
CH 222	General Chemistry for Science Majors
CH 225H	Chemistry
CH 462	Experimental Chemistry II
CH 503	Thesis (Chemistry)
GEO 503	Thesis (Geosciences)
OC 503	Thesis (Oceanography)
Adventures in Learning	Visiting Students
SMILE	Visiting Students
BIOE 111	Bioresource Engineering (OSU)
HC 199	Honors Writing for Engineers (OSU)
	National Science Foundation Sponsored Residents for Undergraduates Program
NS 211	Naval Engineering

Table III.A.2

OSTR Teaching Hours

Description	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
Departmental	330	7,077
Nuclear Engineering	255	
Chemistry	58	
Adventures in Learning	5	
Bioresource Engineering	6	
SMILE	2	
Naval Engineering	2	
E.L.I.	1	
Honors Writing for Engineers	1	
Geosciences(1)	0	
Oceanic and Atmospheric Sciences(1)	0	
Special Classes and Projects(2)	784	4,436
TOTAL TEACHING HOURS(3,4,5)	1,114	11,513

---

(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, community college classes, and classes from other universities. In addition, this category includes 728 hours of reactor operator training.

(3) See Table III.D.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 the 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.

Table III.A.3

OSTR Research Hours

Types of Research	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
OSU Research	473	8,447
Off-Campus Research	1,088	13,492
TOTAL RESEARCH HOURS(1)	1,561	21,939

---

(1) Total research hours statistics:
- (a) 93% (1,561 hours) of the total research hours were user-funded by federal, state, or other organizations.
- (b) 7% (107 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.

Table III.B.1

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

Room	System	Rel. Effic. (%)
B100	Adcam 8k MCA, Ortec HP Ge	26.8
B100	Adcam 8k MCA, Ortec HP Ge	38.1
B100	Adcam 8k MCA, EG&G HPGe	30.0
B100	Adcam 8k MCA, Ortec HP Ge	28.8
C120	Ace 1, 4k Ortec, NaI(Tl) 3x3	N/A
B125	Adcam 8K MCA, Canberra Ge(Li)	16.6
A138	H.P. Scaler, NaI(Tl) 2x2	N/A
A146	Ace2, 4k Ortec, Ortec Si(Li)	N/A
C134	Adcam 8k MCA, PGT Ge(Li)	19.3
B100	Adcam 8k MCA, PGT LEP	N/A
B100	Adcam 8k MCA, Ortec LEP	N/A
A146	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
C118	Beckman, Betamate
C118	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
C120	NMC, PCC-11T and DS 2
A124	NMC AC5 84
A138	Protean MPC 9400
A138	Tennelec LB 5100 Auto Counting System w/IBM PC

Table III.B.4

Thermoluminescent Dosimeter Systems

Room	System
C120	Harshaw Model 2000
A132	Harshaw Model 2000

Table III.C.1

Gammacell 220 ^{60}Co Irradiator Use
(2463 Ci: 7/1/98)

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Sterilization	Blood serum, wood, soil, plastic tubes	1.0×10^6 to 5.0×10^6	49	1092
Material Evaluation	Memory chips, gemstones	1.0×10^5 to 4.0×10^7	24	1263
Botanical Studies	Corn, bean seeds, nectarines, other food items	1.0×10^4 to 1.6×10^5	23	8
Biological Studies	Calf serum, spleen cells, blood, peptide DNA bases	5.0×10^2 to 1.1×10^6	15	41
TOTALS			111	2,230

Table III.D.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 1998	Winter 1999	Spring 1999	Summer 1999
Nuclear Engineering Department Courses						
NE111*	3	Introduction to Nuclear Engineering	19	--	--	--
NE112	3	Introduction to Nuclear Engineering	--	18	--	--
NE113	3	Introduction to Nuclear Engineering	--	--	18	--
NE231	3	Nuclear and Radiation Physics	13	--	--	--
RHP231	3	Nuclear & Radiation Physics	6	--	--	--
NE232	3	Nuclear & Radiation Physics	--	10	--	--
RHP232	3	Nuclear & Radiation Physics	--	5	--	--
NE233*	3	Nuclear Radiation Detection & Instrumentation	--	--	14	--
RHP233*	3	Nuclear Radiation Detection & Instrumentation	--	--	2	--
NE361	3	Nuclear Reactor Systems	--	11	--	--
NE381	3	Principles of Radiation Safety	10	--	--	--
RHP381	3	Principles of Radiation Safety	5	--	--	--
NE405	1-16	Reading & Conference	--	--	--	--
RHP405	1-16	Reading & Conference	--	1	1	--
NE406	1-16	Projects	--	--	--	--
RHP406	1-16	Projects	--	--	--	--
NE407	1	Nuclear Engineering Seminar	9	9	9	--
NE410	1-12	Internship	--	--	--	--
RHP410	1-12	Internship	--	1	1	--
NE414	3	Nuclear Rules and Regulations	--	--	14	--
RHP414	3	Nuclear Rules & Regulations	--	--	9	--
NE454	3	Nuclear Reactor Analysis	6	--	--	--
NE455	3	Nuclear Reactor Analysis	--	6	--	--

ST = Special Topics
* = OSTR used occasionally for demonstration and/or experiments.
** = OSTR used heavily.

Table III.D.1 (continued)

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

NE456	3	Nuclear Reactor Analysis	--	--	6	--
NE457**	3	Nuclear Reactor Laboratory	--	--	6	--
NE467	4	Nuclear Reactor Thermal Hydraulics	5	--	--	--
NE471	3	Nuclear Power Systems Design	--	5	--	--
NE472	3	Nuclear Power Systems Design	--	--	5	--
NE479	1-4	Individual Design Project	--	--	--	--
RHP479	1-4	Individual Design Project	--	--	--	--
RHP480**	1-3	Field Practices in Radiation Protection	1	2	3	1
NE484**	3	Applied Radiation Safety	--	9	--	--
RHP484**	3	Applied Radiation Safety	--	5	--	--
NE486*	3	Radiation Dosimetry	3	-	--	--
RHP486*	3	Radiation Dosimetry	2	--	--	--
RHP488*	3	Radioecology	--	--	1	--
RHP493	3	Non-reactor Radiation Protection	--	--	3	--
NE499	1-16	ST/Environmental Aspects of Nuclear Systems	--	--	--	--
RHP499	1-16	ST/Environmental Aspects of Nuclear Systems	--	2	--	--
NE501	1-16	Research	--	--	--	--
RHP501	1-16	Research	1	2	--	--
NE503*	1-16	Thesis	4	4	5	--
RHP503*	1-16	Thesis	6	5	6	1
NE505	1-16	Reading and Conference	3	--	1	--
RHP505	1-16	Reading & Conference	--	--	--	--
NE506*	1-16	Projects	--	--	1	--
RHP506*	1-16	Projects	--	--	--	--
NE507	1	Nuclear Engineering Seminar	1	4	1	--
NE510	1-12	Internship	--	--	--	--
RHP510	1-12	Internship	--	--	--	--

ST = Special Topics
* = OSTR used occasionally for demonstration and/or experiments.
** = OSTR used heavily.

Table III.D.1 (continued)

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

NE514	3	Nuclear Rules and Regulations	--	--	--	--
RHP514	3	Nuclear Rules & Regulations	--	--	1	--
NE537	3	Application of Nuclear Techniques	--	5	--	--
RHP537	3	Application of Nuclear Techniques	--	5	--	--
NE539	3	ST/Neutron Interaction Physics	--	8	--	--
NE549	3	ST/Low-level Radioactive Waste	2	--	--	--
RHP549	3	ST/Low-level Radioactive Waste	3	--	--	--
NE554	3	Advanced Nuclear Reactor Analysis	3	--	--	--
NE555	3	Advanced Nuclear Reactor Analysis	--	3	--	--
NE556	3	Advanced Nuclear Reactor Analysis	--	--	3	--
NE557**	3	Nuclear Reactor Laboratory	--	--	2	--
NE559*	3	ST/Nuclear Criticality Safety	12	--	--	--
NE567	4	Advanced Nuclear Reactor Thermal Hydraulics	2	--	--	--
NE571	3	Nuclear Power Systems Design	--	2	--	--
NE572	3	Nuclear Power Systems Design	--	--	2	--
RHP580**	1-3	Field Practice Radiation Protection	1	--	--	--
NE584**	3	Applied Radiation Safety	--	--	--	--
RHP584**	3	Applied Radiation Safety	--	1	--	--
NE585	3	Environmental Aspects of Nuclear Systems	--	2	--	--
RHP585	3	Environmental Aspects of Nuclear Systems	--	3	--	--
NE586*	3	Advanced Radiation Dosimetry	--	--	--	--
RHP586*	3	Advanced Radiation Dosimetry	2	--	--	--
RHP588*	3	Radioecology	--	--	2	--
RHP593	3	Non-reactor Radiation Protection	--	--	4	--
NE601	1-16	Research	--	1	--	--
RHP601	1-16	Research	--	--	2	--
NE603*	1-16	Thesis	4	4	2	1

ST = Special Topics
* = OSTR used occasionally for demonstration and/or experiments.
** = OSTR used heavily.

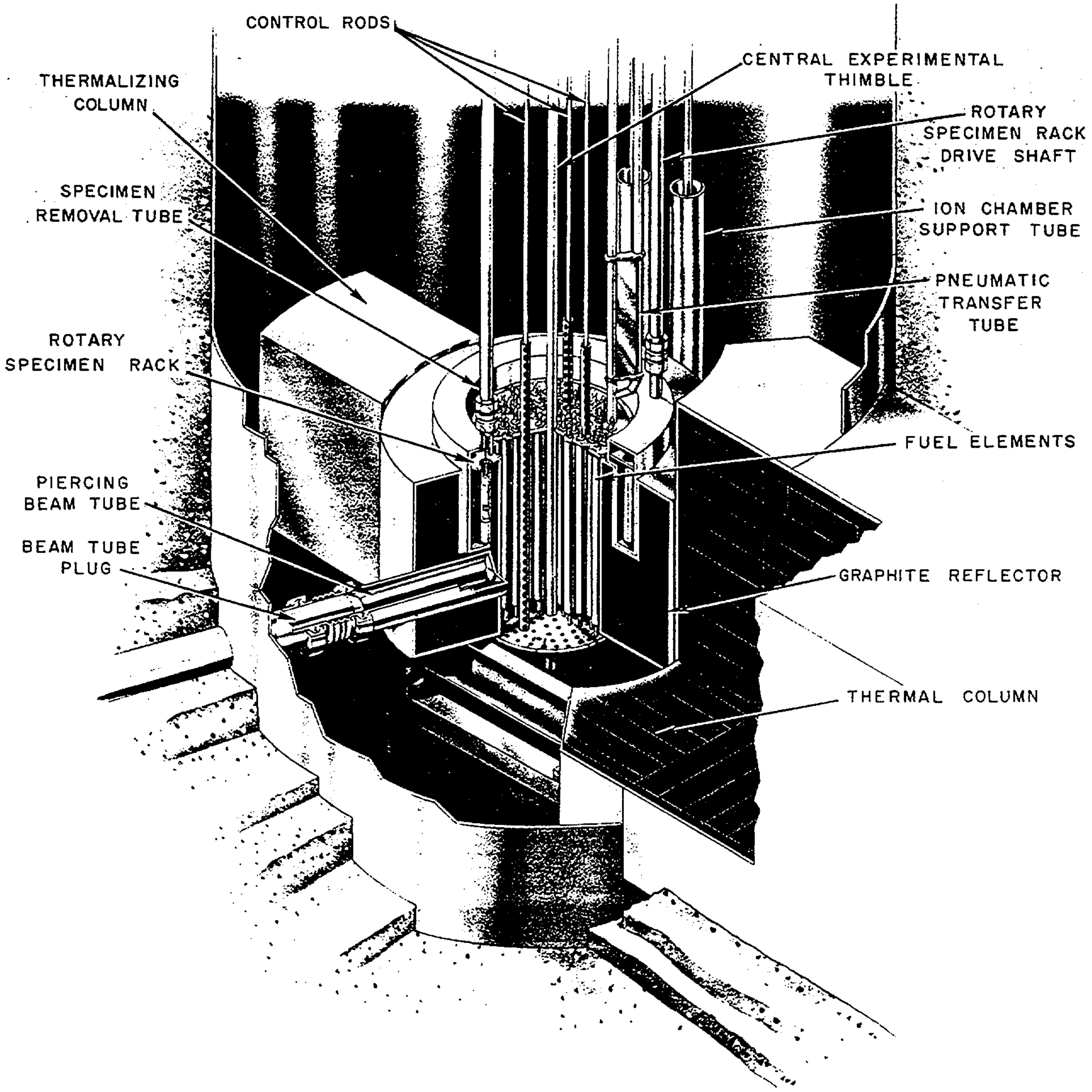
Table III.D.1 (continued)

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

RHP603	1-16	Thesis	1	5	4	2
NE605	1-16	Reading and Conference	--	--	--	1
RHP605	1-16	Reading and Conference	--	--	--	--
NE606	1-16	Projects	--	--	--	--
RHP606	1-16	Project	--	--	--	--
NE607	1	Nuclear Engineering Seminar	--	1	1	--
RHP607	1-16	Nuclear Engineering Seminar	2	--	1	--
RHP610	1-12	Internship	--	--	--	--
NE667	3	Advanced Thermal Hydraulics	--	3	--	--
Courses from Other Departments						
CH222*	5	General Chemistry (Science Majors)	--	456	--	--
CH462*	3	Experimental Chemistry II Laboratory	--	26	--	--
CH503	1-16	Thesis (Chemistry)	2	1	1	--
CHE101	3	Chemical Engineering Orientation	40	--	--	--
CE356	3	Technology and Environmental Systems	--	--	45	--
Courses from Other Institutions						
CH 223*	PCC	Chemistry	--	--	--	40
RH 289	LBCC	Alternate Energy Sources	12	30	--	--
GS 105	CCC	General Science	--	--	--	--
GS 105	LBCC	General Science	--	84	--	--
CH 223	LBCC	Nuclear Energy	--	--	44	--

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.



(MII-27B)

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

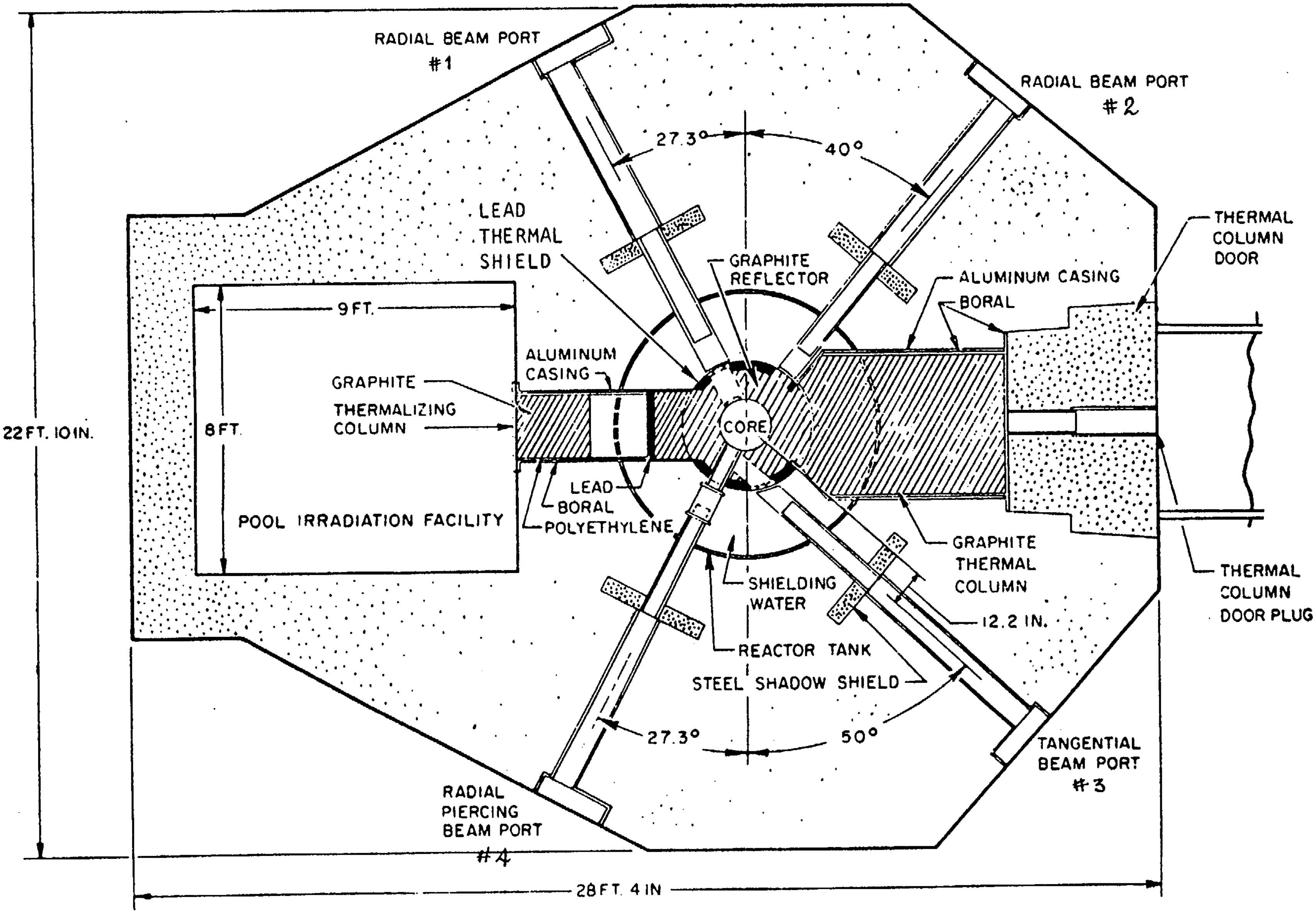


Fig. III.A.2 Horizontal Section of TRIGA Mark II Reactor

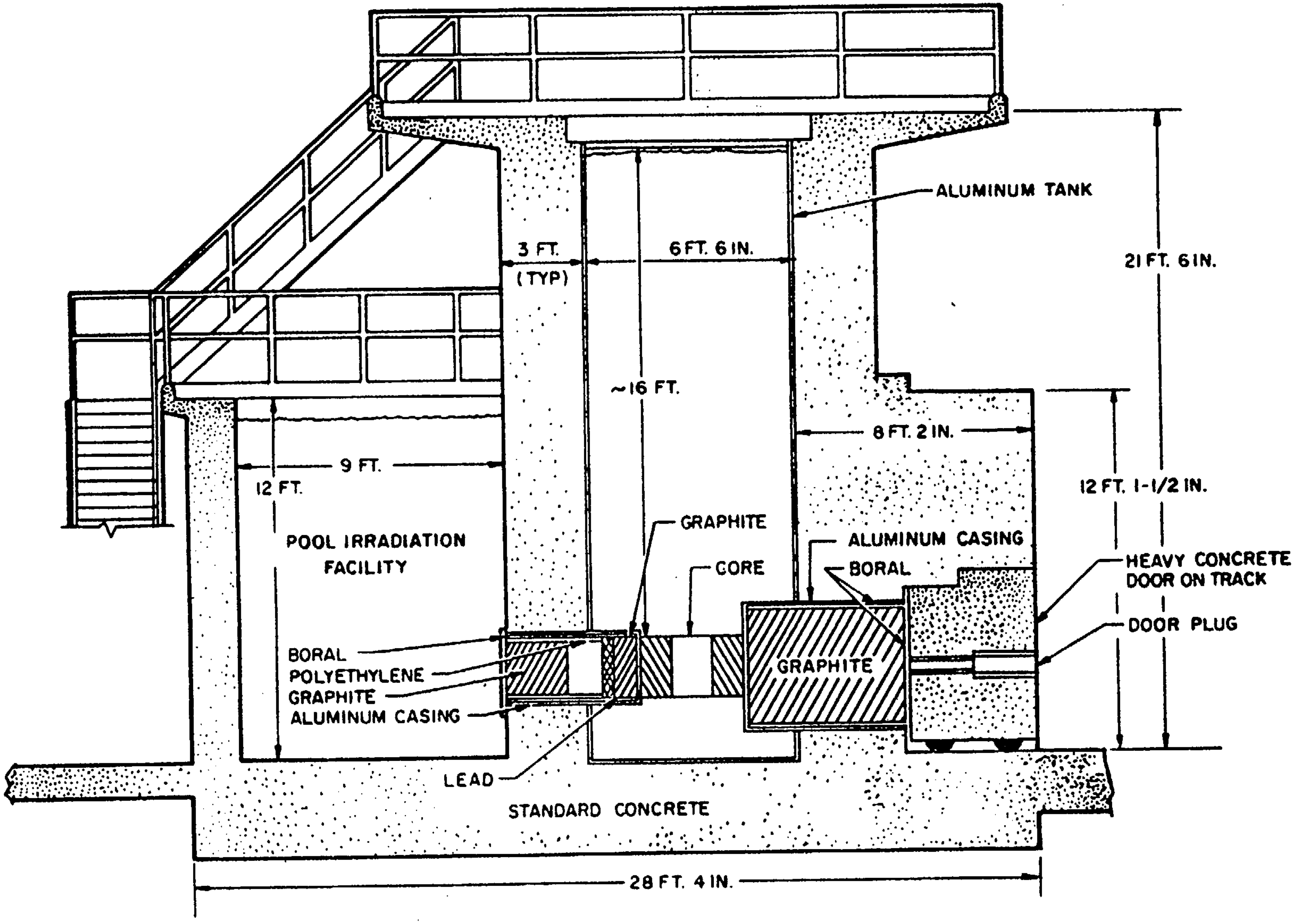


Fig. III.A.3 Vertical Section of TRIGA Mark II Reactor

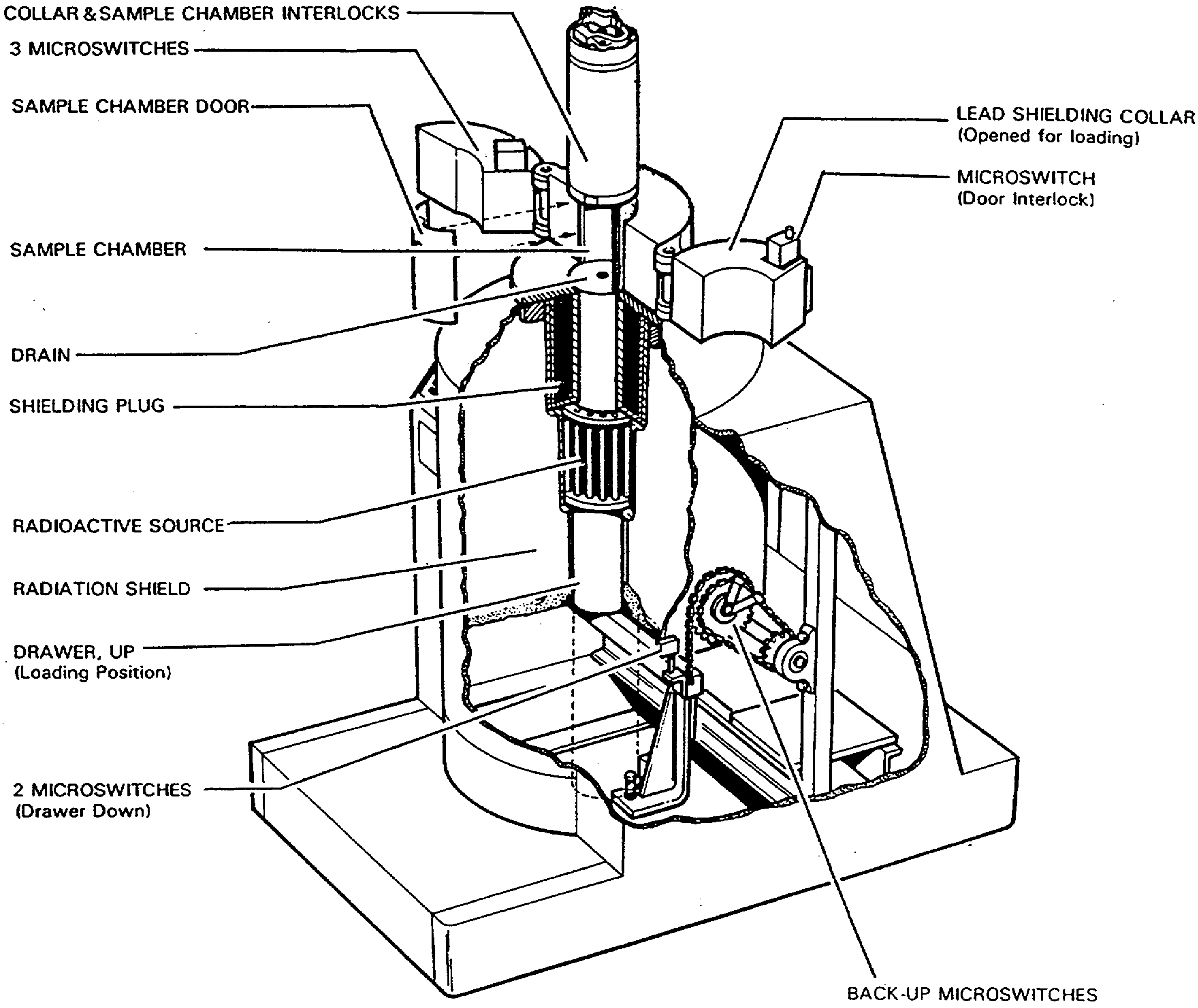
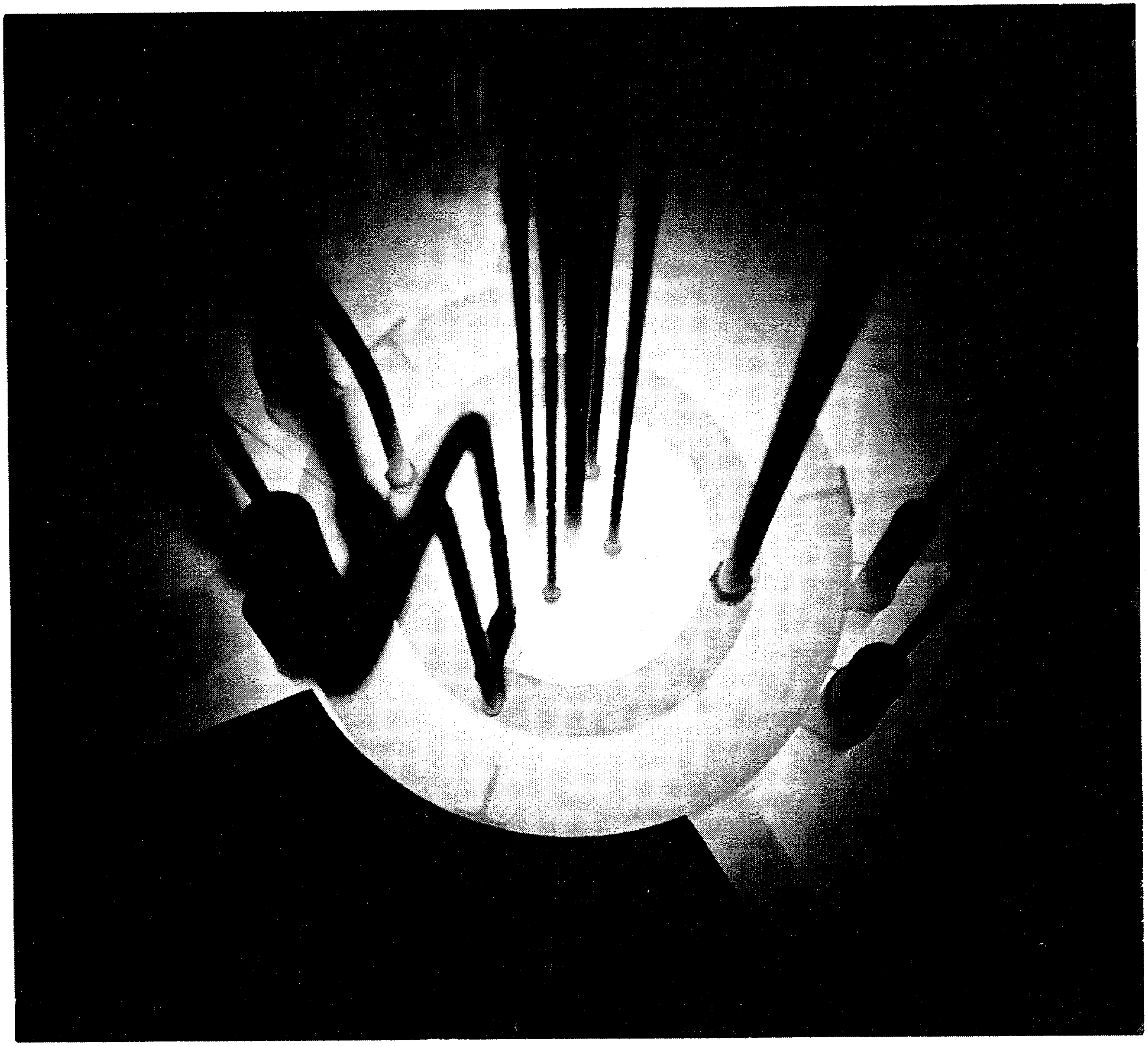


Fig. III.C.1 Gammacell 220 ^{60}Co Irradiator

Part IV

REACTOR



Part IV

REACTOR

A. Operating Statistics

For the current reporting period, the operating statistics for the OSTR made a significant increase 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 46.5 megawatt days (MWD). The cumulative thermal energy generated by the FLIP core now totals 874.9 MWD from August 1, 1976 through June 30, 1999. Reactor use time averaged 89.7% 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.

One fuel element was removed during the reporting period. The reactor core excess reactivity increased slightly (~8¢) over this reporting period. This slight increase is due to the erbium poison in the fuel elements burning at a faster rate than the fuel.

B. Experiments Performed

1. Approved Experiments

During the current reporting period there were seven approved reactor experiments, listed below, available for use in reactor-related programs. 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-31	TRIGA Flux Mapping.
B-32	Argon Production Facility

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.

2. Inactive Experiments

Presently 32 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 32 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.
B-30	NAA of Jet, Diesel, and Furnace Fuels.
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 control 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.

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, there is 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 seven changes to the reactor facility during the reporting period.

(1) *Replacement of the Cooling Tower Float Valve*

a. Description

Make-up water to the cooling tower comes from the city water system and is automatically added as needed by a brass float valve with an adjustable plastic float ball. This float valve system needed to be replaced.

The previous float system consisted of a large float connected to the make-up water valve by a long rod. Over time, the rod tended to bend such that the water level in the basin was continuously overflowing. This led to a lowering of the corrosion inhibitor concentration in the secondary system. The new float system is a self-contained, pilot-actuated float, eliminating the long rod. It is rigidly mounted on a 1" pipe.

(b) Safety Evaluation

There were no safety implications associated with the installation of the new float valve. In the event the valve fails to close, the water level rises to the overflow where it is safely conducted to a roof drain. If the valve fails to open, the cooling tower will eventually reach a point where cooling is inadequate. The operator would see this as a rise in primary water temperature leading eventually to a primary water temperature alarm. This situation would not change as a result of changing the float valve mechanism.

(2) *Installation of the In-Core Irradiation Tube*

(a) Description

An In-Core Irradiation Tube (ICIT) was created and is used and positioned in the reactor core at fuel location B1. The facility was designed to serve the same function as the Sample Handling Dummy Fuel Element (Dummy) with the exception that the new facility eliminates the need to wait for long periods of time after irradiation before samples can be removed. The tube consists of an air-filled aluminum tube with an offset bend and is secured to the center channel. Samples rest upon an aluminum saddle, within the tube, that can be retrieved with the Specimen Lifting Device (Fishing Pole). The saddle has been constructed to duplicate the same sample shelf position as the Dummy.

The ICIT was closely patterned after the CLICIT facility but can be distinguished from the CLICIT by two means. First, the offset bends on the ICIT are positioned closer to the ends rather that equally spaced along the tube as on the CLICIT. Second, the end cap on the ICIT is hexagonal rather than the round cap used on the CLICIT.

The ICIT is a closed tube with a cap securely in place. A quick disconnect is attached to the cap so that a vent line can be connected to the argon vent manifold.

A new section was added to OSTROP 10 to detail the procedures for using the new irradiation facility, and experiment B-3 was modified as necessary to allow irradiations to be performed under this experiment.

(b) Safety Evaluation

Reactivity safety implications of this facility were very similar to those for the Dummy element. Both are primarily composed of aluminum. The amount of aluminum present closely resembles Dummy #1 which has a larger air cavity than that of the other Dummy elements. Air cavity or not, all of the Dummy elements are individually worth -$0.35. The ICIT, therefore is also worth about -$0.35.

The tube is bolted to the reactor facility in such a manner that it will not be easily or unintentionally removed. This prevents any sudden, unplanned addition of reactivity to the reactor. The offset bend in the tube is roughly similar to that of the other in-core facilities to minimize radiation streaming through the tube.

The integrity of the ICIT was tested two ways. First, the facility was pressure tested during construction with no loss of pressure observed. Second, the ICIT was stored in the bulk storage tank for a month, and no water has been observed within the tube.

The procedures and limitations for storage, preparation, transfer and sample insertion/removal follow procedures for the CLICIT outlined in OSTROP 10. The procedures and limitations for irradiation and encapsulation of samples follow procedures outlined in OSTROP 18. No new or untried practices were introduced by adoption of these techniques and procedures.

(3) *Replacement of the Demineralizer Tank*

(a) Description

The demineralizer tank rusted through after almost 30 years of continuous operation. This necessitated a replacement. The new tank was made as similar to the previous tank as possible. The specifications for the old tank required a performance of 10 gallons per minute continuous, up to 100 psi and a maximum temperature of 120° F. The new tank was constructed in such as way as to meet or exceed these specifications. It also was positioned in the same location as the previous tank.

The head, bottom, and main cylinder are composed of 304L stainless steel or better. Atop the head is a stainless steel reducer mated with PVC so that intake and exit tubing can be easily mounted. The intake extends to the bottom of the tank with the exit located to the top. This creates a "reverse flow" system which helps reduce resin compaction (reverse flow was also used in the old tank).

For resin replacement, a resin flush intake tube was mounted horizontally to the side of the tank at the top. An exit tube protrudes from the bottom. This is identical to the previous tank design. The resin is identical to that previously used. No new procedures were required as the piping for both primary water connection and resin replacement was identical.

(b) Safety Evaluation

The new demineralizer tank was made as identical to the current tank as possible. Because the only foreseeable difference was the stainless steel, no change in reactivity was expected. ALARA considerations were also identical.

No reduction in water quality was expected because the amount and type of resin were identical to that currently used.

To ensure system integrity prior to installation, the stainless steel tank itself (without PVC) was satisfactorily tested hydrostatically to 150 psi and inspected for leaks and the ability to maintain the pressure. The fully completed tank assembly (final PVC hook-ups installed) was also satisfactorily leak tested at 70 psi. Heat trace numbers and packing lists were retained for all stainless steel components as well as welding certifications for personnel.

(4) Replacement of the Reactor Power Chart Recorder

(a) Description

The existing chart recorder used to display reactor power was approximately nine years old and in need of replacement. As a result, the reactor operations staff proposed to take out the old recorder and insert a new paperless chart recorder (Trendview Teletrend) in its place.

Recorder Similarities

The linear channel will continue to be monitored and illustrated as a "blue pen" on the display. The log channel will also continue to be monitored and illustrated as the "red pen" on the display.

Recorder Differences

By taking advantage of up to six input channels, fuel temperature is now permanently monitored as a third "pen" on the display. Instead of switching the log channel to fuel temperature, fuel temperature is continuously monitored and the log channel is shorted during pulse mode. Additionally, the paperless recorder has two output channels. In the future, these output channels can be used to time reactivity changes for such things as rod calibrations.

The recorder essentially acts as a data logger. The recorder configuration is password protected to prevent an inadvertent change to the program. It is set so that it writes data to a disk. Based on initial estimates of sampling rate, one 1.44-MB disk will suffice for the three channels for an entire day.

Installation of the new chart recorder necessitated a number of changes to the console. The specific changes are described below:

Power. The old recorder received switched AC power from the console rear center door. The new recorder uses unswitched AC power from the console center door.

Signals. Resistors were changed on the temperature amplifier, the log amplifier, and the linear amplifier of the left hand drawer and on the back plane of the power range monitor. These changed the range of the signals from 0-100 mV to 0-5 V. The temperature signal was routed to the recorder so as to be continuously displayed in all modes. A jumper was installed on the relay card in the left-hand drawer to short out the log channel input to the recorder in pulse mode.

Recorder Control. The old recorder used the input from the console key switch to control the chart drive. The new recorder uses the input from the key switch to stop or start data logging to the disk.

Recorder Relay Output. Relays on the new recorder were connected to a BNC jack on the upper right hand side cabinet. The new recorder allows for the setting of "alarm" set points that send signals through this relay output. By connecting an external timer, the operations staff has been able to collect more accurate and consistent rod calibration data.

Physical changes. The bezel that surrounded the old chart recorder was replaced with a new panel that supports the new recorder. This change was required because the new recorder is dimensionally different. Additionally, space was provided for new rod position displays. Moving the rod position displays to the new panel will be done under a future 50.59 and is not authorized under this 50.59 Safety Evaluation.

Specifications. The new recorder has > 1 MΩ input impedance on all channels, requires >100 VDC channel-to-channel and channel-to-ground to prevent damage to the recorder circuitry, and requires < 30 VA.

Recovery

To ensure that the recorder functioned as intended and that other systems functioned properly, the following tasks were implemented:

The procedures for test signal input to the recorder was performed per OSTROP 2.9.b.

The procedures for the calibration of the fuel element temperature channels was performed per OSTROP 15.VI.

The procedures for a check of the neutron source low count rate interlock was performed per OSTROP 15.I.A.

The procedures for a check of the 1 kW pulse prohibit interlock was performed per OSTROP 15.I.C.

(b) Safety Evaluation

Care was taken to ensure that the new recorder met or exceeded all of the specifications of the recorder it replaced. The Scientific Instrument Technician supervised the installation of the new recorder.

No change in reactivity resulted from addition of the paperless recorder. Because of fewer moving parts, the probability of failure will be equal to or lower than the current chart recorder. There will be no difference in the result of a malfunction of the current recorder and the proposed recorder as they both are connected to the system in fundamentally the same way. Finally, the ability to continuously monitor and view the history of fuel temperature in any mode of operation will undoubtedly improve operational safety.

(5) Removal of one fuel element from the F-ring

(a) Description

The current shutdown margin (SDM), as defined by the Technical Specifications (TS), was approximately $0.80. The reactor Operations Staff proposed to remove one fuel element from F17 in order to increase the SDM to allow a greater difference between the SDM and the TS limit of $0.57. From previous experience and measurements, it was expected that the removed element would increase the SDM to about $1.05± 0.05. Because the fuel element removal required recalibration of the control rods, the rod was pulled just before the next scheduled rod calibrations in the May/June timeframe.

(b) Safety Evaluation

Removing a fuel element increased the already sufficient shutdown margin of the reactor. The movement was performed under the standards outlined in OSTROP 11, Fuel Element Handling Procedures. The element is stored in a fuel storage rack which is largely empty, but which has been shown to be sufficiently subcritical even when completely full. Removing one element from the core did not result in a change to the OSTR physical security category because the mass of non self-protecting ^{235}U is still less than 5 kg. The fuel element in F17 was chosen because it was located on the periphery, maintaining a continuous grouping of 80 FLIP fuel elements, and at the same time sufficiently increasing the SDM.

(6) Use of an external monitoring device for annual control rod calibrations

(a) Description

The reactor operations staff proposed to use an external monitoring device to perform annual control rod calibrations. The old method for control rod calibrations involved using two stopwatches to measure the time for reactor power to increase by a factor of 1.5 as indicated by the linear trace on the recorder. These time measurements were repeated twice for a total of six measurements on three different ranges for each rod pull. The value of the reactivity increment for the pull was obtained by averaging the six measurements.

The proposed method involved a custom built timer connected to the wide range linear channel signal at the CDAS jack on the lower right hand side cabinet. The timer uses comparators to accurately measure the time for reactor power to increase by a factor of four.

The timer uses an AND gate to enable an oscillator with a totalizer. Two precision adjustable voltage regulators are used to produce the reference voltages for the comparators. The linear power signal from the CDAS jack was connected to the timer. As the linear power signal exceeds the first reference voltage, the 1 kHz oscillator signal is gated to the totalizer. When the linear power signal exceeds the second reference voltage, the oscillator gate is closed and the enable latch is dropped out. This prevents the timer from recycling as power drops in response to the scrammed control rod. The resulting display on the totalizer gives the time, in milliseconds, required for the linear power signal to increase from 2 to 8 VDC.

(b) Safety Evaluation

The purpose of this device was to eliminate error associated with the use of stopwatches by individual reactor operators. Formerly, six times (three times each by two operators) were obtained by visually observing the trace crossing a designated power level. By using the timer, error associated with the individual operator and between operators has been virtually eliminated. This has resulted in more consistent control rod calibrations and contributes, at a fundamental level, to reactor safety.

A number of functional checks were performed on the timer prior to each time it is used. First, the existing procedure in OSTROP 26 is used to ensure that the timer can be safely connected to the CDAS panel. Second, the frequency of the time base is checked along with the comparator voltages. Third, the timer is functionally tested by inputting the same test signals into the linear trace that are used for the startup checklist. Ranging through this linear test signal produces a comparable value for each test. Finally, the Reactor Supervisor compares the control rod calibration to previous calibrations to ensure consistency and reproducibility.

A circuit was used to test the reproducibility of the timer. Using the nominal value of the components, the time for voltage to increase from 2 to 8 volts was calculated to be 916.3 ms. In all 25 repetitions of the test, the timer displayed a time of 917 ms.

(7) ^{41}Ar Production Facility

(a) Description

The reactor operations group proposed to construct and install a facility for the production of ^{41}Ar. The main components consisted of an irradiation vessel, a valve manifold, a condenser system, a vacuum pump and tank, and a shipping container manifold system, as well as associated piping. The irradiation chamber was positioned next to the reactor core inside beam port #4. Most other components are outside the beam port behind shielding materials. The condenser system consists of a 25 mL tubular bulb and a Thermos container which can be filled with liquid nitrogen (LN_2) and remotely raised and lowered around the bulb.

Briefly, the procedure calls for connecting the shipping containers at the manifold and evacuating them, the irradiation vessel, intervening lines, and the vacuum tank while all values are open. After the proper vacuum is reached, the system is isolated and ^{40}Ar is allowed to expand into the irradiation chamber. The filling pressure will depend on the activity desired. Once filled, the chamber will be isolated by closing a valve. The reactor is then brought to power and the ^{40}Ar irradiated for a period of time to be determined by the activity desired. At the end of irradiation, LN_2 is poured into the Thermos to immerse the condenser bulb, the irradiation chamber is opened, and the argon gas is condensed into the bulb. Once an optimal pressure is reached, the bulb is closed to the irradiation chamber and opened to the shipping casks. As the LN_2 is removed, the gas expands into the shipping casks. The pressure of the shipping containers is a function of the original irradiation chamber pressure and the difference in volume between the irradiation chamber, shipping containers, and associated valves and tubing. Once the equilibrium pressure is reached, the shipping containers are closed and the tubes are purged to a shielded vacuum storage tank. This prevents unused ^{41}Ar from entering the reactor bay. The beam port (BP) #4 area radiation monitor (ARM) or another ARM is positioned in such a location as to alarm should significant quantities of ^{41}Ar be drawn into the vacuum storage tank.

(b) Safety Evaluation

The only possible effect on core reactivity would be due to the proximity of the irradiation chamber to the reactor core. The vessel is made out of stainless steel, with a 1.8 inch wall thickness for the end plates and 1/16 inch wall for the cylindrical tube. The stainless steel presents a very small amount of additional neutron absorption, and the argon/air/vacuum in the chamber has a negligible reactivity effect. Based on experience with the positive reactivity effect of a water-filled aluminum chamber in the beam port, it was estimated that the negative reactivity effect would be $0.15 or less. As part of the commissioning of the facility, the reactivity effect was measured prior to going to power.

There is no possibility of the chamber being inadvertently removed and causing any reactivity excursion while the reactor is operating due to the fact that the shielding plugs are in place. Therefore, this is considered to be a secured experiment.

All of the facility is behind sufficient shielding to keep dose rates ALARA. Having the system in BP#4 made it easy to stack shielding materials on the floor around the beam port. Each of the valves has long-handled extensions which penetrate the shielding to minimize hand dose while operating. At some time in the future, remotely operated valves may be installed. The greatest potential for personnel dose occurs during the disconnection and preparation of the shipping containers for transport. Discussions with personnel at the Texas A&M reactor facility, who are currently doing this, indicated that these handling doses were not excessive and well within regulatory limits.

Technical Specification (TS) 3.8.e currently states that: "Where the possibility exists that the failure of an experiment (except fueled experiment) under (1) normal operating conditions of the experiment or reactor, (2) credible accident conditions in the reactor, or (3) possible accident conditions in the experiment, could release radioactive gases or aerosols to the reactor bay or the unrestricted area, the quantity and type of material in the experiment shall be limited such that the airborne concentration of radioactivity in the reactor bay and the unrestricted area will not exceed the applicable regulatory concentration limits in 10 CFR 20, assuming 100% of the gases and aerosols escape from the experiment." It was argued that none of these three conditions is relevant to the current experiment.

(1) Normal operating conditions of the experiment cannot result in a release of ^{41}Ar since the system is designed to fully contain the gas at all times. Normal operating conditions of the reactor have no impact whatsoever on this experiment since they are totally external to the reactor and its tank.

(2) Credible accident conditions in the reactor similarly do not impact the argon facility. None of the credible or incredible accident conditions postulated in the OSTR Safety Analysis Report results in any damage to the beam ports or equipment external to the reactor itself.

(3) The accident conditions in the experiment itself which require evaluating with respect to their "possibility" are (a) rupture of piping or components; and (b) operator error.

    (a) The ^{41}Ar production facility has been pressure tested up to 350 psig and is routinely vacuum tested prior to each operation. The relief valve for the argon supply lifts at 100 psig, so that is the maximum possible pressure for the irradiation chamber side of the system. The maximum setting on the variable relief valve is 350 psig, but the actual setting is usually 20 psig above that expected in the shipping containers after filling. Since the maximum system pressure cannot exceed that set on the relief valve, rupture of components and plumbing under any conditions of operation is deemed not possible.

(b) The only release pathways to be considered with respect to operator error are via (i) the argon supply relief valve; (ii) the vacuum pump valve; (iii) the shipping container valves; and (iv) the condenser bulb relief valve.

(i) A check valve has been installed in the system to preclude the possibility of releasing ^{41}Ar via the argon supply relief valve if the argon supply tank is left open to the system.

(ii) The system is pumped down to a vacuum, and that vacuum held for a least 5 minutes prior to any ^{41}Ar production. The vacuum also is checked at the end of the irradiation prior to any valve reconfiguration. Therefore, if the vacuum pump valve has been left open, the loss of vacuum is obvious and no transfer is made. If it is left open after irradiation, the vacuum will not be lost for about 3 hours because of the check valves in the pump itself. In the event that it is inadvertently left open during volatilization of the argon, the BP#4 ARM will alarm and draw attention to the error. More importantly, the volume of the vacuum tank is so large (15 gallons/57 liters) that its pressure only rises to about 0.5 psi. This is well below atmospheric pressure, and so there is no force to drive gas out of the vacuum pump. Therefore, there is no possibility of release via the vacuum pump valve.

(iii) In the event that a shipping container valve is not closed after volatilization, most of the ^{41}Ar in the container will be sucked into the vacuum tank as the lines are cleared. If this happens, BP#4 ARM will alarm, as the dose rate in the tank will increase significantly. This provides ample warning to the operator that the shipping container valve was not closed. However, even if it was subsequently disconnected, the ^{41}Ar remaining in the container at this point is less than that required to create an airborne concentration of radioactivity in the reactor bay exceeding the applicable regulatory concentration limit in 10 CFR 20.

(iv) The condenser bulb relief valve does not vent to the atmosphere; rather it vents to the vacuum tank. If over-pressurization occurs, the ^{41}Ar will vent to the vacuum tank causing BP#4 ARM to alarm. However, the pressure in the vacuum tank will still remain well below atmospheric.

The experiment described above was 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 experiment 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.

2. 10 CFR 50.59 Changes to Reactor Procedures

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

(1) *Revisions to the Radiation Center and OSTR Emergency Response Plan*

(a) Description

Annual revisions to the Emergency Response Plan are given below. The revisions represent typographical corrections, changes in personnel that have occurred in the last year, and changes in reporting contacts with the NRC.

Page i: Deleted space in 3.3.2.

Changed "Oregon Department of Energy" to "Oregon Office of Energy" everywhere it appeared in the text.

Changed "ODOE" to "OOE" everywhere it appeared in the text.

Figure 3.2: Changed "Operations Committee Chairman" to "Reactor Operations Committee Chairman".

Section 4.3.b: Changed "project" with "projected" and "20 mrem/hr^{-1}" with "20 mrem/hr"

Changed "APEX" to "APEX/ATHRL" everywhere it appeared in the text.

Section 6.0, changed "emergency planning zone" to "emergency planning zone (EPZ)"

Section 7, outlined subtitles not currently outlined.

Changed "Continuous-Air-Monitor" to "Continuous Air Monitor" everywhere it appeared in the text.

Section 7.2.2, changed "μCi/cm^{-3}" to "μCi/cm^{3}" everywhere it appeared.

Section 7.2.3, changed "Campus Security" to "Security Services" and change "couse" to "course".

Section 7.3.1.d, changed "Campus Security" to "Security Services"

Section 7.3.3.c.ii, changed "tnak" to "tank".

Section 7.4.3, changed "persones" to "persons". Considered changing the outline nomenclature from "7.4.1" to just "1)".

Section 8.2.1.a.ii, changed "gama" to "gamma".

Section 8.2.1.b.iii, changed "multi-channel" to "multichannel".

Section 8.2.3.a.i-iii, changed ". Normally in" to ", normally in"

Section 8.2.5.c, changed "Deminerlizer" to "Demineralizer".

Deleted Section 8.3.4.a.iii.

Section 10.3.c, changed "Regional Administrator" to "Project Manager, Non-Power Reactors and Decommissioning Project Directorate"

Section 10.4.3.b, replaced with "Emergency equipment located in a cabinet at the Good Samaritan Hospital and with the Regional HAZMAT vehicle owned by the Corvallis Fire Department is inspected and inventoried semi-annually."

Changed figure A.2 to include the ATHRL facility.

Section E-2-1, changed footnote from "This value is 8.13X10^{-4} (0.0008) of the 15 mrem action level" to "This value is 1.63X10^{-4} (0.00016) of the 75 mrem action level"

Section E-5-6 needed to be updated to reflect personnel changes. The new text reads:

Corridor	Monitor	Alternate
A	E. G. Schütfort	R. H. Farmer
B	K. M. Brock	D. C. Carver
C	M. R. Conrady	A.C. Klein
D	A. D. Hall	G. M. Wachs
E	J. L. Robinson	K. A. Higley
APEX/ATHRL	J. T. Groome	M. Yundt

Section E-5-8, changed "(S. E. Binney)" to "(J. F. Higginbotham)".

Section E-5-9, changed "(J. F. Higginbotham)" to "(S. R. Reese)".

ERIP 4 referenced RCHPP 3. It should reference RCHPP 34.

Section E-5-16, changed "(S. R. Smith)" to "(D. G. Carver)".

Section E-5-17.3, changed "corridors" to "corridor".

Section E-5-18, changed the checklist table to:

Name	Corridor
E. G. Schütfort	A
K. M. Brock	B
M. R. Conrady	C
A. D. Hall	D
J. L. Robinson	E

Section E-7-3, changed the call list to:

Gary Wachs	753-2749
Art Hall	929-4592
Steve Reese	758-0379
Dave Pratt	757-8914
Steve Smith	967-8691
Kathy Brock	754-8351
Steve Binney	752-5848

Replaced Section E-7-4 with the latest version of the directory.

Section E-7-5 needed to be updated to reflect the reporting contact numbers to the NRC. Specifically, changed "USNRC " Region IV (CST working hours)" with the following:

"Non-Power Reactors and Decommissioning Project Directorate Division of Reactor Program Management Office of Nuclear Reactor Regulation".9-1-301-415-2170-9934546"

Replaced section E-7-6 with the following:

Emergency Position	1st Choice	2st Choice	3st Choice
Emergency Director	S. E. Binney	J. F. Higginbotham	S. R. Reese
Emergency Coordinator	S. R. Reese	A. D. Hall	S. E. Binney
Senior Health Physicist	D. S. Pratt	K. M. Brock	R. H. Farmer
APEX/ATHRL Coordinator	J. T. Groome	M. Yundt	J. N. Reyes

Radiological Assessment Team	K. M. Brock M. R. Conrady D. R. Carver	R. H. Farmer D. Hall D. L. Harlan	E. G. Schütfort S. P. Smith
Public Information Officer	Designated Rep. From OSU News and Communication Services	J. F. Higginbotham	S. E. Binney
Recovery Operations Coordinator	S. R. Reese	A. D. Hall	S. E. Binney
Historian	L. M. James	D. K. Dalton	S. C. Campbell
Chairman of Reactor Operations Committee	J. F. Higginbotham	J. C. Ringle	A. C. Klein (or any available ROC member
First Aid Responders	D. R. Carver	K. M. Brock	

Changed section E-8-2 with the following:
Radiation Center Director - Steve Binney
ROC Chairman - Jack Higginbotham
Reactor Administrator - Steve Reese

Checked section E-8-4 to ensure that the phone numbers were correct and current.

Changed section E-8-5 to reflect that Steve Binney is the current Radiation Center Director.

(b) Safety Evaluation

There were no safety implications associated with the proposed revisions. The intent of the plan was in no way altered.

(2) Revision of OSTROP 26, "Procedures for the Connection of External Monitoring and Recording Devices"

(a) Description

As a result of an audit performed by the Reactor Operations Committee during the meeting held on May 29, 1998, it was recommended that the following changes be made to OSTROP 26.

Proposed changes:

In section 1.B, deleted "or 26.4".

2) Deleted sections 4 and 5. The contents of these sections were previously deleted.

(b) Safety Evaluation

These changes represented only minor text editing. These changes in no way reduced or altered the intent or meaning of the OSTROP.

(3) Revision of OSTROP 11, "*Fuel Element Handling Procedures*"

(a) Description

As a result of an audit performed by the Reactor Operations Committee during the meeting held on February 26, 1999, it was recommended that the following changes be made to OSTROP 11.

Proposed changes:

Changed the entire OSTROP to the new format.

In section C.4, changed "he will" to "who will"

In section D.1.e, changed "long extension that" to "long extensions that"

Replaced section E.1.c with, "Fuel must be kept within the OSTR material access area."

The In-Core Irradiation Tube was approved with 10 CFR 50.59 Safety Evaluation 98-6. In section D.2, included references to the new ICIT facility with the following specific changes:

In section D.2, changed the title from, "Fuel Element Handling to Insert and Remove the Sample-Holding Dummy Element or the Cadmium-Lined In-Core

Irradiation Tube (CLICIT)" to "Fuel Element Handling to Insert and Remove the Sample-Holding Dummy Element (SHDFE), the In-Core Irradiation Tube (ICIT) or the Cadmium-Lined In-Core Irradiation Tube (CLICIT)"

In the note following the title of section D.2, changed "sample-holding dummy fuel element and the cadmium-lined in-core irradiation tube" to "SHDFE, the ICIT and the CLICIT"

In section D.2.a, changed "dummy fuel element or the CLICIT" to "SHDFE, ICIT or CLICIT"

In section D.2.b, changed "where the dummy fuel element or CLICIT" to "where the SHDFE, ICIT or CLICIT"

In section D.2.c, changed "position the CLICIT" to "position the ICIT or CLICIT"

In section D.2.d and D.2.f, changed "the dummy element or the CLICIT" to "the SHDFE, ICIT or CLICIT"

(b) Safety Evaluation

These changes represented only minor text editing. These changes in no way reduced or altered the intent of the OSTROP.

(4) Revision of OSTROP 18, "*Procedures for the Approval and Use of Reactor Experiments*"

(a) Description

As a result of an audit performed by the Reactor Operations Committee during the meeting held on February 26, 1999, it was recommended that the following changes be made to OSTROP 11.

Proposed changes:

Changed section I.B.1 from, "Where applications to the" to "Whenever applications to the"

In section II.B.4, changed the first sentence from, "The experiment will then be submitted to the Reactor Operations committee, who will analyze it with regard to reactor safety." to "The experiment will then be submitted to the Reactor Operations Committee, whose members will analyze it with regard to reactor safety."

In section III.A.4, changed the last sentence from, "completed by the reactor operations staff" to "completed by the reactor operations or health physics staff"

Changed the heading in Table 18.2 from "(MWh) " to "(kWh)".

(b) Safety Evaluation

These changes represented only minor text editing. These changes in no way reduced or altered the intent of the OSTROP.

(5) Revision of OSTROP 6, "*Administrative and Personnel Procedures*"

(a) Description

The Reactor Operations Committee initiated the following changes during the meeting held on April 1, 1999.

Proposed changes:

In the table of contents, the page number was changed on section V.B.2 from "11" to "12".

In section III.B.1, the last sentence was changed from, "The procedure from becoming an authorized "Program Director" for radiation use is given in the document entitled "Guidelines for the Radiation Protection Program at the OSU Radiation Center" to "The procedures for becoming an authorized "Program Director" are given in RCHPP 34."

In section V.B.4.e, "reactor facility" was changed to "Radiation Center".

In section VI.B.2, "radio receiver" was changed to "radio receiver or cell phone" wherever it appeared in the text.

In the organizational chart in section I, "Vice Provost for Research and International Programs" was changed to "Vice Provost for Research."

In section V.B.2.a, "and direct technical" was changed to "and directs technical"

(b) Safety Evaluation

These changes represented only minor text editing. These changes in no way reduced or altered the intent of the OSTROP.

(6) The following changes were made to OSTROP 9, *Control Rod Calibration Procedures*:

(a) Description

Sections II.A and II.B were changed to II.B and II.C, respectively. The new section II.A was added as follows:

Rod Calibration Timer
The reactor shall be shutdown.
The frequency and comparator voltages shall be check and not exceed the range of values given in Table 1.

Table 1 " Control Rod Calibration Timer Check Specifications

Measurement	Location	Specification
Frequency	TP3(+) to TP4(-)	1000 " 5 Hz
Low Comparator	TP1(+) to TP4(-)	2 " 0.005 VDC
High Comparator	TP2(+) to TP4(-)	8 " 0.005 VDC

Procedures given in OSTROP 26.I.A shall be performed on the control rod calibration timer.

Disconnect the timer from CDAS panel J2 and connect it to CDAS panel J1.

Place the range switch in the 30W position and rotate the period/log test switch to position #2.

Press the reset button, the timer enable and observe that the green light is on.

Rotate the range switch to the 3W position.

The timer should display 1200 " 100 ms. The Reactor Supervisor shall be notified if the timer displays a value outside of this range.

Return the period/log test switch to the operate position.

In section II.C (current section II.B), replace sections II.C.1, 2, 3, and 7 with:

After the reactor has reached equilibrium, place the reactor in the steady state (manual) mode, rotate the range switch to 1 kW, press the timer reset, press the timer enable and observe that the green light is on. Induce a positive period of 6 to 15 seconds by withdrawing the control rod from its lower limit.

After the reactor settles on a stable period, record the period meter indication.

When the green light on the timer turns off, scram the regulating rod.

Place the reactor in the automatic mode. After the reactor reaches equilibrium, place the reactor in the steady state (manual) mode, rotate the range switch to 1 kW, press the timer reset, press the timer enable and observe that the green light is on. Induce a positive period of 6 to 15 seconds by withdrawing the control rod.

Delete the note following current section II.B.2.

Replace current section II.B.4 with "Calculate the differential reactivity worth."

3. 10 CFR 50.59 Changes to Reactor Experiments

There were two changes to reactor experiments during this reporting period.

(1) Revision of Experiment B-3, "Irradiation of Materials in the Standard OSTR Irradiation Facilities"

(a) Description

Use of the new in-core irradiation tube (ICIT) was approved by a previous 50.59 Safety Evaluation. The change below modified Experiment B-3 to include procedures for the ICIT facility.

Proposed changes:

In the Description of Experiment B-3, changed the second sentence in the first paragraph from, " These facilities include the rotating rack, the" to "These facilities include the in-core irradiation tube, the rotating rack, the"

(b) Safety Evaluation

This change only added the ICIT to the list of approved facilities to be used in Experiment B-3. This change in no way reduced the effectiveness, intent or meaning of Experiment B-3.

(2) Addition of Experiment B-32, Argon Production Facility

(a) Description

Creation of Experiment B-32, *Argon Production Facility*, was approved under the facility change 10 CFR 50.59 safety evaluation for the Argon Production Facility. Procedures were reviewed and approved by the Reactor Operations Committee under a non-10 CFR 50.59 evaluation process.

E. Surveillance and Maintenance

1. Non-Routine Maintenance

July 30, 1998	Replaced a Nixie tube in the Safety Rod position indicator.
August 4, 1998	Terminated use of the local chart recorder on the Reactor Top Constant Air Monitor.
August 17, 1998	Replaced the Regulating Rod Drive gear box.
October 15, 1998	Removed the primary system demineralizer tank (original equipment).
October 26, 1998	Installed the irradiation chamber for the new Argon Production Facility into B.P. 4.
November 24, 1998	Installed the new primary system demineralizer tank.
November 25, 1998	Changed out the particulate water filter on the primary demineralizer skid.
December 3, 1998	Performed core excess with the new ICIT Facility.
December 14, 1998	Honed down the mid-section weld inside the ICIT Facility.
January 2, 1999	Installed a new power supply in the Hold Up Tank (HUT) level alarm system.
January 4, 1999	Demineralizer system valves, DV-1 and DV-18, will remain normally open at all times.
January 8, 1999	Replaced the starting capacitor on the Rotating Rack Facility.
January 25, 1999	Testing completed on the Argon-41 Production Facility (APF). APF approved for production level operation.
February 3, 1999	Installed a new cooling tower make up float valve.
February 3, 1999	Flushed out the main lines of the primary emergency make-up system.

March 8, 1999	Replaced the belts on the reactor bay supply fan.
March 22, 1999	Replaced the belts on the cooling tower fans.
April 7, 1999	Repaired the pre-heat coil in the reactor bay ventilation system.
April 30, 1999	Rewired the west reactor tank underwater light.
May 8, 1999	Reactor power chart recorder replaced with a new TrendView paperless chart recorder.
May 12, 1999	Rewired the rear console plug connection to the IFE's middle thermocouple.
June 7, 1999	Removed a fuel element from the reactor core for increased shut-down margin.
June 8, 1999	Performed control rod calibrations using the new external monitoring device connected through the Reactor CDAS panel.
June 9, 1999	Installed the spare rabbit system blower.
June 16, 1999	Replaced the automatic condensate drain cell on the Corken air compressor.
June 21, 1999	Replaced the membrane on the reverse osmosis (RO) unit that supplies makeup water to the reactor.
June 24, 1999	Cleaned out the reactor makeup tank.

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 two reportable occurrences during the reporting period. The first involved a failure to submit a Material Balance Report, required by 10 CFR 74.12 (a)(1), within 30 days following the end of the reporting period. The occurrence was self-identified and was addressed in detail in a report to the NRC dated March 5, 1999.

The second event involved a violation of the OSTR Physical Security Plan. The occurrence was self-identified and corrected in a timely manner. A detailed description of events can be found in a letter to the NRC dated April 20, 1999.

Table IV.A.1

OSTR Operating Statistics (Using the FLIP Fuel Core)

Operational Data for FLIP Core	**August 1, 1976 Through June 30, 1977**	**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

See footnotes following the table.

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	-2	0	-1,+1	-1	0
Number of Irradiation Requests	407	403	387	373	290	301	286	297

See footnotes following the table.

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	1226	1124	1029	1241	
Megawatt Hours	1026	1122	1117	1105	985	927	1115	
Megawatt Days	42.7	46.7	46.6	46.0	41.0	38.6	46.5	
Grams ^{235}U Used	53.6	58.6	58.4	57.8	51.5	48.5	58.3	
Hours at Full Power (1 MW)	1000	1109	1110	1101	980	921	1109	
Numbers of Fuel Elements Added or Removed (-)	0	0	0	-1(5)	-1, +1(7)	0	-1(5)	
Number of Irradiation Requests	329	303	324	268	282	249	231	

(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.
(2) No fuel elements were added, but one fueled follower control rod was replaced.
(3) Two fuel elements were removed due to cladding deformation.
(4) One fuel element removed due to cladding deformation and one new fuel element added.
(5) One fuel element removed for core excess adjustment.
(6) No fuel elements were added, but the instrumented fuel element was replaced.
(7) One fuel element removed due to cladding deformation and one used fuel element added.

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**	**Jul 1, 68 Through Jun 30, 69**	**Jul 1, 69 Through Mar 31, 70**	**Apr 1, 70 Through Mar 31, 71**	**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**	**TOTAL: March 67 Through July 76**
Operating Hours (critical)	904	610	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	6.1	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; 250kW). Note: This period length is 1.33 years as initial criticality occurred in March of 1967.

(2) Reactor shutdown August 22, 1969 for one month for upgrading to 1MW (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 shutdown June 1, 1971 for one month for cooling system upgrading.

(4) Reactor shutdown 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	1,115	20,996
MWD of energy produced	46.5	874.9
Grams ^{235}U used	58.3	1097.9
Number of fuel elements added to (+) or removed from (-) the core	-1	80 + 3 FFCR(1)
Number of pulses	11	1,301
Hours reactor critical	1,241	25,844
Hours at full power (1 MW)	1,109	20,598
Number of startup and shutdown checks	255	5,809
Number of irradiation requests processed(2)	231	7,870
Number of samples irradiated	3,632	97,119

---

(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 0 to 160 samples. The number of samples per irradiation request averaged 15.7 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)	1,114	11,512
OSU research(2)	473	8,447
Off-campus research(2)	1,088	13,492
Forensic services	5	221(3)
Reactor preclude time	892	17,644
Facility time(4)	53	6,992
Visitor demonstration(5)	6	318
TOTAL REACTOR USE TIME	3,631(6)	58,626

---

(1) See Tables III.A.2 and III.D.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.

(6) Total reactor use time includes all multiple use hours added separately.

Table IV.A.5

OSTR Multiple Use Time(1)

Number of Users	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
Two	371	3,627
Three	81	1,161
Four	32	434
Five	3	114
Six	0	45.5
Seven	0	11
TOTAL MULTIPLE USE TIME	487(2)	5,392.5(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 39% of the total hours the reactor was critical during this reporting period.

(3) This represents 21% 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)

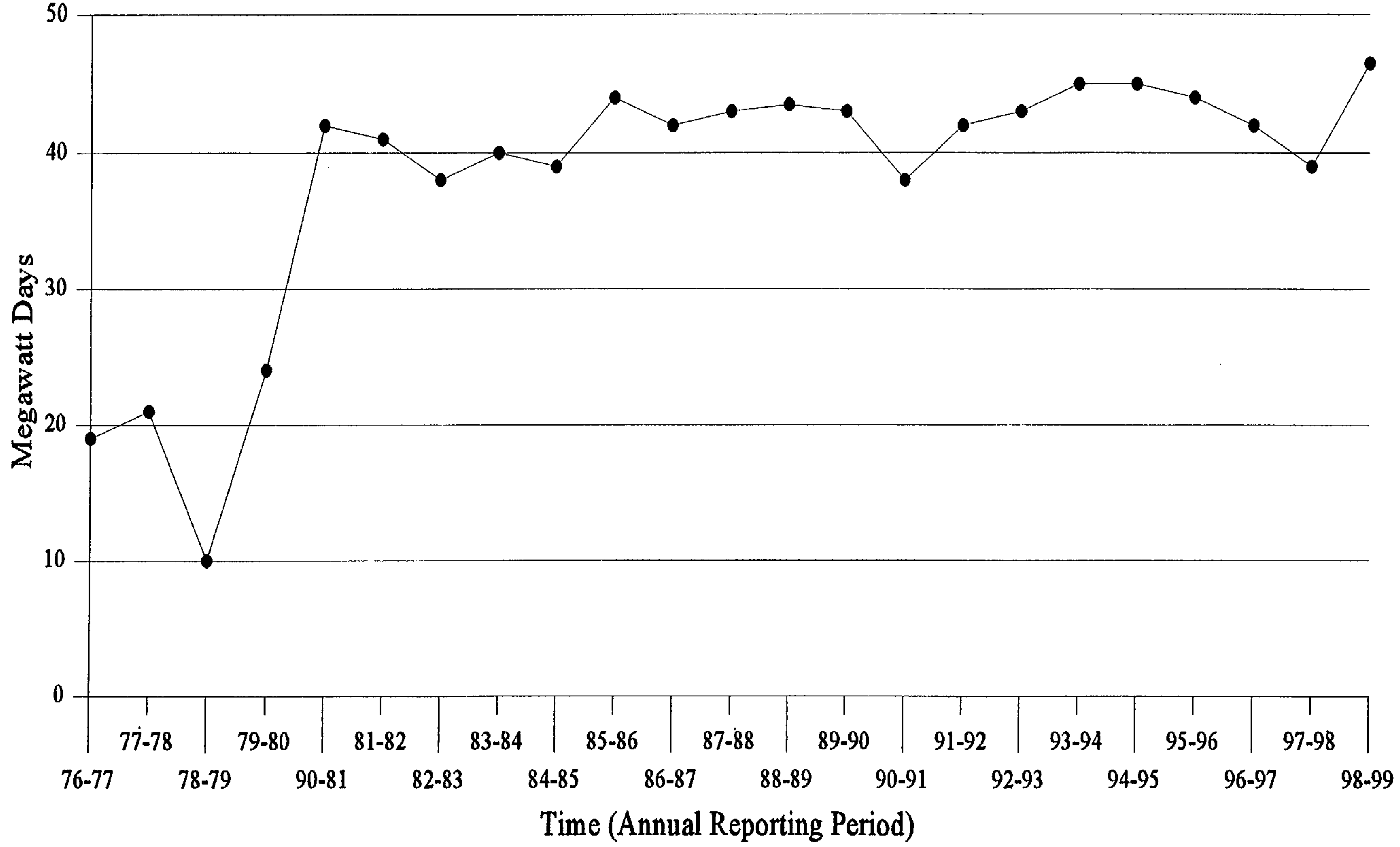


Table IV.B.1

Use of OSTR Reactor Experiments(1)

Reactor Experiment Number(2)	Research	Teaching	Forensic	Facility Time(3)	TOTAL
A-1	2	37	0	13	52
B-3	147	20	1	N/A	168
B-12	8	0	0	N/A	8
B-32	3	0	0	N/A	3
TOTAL	160	57	1	13	231

---

(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-12	Exploratory Experiments
B-32	Argon Production Facility

(3) The number of times the OSTR operated to meet NRC facility license requirements.

Table IV.C.1

Unplanned Reactor Shutdowns and Scrams

Type of Event	Number of Occurrences	Cause of Event
Safety Channel Power Scram	2	The scram set point on the safety channel was reached while balancing rods at 1MW.
Manual Scram	1	Nixie tube failure in the safety rod position indicator.
Fuel Element Temperature Scram	1	Spurious fuel element temperature alarm and scram. The operator was rotating the fuel temperature selector switch between thermocouple positions when the scram occurred.
Safety Channel Power Scram	1	Spurious safety channel scram in conjunction with a reactor low water level alarm. Noted significant bubbling (voiding) around the safety channel ion chamber from air taken in through the reactor tank surface skimmer.
Safety Channel Power Scram	1	Operator performed an overinsertion of reactivity in square wave mode.
Manual Scram	2	Stack monitor filter failure alarm. The filter was replaced and reactor operation was resumed.
Period Scram	1	Operator withdrew too much control rod while taking the reactor to power.
Manual Scram	1	Manual scram performed in response to a loss of fuel temperature indication on IFE thermo couple position #2.

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 & 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					
	S.G.: >1.250					
INVERTER	FUNCTIONAL CHECK					
	S.G.: >1.250					
GENERATOR	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 ¼" LEFT					
7 REVIEW REACTOR SUPERVISOR'S LOG	CURRENT					
8 CHANGE LAZY SUSAN FILTER	FILTER CHANGED					
9 LUBRICATE THE TRIGA TUBE LOADING TOOL (REEL)	USE OIL GUN	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 time 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 ______/______/______ 19____**

	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	(NOT BEING USED)						
11	ARM SYSTEM ALARM CHECKS	FUNCTIONAL					

CHAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14
AUD														
LIGHT														
PANEL														
ANN														

‡ Physical Security Plan Requirement
* 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.

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Figure IV.E.2 (Continued)

Quarterly Surveillance and Maintenance (Sample Form)

OSTROP 14 (CONTINUED) **SURVEILLANCE & MAINTENANCE FOR THE *QUARTER* OF ________/________/________ 19____**

	SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
12	OPERATOR LOG	a) ≥4 hours: at console (RO) or as Rx. Sup. (SRO) b) Complete Operating Exercise	a) TIME	b) OPERATING EXERCISE			
	NAME						
13	CHECK FILTER TAPE SPEED ON STACK MONITOR	1"/HR ± 0.2					
14	INCORPORATE 50.59 & ROCAS INTO DOCUMENTATION	QUARTERLY					
15	(NOT BEING USED)						
16	FUNCTIONAL CHECK OF EVACUATION ALARMS	ALL FUNCTIONAL					
17	(NOT BEING USED)						
18	STACK MONITOR ALARM CIRCUIT CHECKS	ALARM ON CONTACT					
19	ALARM TESTING OF VITAL AREA DOUBLE DOORS	FUNCTIONAL					

‡ Physical Security Plan Requirement

* 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.

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Figure IV.E.3 (Continued)

Semi-Annual Surveillance and Maintenance (Sample Form)

Semi-annual surveillance and maintenance for ____________

OSTROP 15 (continued)

SURVEILLANCE & MAINTENANCE TO BE PERFORMED			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
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 ____				

- * 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

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, an Assistant Health Physicist, 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 Office 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).

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 two liquid effluent releases 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.

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 3 x 10 $^{-11}$ μCi/ml to 1 x 10^{-9} μCi/ml. 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 eight 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.

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(γ)] film or TLD 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(γ) 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 electronic dosimeter as their basic monitoring device. A few Facilities Services personnel who routinely perform maintenance on mechanical or refrigeration equipment are issued a quarterly Xβ(γ) TLD badge and other dosimeters as appropriate for the work being performed.

Students attending laboratory classes are issued quarterly Xβ(G) TLD 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 electronic dosimeter. These results are not included with the laboratory class students.

OSU police and security personnel are issued a quarterly Xβ(γ) TLD 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 electronic dosimeters. 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.

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. 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 or TLD 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.

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.

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.

During third and fourth quarters 1998 each fence environmental station also utilized a $CaSO_4$ TLD monitoring packet supplied and processed by Radiation Detection Company (RDC), Sunnyvale, California. Each RDC packet contained two $CaSO_4$ TLDs and was exchanged quarterly for a total of 36 samples during the reporting period (9 stations x 2 TLDs per station per quarter x 2 quarters). During first and second quarters 1999 each fence environmental station utilized an LIF TLD monitoring packet supplied and processed by ICN Worldwide Dosimetry Service (ICN), Costa Mesa, California. Each ICN packet contained three LIF TLDs and was exchanged quarterly for a total of 54 samples during the reporting period (9 stations x 3TLDs per station x two quarters). The total number of RDC/ICN TLD samples for the reporting period was 90. A summary of RDC/ICN 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.

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 it is 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 Laboratory and National Forage Seed Laboratory, 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 RDC TLD samples for the reporting period was 50 (13 stations x 2 TLDs per station x 2 quarters minus 1 lost station x 2 TLDs per station). The total number of ICN TLD samples for the reporting period was 78 (13 station x 3 TLDs per station x 2 quarters). The total number of RDC/ICN TLD samples for the reporting period was 128. A summary of RDC/ICN TLD data for the off-site monitoring stations is also given in Table V.E.2.

In a manner similar to that described for the on-site fence stations, monthly measurements of the direct gamma exposure rate in microrem 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, it is 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.

F. Radioactive Material Shipments

A summary of the radioactive material shipments originating 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 90005 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.

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).

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. Inventory and inspect Radiation Center equipment located in the Corvallis Fire Department Haz/Mat van and at Good Samaritan Hospital.
Annual	Calibrate portable radiation monitoring instruments and personnel pocket ion chambers. 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. Conduct personnel dosimeter training. Perform contamination smear survey of Radiation Center ventilation stacks. Update decommissioning logbook.

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 and 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/cm³ (µCi/ml)	Total Quantity of Each Detectable Radionuclide Released in the Waste (Curies)	Average Concentration of Released Radioactive Material at the Point of Release (µCi/ml)	Percent of Applicable Monthly Average Concentration for Released Radioactive Material (%) (3)	Total Volume of Liquid Effluent Released Including Diluent (4) (gal)
August 1998 **(No OSTR Contribution)**	≤LLD (95%) of 2.27×10^{-5}	None	Not Applicable	Not Applicable	≤LLD (95%)(5) of 4.18×10^{-6}	Not Applicable	1435
May 1999	≤LLD (95%) of 3.85×10^{-5}	None	Not Applicable	Not Applicable	≤LLD (95%)(5) of 4.15×10^{-6}	Not Applicable	2451
Annual Total for Radiation Center	≤LLD (95%) of 6.12×10^{-5}	None	Not Applicable	Not Applicable	≤LLD (95%)(5) 8.33×10^{-6}	Not Applicable	3886
OSTR Contribution to Above	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

(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 the water analysis data and not background radioactivity in the Corvallis city water.

(3) Based on values listed in 10 CFR 20, Appendix B to 20.1001 - 20.2401, Table 3, which are applicable to sewer disposal.

(4) 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.

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

Table V.B.1.b

Annual Summary of Liquid Waste Generated and Transferred

Origin of Liquid Waste	Volume of Liquid Waste Packaged(1) (gallons)	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
TRIGA Reactor Facility	32	^{24}Na, ^{46}Sc, ^{47}Sc, ^{60}Co	7×10^{-5}	11/30/98, 5/12/99	12/7/98, 5/20/99
Radiation Center Laboratories	0	Not Applicable	Not Applicable	Not Applicable	Not Applicable(2)
TOTAL	32	^{24}No, ^{46}Sc, ^{47}Sc, ^{60}Co	7×10^{-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) The short-lived waste was held by the Radiation Safety Office for decay.

Table V.B.2

Monthly Summary of Gaseous Effluent Releases(1)

Date of Discharge (Month and 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 98	0.47	0.47	3.6×10^{-8}	0.9%
August 98	0.57	0.57	4.3×10^{-8}	1.1%
September 98	0.68	0.68	5.4×10^{-8}	1.3%
October 98	0.45	0.45	3.5×10^{-8}	0.9%
November 98	0.39	0.39	3.0×10^{-8}	0.8%
December 98	0.41	0.41	3.2×10^{-8}	0.8%
January 99	0.31	0.31	2.4×10^{-8}	0.6%
February 99	0.48	0.48	4.1×10^{-8}	1.0%
March 99	0.31	0.31	2.4×10^{-8}	0.6%
April 99	0.56	0.56	4.4×10^{-8}	1.1%
May 99	0.26	0.26	2.0×10^{-8}	0.5%
June 99	0.24	0.24	1.9×10^{-8}	0.5%
ANNUAL VALUE	5.13	5.13	3.3×10^{-8}	0.8%

---

(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⁾	^{24}Na, ^{46}Sc, ^{47}Sc, ^{51}Cr, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{89}Rb, ^{124}Sb, ^{131}I, ^{133}I, ^{137}Cs, ^{139}Ba, ^{140}Ba, ^{152}Eu	3.0×10^{-3}	11/30/98 5/12/99	5/20/99
Radiation Center Laboratories	10	^{24}Na, ^{46}Sc, ^{47}Sc, ^{59}Fe, ^{60}Co, ^{86}Rb, ^{122}Sb, ^{124}Sb, ^{210}Bi	4.1×10^{-6}	11/30/98	12/7/98
TOTAL	30	See Above	3.0×10^{-3}	---	---

---

(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.

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	42	394	76	1409	378	3447
Key Facility Research Personnel	21	4	40	29	170	29
Facilities Services Maintenance Personnel	14	N/A	18	N/A	54	N/A
Laboratory Class Students	12	8	25	51	551	250
Campus Police and Security Personnel	6	N/A	24	N/A	109	N/A
Visitors	<1	N/A	35	N/A	161	N/A

---

(1) "ND" 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 (RDC 30 mrem, ICN 10 mrem). "N/A" indicates that there was no extremity monitoring conducted or required for the group.

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(γ) (mrem)	**Neutron (mrem)**
MRCTNE	D104: North Badge East Wall	106	ND
MRCTSE	D104: South Badge East Wall	46	ND
MRCTSW	D104: South Badge West Wall	310	ND
MRCTNW	D104: North Badge West Wall	87	ND
MRCTWN	D104: West Badge North Wall	196	ND
MRCTEN	D104: East Badge North Wall	540	ND
MRCTES	D104: East Badge South Wall	695	ND
MRCTWS	D104: West Badge South Wall	326	ND
MRCTTOP	D104: Reactor Top Badge	718	113
MRCTHXS	D104A: South Badge HX Room	486	ND
MRCTHXW	D104A: West Badge HX Room	59	ND
MRCD-302	D302: Reactor Control Room	197	ND
MRCD-302A	D302A: Reactor Supervisor's Office	50(3)	N/A
MRCBP1	D104: Beam Port Number 1	579	ND
MRCBP2	D104: Beam Port Number 2	151	ND
MRCBP3	D104: Beam Port Number 3	152	ND
MRCBP4	D104: Beam Port Number 4	347	ND

---

(1) The total recorded dose equivalent values do not include natural background contribution and, except as noted, reflect the summation of the results of two quarterly and six monthly beta-gamma dosimeters or four quarterly fast neutron dosimeters for each location. A total dose equivalent of "ND" 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 (RDC 50 to 100 mrem, ICN 10 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)**	
			$x\beta(\gamma)$ (mrem)	**Neutron (mrem)**
MRCA100	A100:	Receptionist's Office	17(2)	N/A
MRCBRF	A102H:	Front Personnel Dosimetry Storage Rack	12(2)	N/A
MRCA120	A120:	Stock Room	26(2)	N/A
MRCA120A	A120A:	NAA Temporary Storage	30	N/A
MRCA126	A126:	Campus RSO's Isotope Receiving Lab	249(2)	N/A
MRCCO-60	A128:	^{60}Co Irradiator Room	476(2)	N/A
MRCA130	A130:	Shielded Exposure Room	12(2)	N/A
MRCA132	A132:	TLD Equipment Room	24(2)	N/A
MRCA134-2	A134:	Graduate Student Office	196(2)	N/A
MRCA138	A138:	Health Physics Laboratory	22(2)	N/A
MRCA146	A146:	Gamma Analyzer Room (Storage Cave)	ND	N/A
MRCB100	B100:	Gamma Analyzer Room (Storage Cave)	370	N/A
MRCB114	B114:	α Lab (^{226}Ra Storage Facility)	2108	ND
MRCB119-1	B119:	Source Storage Room	222(2)	N/A
MRCB119-2	B119:	Source Storage Room	493(2)	N/A
MRCB119A	B119A:	Sealed Source Storage Room	4136	2318
MRCB120	B120:	Instrument Calibration Facility	50(2)	N/A
MRCB122-2	B122:	Radioisotope Storage Hood	157(2)	N/A
MRCB122-3	B122:	Radioisotope Research Laboratory	23(2)	N/A
MRCB124-1	B124:	Radioisotope Research Lab (Hood)	12(2)	N/A
MRCB124-2	B124:	Radioisotope Research Laboratory	28(2)	N/A
MRCB124-6	B124:	Radioisotope Research Laboratory	37(2)	N/A
MRCB128	B128:	Instrument Repair Shop	ND(2)	N/A
MRCC100	C100:	Radiation Center Director's Office	ND(2)	N/A
MRCC106A	C106A:	Staff Lunch Room	11(2)	N/A
MRCC106B	C106:	Solvent Storage Room	43(2)	N/A
MRCC106-H	C106H:	East Loading Dock	26(2)	N/A
MRCC118	C118:	Radiochemistry Laboratory	70(2)	N/A

See footnotes following the table.

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)	
		xβ(γ) (mrem)	Neutron (mrem)
MRCC120	C120: Student Counting Laboratory	ND(2)	N/A
MRCC121	C121: APEX Facility	ND(2)	N/A
MRCC122	C122: APEX Control Room	14(2)	N/A
MRCC123N	C123: Gamma Analyzer Room (Storage Cave)	335(2)	N/A
MRCC123S	C123: Gamma Analyzer Room	ND	N/A
MRCC124	C124: Student Computer Laboratory	64(2)	N/A
MRCC130-1	C130: Radioisotope Laboratory (Hood)	92(2)	N/A
MRCC134	C134: Gamma Analyzer Room (Storage Cave)	ND	N/A
MRCD100	D100: Reactor Support Laboratory	ND	N/A
MRCD102	D102: Pneumatic Transfer Terminal Lab	79(3)	ND
MRCD102-H	D102H: 1st Floor Corridor at D102	336(3)	ND
MRCD106-H	D106H: 1st Floor Corridor at D106	106(2)	N/A
MRCD200	D200: Reactor Administrators's Office	89(3)	ND
MRCD202	D202: Senior Health Physicist's Office	139(3)	ND
MRCBRR	D200H: Rear Personnel Dosimetry Storage Rack	27(2)	N/A
MRCD204	D204 Health Physicist Office	108(3)	ND
MRCD300	D300: 3rd Floor Conference Room	63	ND

---

(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 "ND" 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 (RDC 50 to 100 mrem, ICN 10 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.

(3) The total recorded dose equivalent reflects two quarterly beta and gamma dosimeter and six monthly beta-gamma dosimeters.

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/hr)**		**Contamination Levels(1) (dpm/cm)**	
	Average	**Maximum**	**Average**	**Maximum**
TRIGA Reactor Facility:				
Reactor Top (D104)	<1	100	<500	<500
Reactor 2nd Deck Area (D104)	3	50	<500	<500
Reactor Bay SW (D104)	<1	4	<500	<500
Reactor Bay NW (D104)	<1	85	<500	<500
Reactor Bay NE (D104)	<1	8	<500	<500
Reactor Bay SE (D104)	<1	2	<500	<500
Class Experiments (D104, D302)	<1	80	<500	<500
Demineralizer Tank--Outside Shielding (D104A)	<1	8	<500	<500
Particulate Filter--Outside Shielding (D104A)	<1	2	<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 and calibration rooms (A128, A130, B120)	<1	3	<500	<500
Radiation Research Labs (B108, B114, B122, B124, C130, C132A)	<1	<1	<500	<500
Radioactive Source Storage (A120A, B119, B119A)	<1	2	<500	<500
Student Chemistry Laboratory (C118)	<1	<1	<500	<500
Student Counting Laboratory (C120)	<1	1	<500	<500
Operations Counting Room (B136, C123)	<1	2	<500	<500
Pneumatic Transfer Laboratory (D102)	<1	3	<500	<500
TRIGA Tube Wash Room (D100)	<1	1	<500	<500

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

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 (Including Background) Based on RDC/ICN TLDs(1) (mrem)	Total Recorded Dose Equivalent (Including Background) Based on OSU TLDs(2)(3) (mrem)	Total Calculated Dose Equivalent (Including Background) Based on the Annual Average µrem/h Dose Rate(3) (mrem)
MRCFE-1	85	59 ± 6	61 ± 16
MRCFE-2	79	57 ± 6	61 ± 16
MRCFE-3	76	56 ± 7	61 ± 20
MRCFE-4	92	67 ± 6	76 ± 20
MRCFE-5	80	56 ± 6	68 ± 18
MRCFE-6	86	59 ± 7	72 ± 30
MRCFE-7	83	58 ± 6	59 ± 20
MRCFE-8	77	58 ± 7	63 ± 18
MRCFE-9	83	53 ± 5	71 ± 16

---

(1) RDC/ICN TLD totals include their annual natural background contribution of 69 mrem for the reporting period. Average Corvallis area natural background using RDC/ICN TLDs totals 74 mrem for the same period.

(2) OSU fence totals include a measured natural background contribution of 51 ± 4 mrem.

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

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 (Including Background) Based on RDC/ICN TLDs(2) (mrem)	Total Recorded Dose Equivalent (Including Background) Based on OSU TLDs(3)(4) (mrem)	Total Calculated Dose Equivalent (Including Background) Based on the Annual Average μrem/h Exposure Rate(4) (mrem)
MRCTE-2L	---	45 ± 5	46 ± 18
MRCTE-3	89	50 ± 7	67 ± 14
MRCTE-4	83	62 ± 11	59 ± 24
MRCTE-5L	---	49 ± 9	64 ± 14
MRCTE-6	85	59 ± 7	69 ± 24
MRCTE-7L	---	48 ± 6	65 ± 16
MRCTE-8	93	60 ± 6	80 ± 12
MRCTE-9	89	48 ± 6	63 ± 18
MRCTE-10	78	45 ± 5	55 ± 14
MRCTE-11	77	48 ± 5	61 ± 30
MRCTE-12	60(5)	45 ± 3	67 ± 26
MRCTE-13L	---	50 ± 4	57 ± 20
MRCTE-14L	---	47 ± 6	52 ± 20
MRCTE-15	69	47 ± 7	47 ± 22
MRCTE-16L	---	64 ± 4	61 ± 14
MRCTE-17	79	55 ± 8	58 ± 22
MRCTE-18L	---	58 ± 8	65 ± 14
MRCTE-19	89	58 ± 8	72 ± 24
MRCTE-20L	---	54 ± 7	64 ± 24
MRCTE-21	68	53 ± 10	48 ± 16
MRCTE-22	72	45 ± 5	52 ± 18

---

(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 RDC/ICN TLD monitoring pack.

(2) RDC/ICN TLD totals include their annual natural background contribution of 69 mrem for the reporting period. Average Corvallis area natural background using RDC/ICN TLDs totals 74 mrem for the same period.

(3) OSU off-site totals include a measured natural background contribution of 51 ± 4 mrem.

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

(5) Fourth quarter 1998 RDC TLD pack lost.

Table V.E.3

Annual Average Concentration of the Total Net Beta Radioactivity (Minus ^3H)
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 ^3H) Radioactivity⁽¹⁾	Reporting Units
1-W	Water	5.77E-08 ± 1.89E-08⁽²⁾	µCi/cm³
4-W	Water	1.20E-07 ± 1.69E-07⁽²⁾	µCi/cm³
11-W	Water	3.66E-08 ± 1.18E-08⁽²⁾	µCi/cm³
19-RW	Water	4.32E-08 ± 1.19E-08⁽²⁾	µCi/cm³
3-S	Soil	2.69E-04 ± 5.97E-04	µCi/g of dry soil
5-S	Soil	1.89E-04 ± 2.34E-04	µCi/g of dry soil
20-S	Soil	2.51E-04 ± 4.90E-04	µCi/g of dry soil
21-S	Soil	2.62E-04 ± 4.69E-04	µCi/g of dry soil
2-G	Grass	3.94E-04 ± 2.46E-04	µCi/g of dry ash
6-G	Grass	2.62E-04 ± 2.11E-04	µCi/g of dry ash
7-G	Grass	7.60E-04 ± 6.79E-04	µCi/g of dry ash
8-G	Grass	5.02E-04 ± 4.57E-04	µCi/g of dry ash
9-G	Grass	4.84E-04 ± 1.51E-04	µCi/g of dry ash
10-G	Grass	4.82E-04 ± 3.49E-04	µCi/g of dry ash
12-G	Grass	5.51E-04 ± 5.09E-04	µCi/g of dry ash
13-G	Grass	5.16E-04 ± 3.45E-04	µCi/g of dry ash
14-G	Grass	2.81E-04 ± 2.40E-04	µCi/g of dry ash
15-G	Grass	3.12E-04 ± 3.02E-04	µCi/g of dry ash
16-G	Grass	3.56E-04 ± 2.74E-04	µCi/g of dry ash
17-G	Grass	4.34E-04 ± 3.80E-04	µCi/g of dry ash
18-G	Grass	4.22E-04 ± 2.63E-04	µCi/g of dry ash
22-G	Grass	4.28E-04 ± 3.23E-04	µCi/g 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.

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	2.95E-05	1.07E-07 *to* 9.37E-05	µCi/gram of dry soil
Water	6.25E-08	3.16E-08 *to* 2.41E-07	µCi/cm^3
Vegetation	3.94E-05	1.11E-05 *to* 5.30E-04	µCi/gram of dry ash

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 (TBq)**	**Number of Shipments**			
		Limited Quantity	**Yellow II**	**Yellow III**	**Total**
OSU Oceanography Corvallis, OR	1.04×10^{-4}	0	4	0	4
Tru Tec Baton Rouge, LA	Empty Package	2	0	0	2
OSU Electrical and Computer Engineering Corvallis, OR	1.24×10^{-6}	3	0	0	3
Berkeley Geochronology Center Berkeley, CA	3.34×10^{-6}	10	0	0	10
University of California Berkeley, CA	2.18×10^{-5}	1	3	0	4
University of Arizona Tucson, AZ	5.24×10^{-8}	1	0	0	1
Stanford University Stanford, CA	2.84×10^{-6}	4	1	0	5
Idaho State University Pocatello, ID	5.90×10^{-5}	0	6	0	6
University of Washington Seattle, WA	2.95×10^{-7}	1	0	0	1
University of California Santa Barbara, CA	1.42×10^{-6}	4	0	0	4
University of Wyoming Laramie, WY	1.39×10^{-6}	3	0	0	3
Brigham Young Provo, UT	2.41×10^{-6}	3	0	0	3
SUNY-Plattsburgh Plattsburgh, NY	1.13×10^{-6}	2	0	0	2
Columbia University Pallisades, NY	5.03×10^{-6}	7	0	0	7
Union College Schenectady, NY	2.57×10^{-7}	3	0	0	3
Colorado State University Fort Collins, CO	2.41×10^{-5}	0	4	0	4
ICI Tracerco Blaine, WA	4.7×10^{-2}	0	0	4	4
TOTALS	4.70×10^{-2}	44	18	4	66

Table V.F.2

Annual Summary of Radioactive Material Shipments Originating From the Radiation Center's State of Oregon License ORE 90005

Shipped To	**Total Activity (TBq)**	**Number of Shipments**			
		Limited Quantity	**White I**	**Yellow II**	**Total**
Lawrence Berkeley National Laboratory Berkeley, CA	1.31×10^{-2}	3	1	1	5
Oregon State University Physics Department Corvallis, OR	5.7×10^{-7}	1	0	0	1
Oregon State University Oceanography Department Corvallis, OR	7.55×10^{-7}	0	0	1	1
Totals	1.3×10^{-2}	4	1	2	7

Table V.F.3

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

Shipped To	Total Activity (TBq)	Number of Shipments			
		Limited Quantity	Yellow II	Yellow III	Total
Vrije Universiteit Amsterdam, The Netherlands	4.43×10^{-6}	1	1	0	2
Scottish Universities Research and Reactor Centre Scotland, UK	9.50×10^{-5}	0	4	0	4
University of Geneva Geneva, Switzerland	2.01×10^{-6}	2	1	0	3
University of Waikato Hamilton, New Zealand	5.08×10^{-6}	1	2	0	3
University of Queensland Brisbane, Australia	3.12×10^{-6}	0	3	0	3
Uppsala University Uppsala, Sweden	1.58×10^{-8}	1	0	0	1
TRIUMF Vancouver BC, Canada	1.27×10^{-5}	0	2	0	2
University of British Columbia Vancouver BC, Canada	1.32×10^{-5}	0	2	0	2
TruTec Edmonton, Canada	6.80×10^{-2}	0	0	5	5
FAPIG Research and Reactor Centre Yokosuka, Japan	3.38×10^{-7}	1	0	0	1
Universite Paris-Sud Paris, France	7.76×10^{-6}	0	2	0	3
TOTALS	6.81×10^{-2}	6	17	5	28

Figure V. D. 1

TRIGA Facility and Radiation Center Area Dosimeter Locations

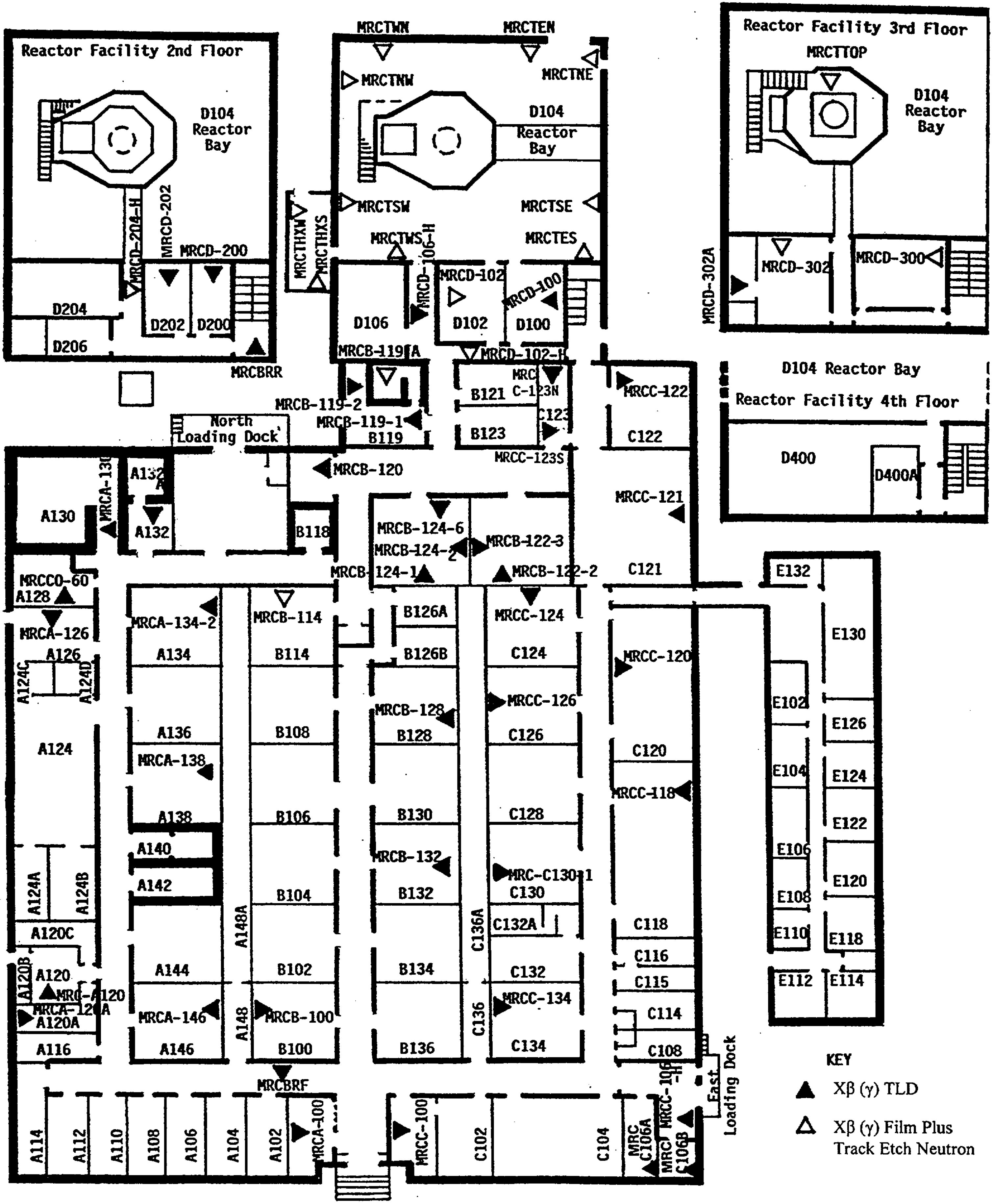


Figure V. E. 1

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

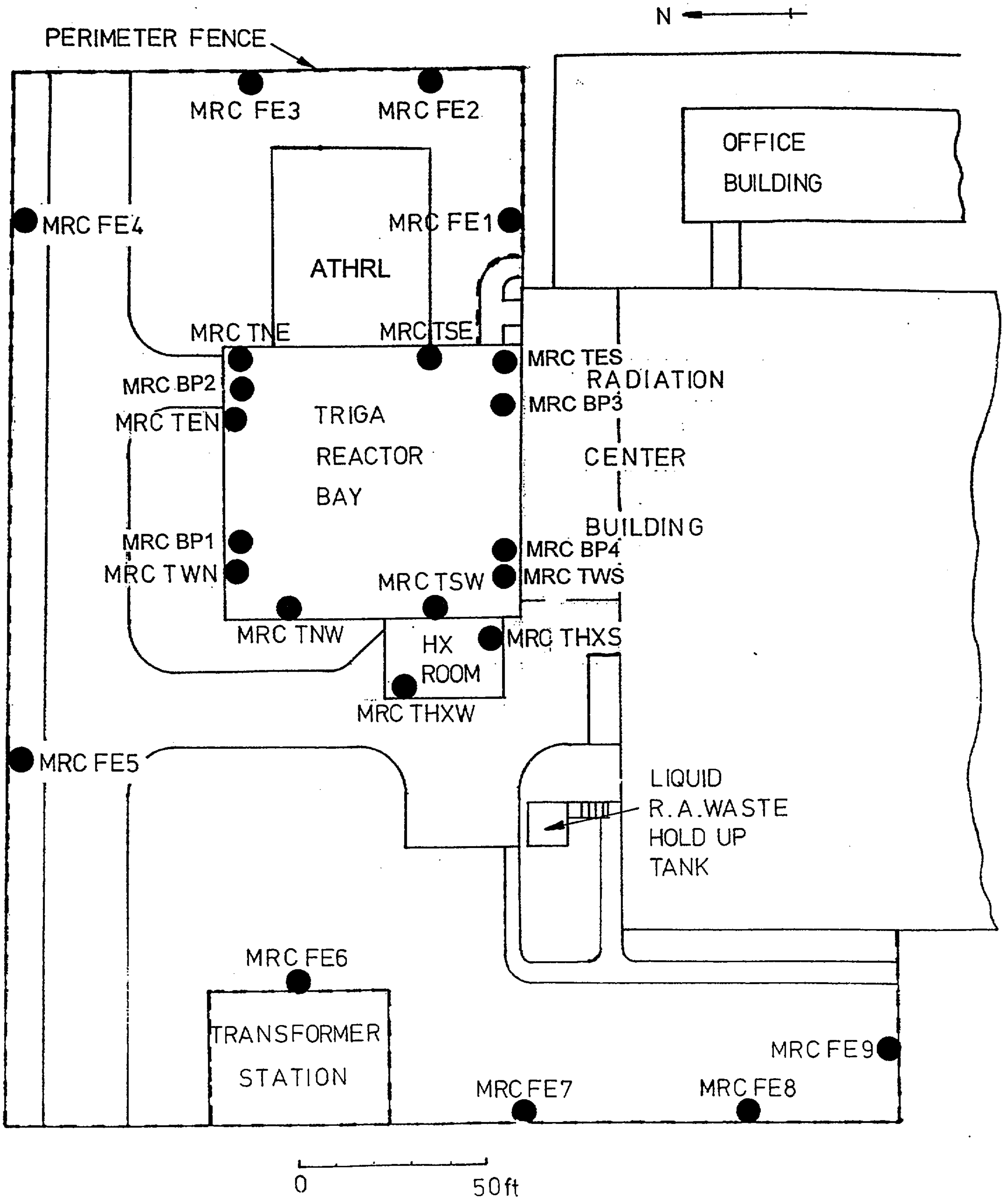
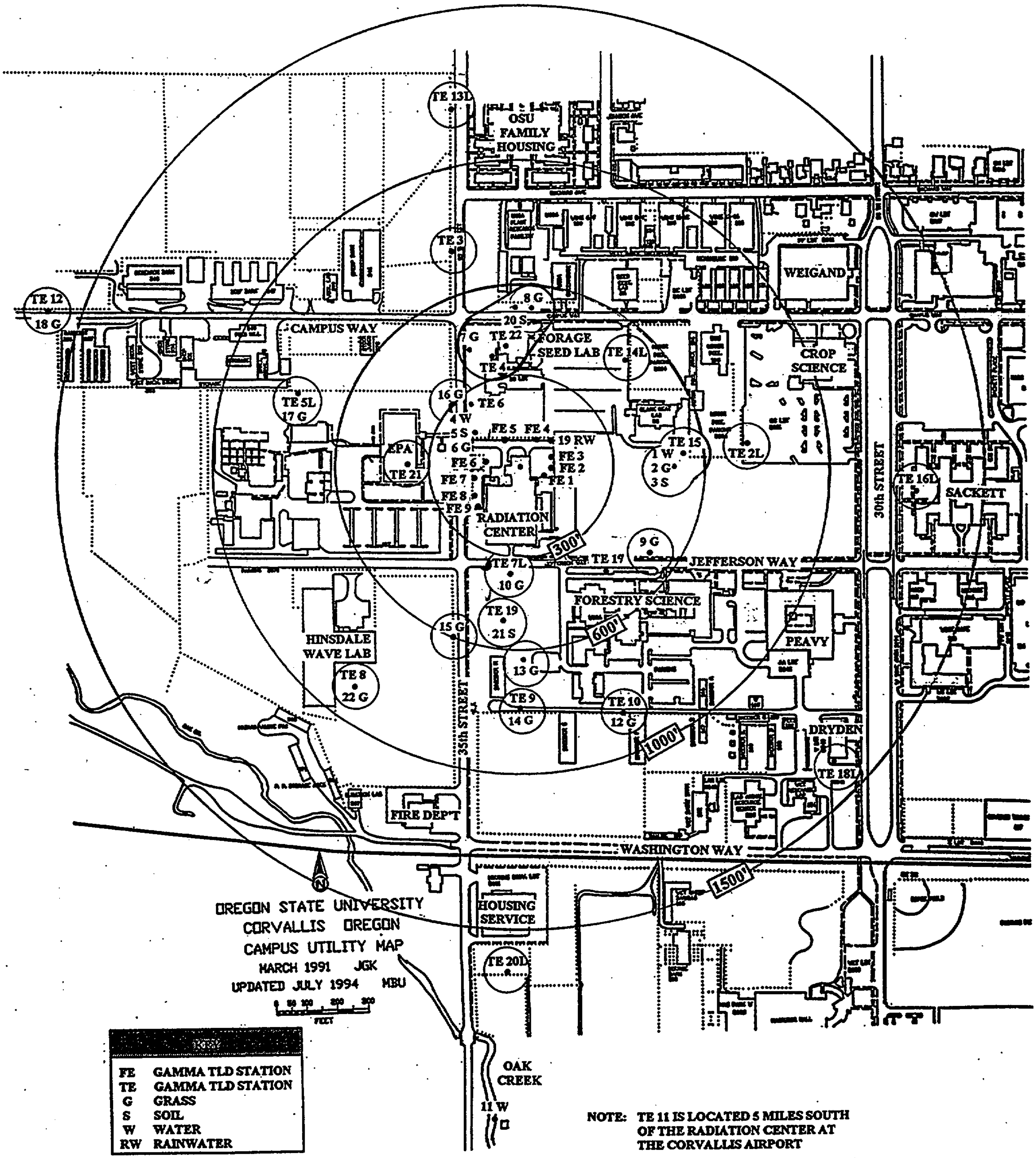


Figure V. E. 2

Monitoring Stations for the OSU TRIGA Reactor



NOTE: TE 11 IS LOCATED 5 MILES SOUTH OF THE RADIATION CENTER AT THE CORVALLIS AIRPORT

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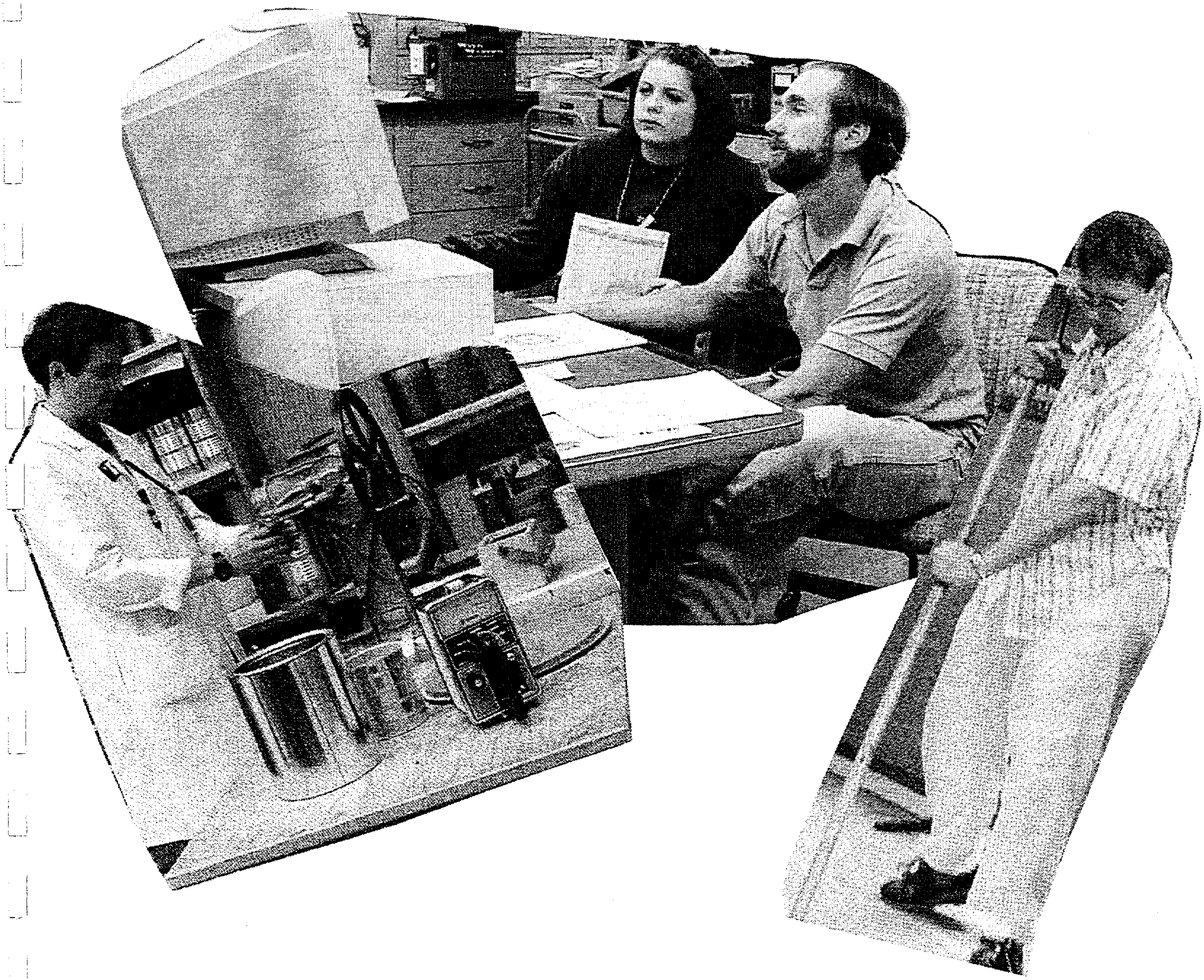

Part VI

WORK

A. Summary

The Radiation Center offers a wide 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 the 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 participation in University research programs. For example, during the current reporting period, the Radiation Center accommodated 96 academic classes involving a number of different academic departments from OSU and other Oregon universities. The OSU teaching programs (not including research) utilized 1,114 hours of reactor time. Tables III.A.1 and III.D.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 database. When a request for facility use is received, a project number is assigned, a project cover 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, information about students involved, a description of the project, Radiation Center resources needed, the Radiation Center project manager, estimated costs and billing information 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.

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. Computerized data reduction of the gamma ray spectra then yields the concentrations of the 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 activable 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 the major, minor, and trace element content of tens of 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 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. The team can also 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 Office 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.

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

5. Training and Instruction

In addition to the academic laboratory classes and courses discussed in Parts III.A.2, III.D, 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 fellows; special short-term courses; or individual reactor operator or health physics training programs. During this reporting period there were a large number of such people as shown in Part II.B.

As has been the practice since 1985, Radiation Center personnel annually present a HAZMAT Response Team Radiological Course. This year the course was held at the HAMMER facility in Richland, Washington.

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 radiation laboratory to the Oregon State Health Division (OSHD) in the event of a radiological emergency within the state of Oregon. In this role, the Radiation Center will provide gamma ray spectrometric 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-institution drills.

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 detectors 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 available to provide consultation services in any of the areas discussed in this Annual Report, but in particular on the subjects of 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 ongoing professional consulting functions with various organizations, in addition to sitting on numerous committees in advisory capacities.

9. 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 125 scheduled tours including 1,326 people were given during this reporting period. See Table VI.F.1 for statistics on scheduled visitors.

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	19	10	21	301⁽²⁾
National Forage Seed Protection Research Center Corvallis, Oregon	1	1	0	2
*ARCADIS Geraghty and Miller Durham, North Carolina	1	NA	NA	6
*Benton County Sheriff's Office Corvallis, Oregon	1	NA	NA	1
*Colorado School of Mines Golden, Colorado	1	1	0	2
*Colorado State University Fort Collins, Colorado	1	1	0	1
*Department of Energy Albany Research Center Albany, Oregon	2	NA	NA	2
Oregon Medical Laser Institute Portland, Oregon	1	1	1	21
Oregon Office of Energy Salem, Oregon	2	NA	NA	3
*Texas Tech University Lubbock, Texas	5	2	0	5
*Williams College Williamstown, Massachusetts	1	1	2	1
*Colorado College Colorado Springs, Colorado	1	1	1	1
*Franklin and Marshall Lancaster, Pennsylvania	2	1	2	2
*College of Wooster Wooster. Ohio	1	1	1	1
*Pomona College Claremont, California	1	1	1	1

(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, others in the Department of Nuclear Engineering or Department of Chemistry, or projects conducted by Dr. W. D. Loveland, which involve daily use of Radiation Center facilities.

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* Project which involves the OSTR.

Table VI.C.1 (continued)

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
*Amherst College Amherst, Massachusetts	1	1	1	1
*Tracerco Houston, Texas	1	NA	NA	2
*Tru-Tec Edmonton, Alberta, Canada	1	NA	NA	1
*University of California at Santa Barbara Santa Barbara, California	2	2	5	7
*University of Georgia at Savannah Savannah, Georgia	1	1	0	2
*University of Oregon Geosciences Eugene, Oregon	1	1	0	2
U.S. Army Corps of Engineers Portland, Oregon	1	NA	NA	1
Oregon Health Sciences University Portland, Oregon	1	NA	NA	1
*Geovic Limited Beaverton, Oregon	1	NA	NA	4
Rogue Community College Grants Pass, Oregon	1	1	0	2
Umpqua Research Company Myrtle Creek, Oregon	1	NA	NA	2
*Idaho State University Pocatello, Idaho	2	1	6	3
*University of Washington Seattle, Washington	1	1	0	1
*Berkeley Geochronology Center Berkeley, California	1	NA	NA	20
*Montana State University Bozeman, Montana	2	1	2	2
*Stanford University Stanford, California	2	2	2	5
*University of California at Berkeley Berkeley, California	2	2	2	4
*University of California at Los Angeles Los Angeles, California	1	1	1	1
*Brigham Young University Provo, Utah	2	2	2	4

* Project which involves the OSTR.

Table VI.C.1 (continued)

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
*University of Wyoming Laramie, Wyoming	1	1	2.	3
*University of Arizona Tucson, Arizona	1	1	0	1
*University of Geneva Geneva, Switzerland	2	2	5	5
*University of New Orleans New Orleans, Louisiana	2	1	2	1
*Columbia University Palisades, New York	2	2	3	11
*George Washington University Washington, DC	2	1	1	3
*North Carolina State University Raleigh, North Carolina	1	1	0	1
*Plattsburgh State University Plattsburgh, New York	3	1	3	2
*State University of New York at Stonybrook Stonybrook, New York	1	1	0	1
*Union College Schenectady New York	3	1	6	5
*University of Florida Gainesville, Florida	1	1	2	1
*FAPIG Yokosuka, Kanagawa, JAPAN	1	NA	NA	1
*Scottish University Research and Reactor Centre Glasgow, Scotland	1	1	15	6
*University of Paris-Sud Paris, France	1	1	1	5
*Vrije Universiteit Amsterdam, The Netherlands	1	1	1	3
*University of Waikato Hamilton, New Zealand	1	1	1	4
*University of Queensland Brisbane, Queensland, Australia	1	1	1	3
Total	90	55	93	471

* Project which involves the OSTR.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Brigham Young University				
E. Lee Bray	MS	Geology	Nelson	Petrogenesis of the Absaroka Volcanic Supergroup, WY.
Kevin Hae Hae	MS	Geology	Kowallis	Subsidence and Uplift History of the Uinta Basin from Apatite Fission Track Analysis.
Tamalyn Pulsipher	MS	Geology	Keith	Possible Correlation of Mineralized Intrusive Unit from the Cu Porphyry at Bingham Mine, Utah with Nearby Volcanic Units
California State University, Northridge				
Vincent Devlahovich	MS	Geological Sciences	Weigand	Geochemistry of volcanic rocks associated with the Miocene San Onofre Breccia, southern California
Columbia University				
Malka Machlus	PhD	Earth Sciences	Hemming	Milankovitch cyclicity in the Eocene Green River Fm., including dating tuff beds within the formation by Ar-Ar dating.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Diane McDaniel	PhD	Earth Sciences	Hemming	Assessment of Correlation between Climatic Changes and Differences in Provenance in the Amazon Drainage Basin.
Idaho State University				
Jason Casper	MS	Geology	Hughes	Petrology and Volcanic History of Circular Butte, Eastern Snake River Plain, Idaho
Jason Casper	MS	Geology	Hughes	Geology of Circular Butte Volcano.
Jason Casper	MS	Geology	Hughes	Petrography and Geochemistry of Volcanic Centers near the Test Area North on the INEE.
Songqiao Chen	MS	Geology	Hughes	To be decided
Katherine Pickett	MS	Geology	Hughes	Undecided
Anni Watkins	MS	Geology	Hughes	Not Determined.
Paul Wetmore	MS	Geology	Hughes	Accumulation Rates and Stratigraphy of INEEL Basalts.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Karen Wright	MS	Geology	Hughes	Not Determined.
Lamont-Doherty Earth Observatory				
Amy Young	PhD	UCLA Geology	Turrin	Petrology and geochemical evolution of the Damavand trachyandesite volcano in northern Iran.
George Washington University				
Sandra Nyman	B.S.	Geology	Hughes	Petrology of Precambrian Basement, Shenandoah National Park and Vincinity, Madison County, Virginia
Montana State University				
Charles Lindsay	MS	Earth Sciences	Feeley	Geochemistry of High-K Lavas and Co-genetic Instrusions from Sepulchur Mountain and Electric Peak, Yellowstone National Park.
Oregon State University				
Sabooh Asghar	MS	Nuclear Engineering	Reyes	Core Makeup Tank Recirculation, Drainage, and Condensation Behavior.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Jin Young Choi	PhD	Agricultural Chemistry	Kerkvliet	Undecided.
Sarah Colpo	MS	Nuclear Engineering	Reyes	Counter Current Flow Limitation in the APEX Facility's Pressurizer Surge Line.
Erica Dearstyne	PhD	Agricultural Chemistry	Kerkvliet	Fate of T Cells in TCDD-Treated Mice: Anergy of Apoptsis?
Sebastian Geiger	PhD	Geosciences	Haggerty	Diffusion in Geologic Materials.
Sung Mo Kang	MS	Forest Products	Morrell	Fungi Colonization of Douglas Fir Sapwood and their Role in Biological Discoloration.
Tracy Lee	MS	Physics	Gardner	Oxygen Vacancy Concentration Dependence on Processing and Sintering Conditions in ZrO_2 Studied using Pac Spectroscopy
Mark Mankowski	MS	Forest Products	Morrell	Biology of Carpenter Ants in the Pacific Northwest and its Relationship with Fungal Decay in Buildings.
Oleg Povetko	MS	Nuclear Engineering	Higley	Long-Lived Radionuclide Migration through Soils.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Rodney Prell	PhD	Agricultural Chemistry	Kerkvliet	Role of B7 Co-stimulation in TCDD Immunotoxicity.
Mari Rios	MS	Physics	Krane	Neutron Cross Section Measurements of Radioactive Ge-68 and Gd-148.
Carl Ruby	PhD	Agricultural Chemistry	Kerkvliet	Involvement of NFKB in TCDD Immunotoxicity.
Christopher Rusher	MS	Nuclear Engineering	Reyes	Level Swell in a Boiling Pool.
David Shepherd	PhD	Agricultural Chemistry	Kerkvliet	A T-Cell Receptor-Transgenic Model for Immunoticity Testing.
Christopher Sinton	PhD	Oceanography	Duncan	Age and Compostion of Two Large Igneous Provinces: The North Atlantic Volcanic Rifted Margin and the Caribbean Plateau.
Mark Strohecker	MS	Nuclear Engineering	Reyes	Flow Modeling of the APEX Facility's IRWST.
Beth Vorderstrasse	PhD	Agricultural Chemistry	Kerkvliet	Dendritic Cells: Role in TCDD-Induced Suppression of CTL Activity.
Dan Wachs	MS	Nuclear Engineering	Reyes	Prediction and Modeling of Thermal Stratification in the Cold Legs of the OSU APEX Facility.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Rockie Yarwood	PhD	Microbiology	Bottomley	2, 4-D Degradation by Soil Micro-organisms.
Lissa Zyromski	PhD	Chemistry	Loveland	Measurement of Fusion Enhancements with Neutron-rich Stable and Radioactive Projectiles.
Scottish University Research and Reactor Centre				
T. Barry	PhD	Leicester University	Pringle	Mongolian Basalts/Tectonics
J. Blecher	PhD	Oxford University	Pringle	Aden Volcanic Differentiation.
S. Carn	PhD	Cambridge University	Pringle	Indonesian Volcanics.
L. Chambers	PhD	Edinburgh University	Pringle	North Atlantic Tertiary Province.
H. Dixon	PhD	Bristol University	Pringle	Subglacial Volcanics.
C. Harford	PhD	Bristol University	Pringle	Montserrat Volcanic Hazards.
E. Heath	PhD	Lancaster University	Pringle	St. Vincent Volcano Hazards.
G. May	PhD	Aberdeen University	Pringle	Chilean Basins.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
S. McElderry	PhD	Liverpool University	Pringle	Chilean Tertiary Faulting.
Y. Najman	PhD	Edinburgh University	Pringle	Himalayan Foredeep.
M. Purvis	PhD	Edinburgh University	Pringle	Turkish Basin Tectonics.
R. Shelton	PhD	Queens University	Pringle	North Channel Basin Evolution.
A. Sowerbutts	PhD	Edinburgh University	Pringle	Sardinia Evolution.
G. Steele	PhD	Aberdeen University	Pringle	Cerro Rico Silver.
R. White	PhD	Leicester University	Pringle	Caribbean Crustal Growth.
Stanford University				
Daniel Stockli	PhD	Geological and Environmental Sciences		Dumitru Timing of Extensional Faulting in the Northern Basin and Range Province, and the Structured and Thermal Transition to the Central. Sierra Nevada
Da Zhou	PhD	Geological and Environmental Sciences		Dumitru Amalgamation and Uplift History of the Tian Shan, Western China.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
The University of Waikato				
Ming Hung Ho	Ph.D.	Earth Sciences	Kamp	Thermo-tectonic History of Marlborough, New Zealand.
U.C. Berkeley				
James Cole	MS	Nuclear Engineering	Olander	Volatilization of Uranium in the Presence of Organic Material
UCLA				
Amy Young	PhD	Earth and Space Sciences	Davidson	Petrogeneis, Stratigraphy, and Origin of Damavand Volcano, Iran.
Union College				
Matthias Bernet	PhD	Yale University	Garver	Evolution of the exhumation of ALPS as recorded in the Po Basin, Italy
Michael Bullen	MS	Pennsylvania State	Garver	Evolution of the Tren Shan region
Stephen Hadley	AB	Geology	Fleischer	Environmental Radioactivity

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Alex Soloviev	Post-Doc	Inst. Lithosplere, Moscow	Garver	Detrital Zircon in Russia
Univ. of California, Santa Barbara				
Andy Calvert	PhD	Geological Sciences	Gans	Tectonic Studies in Eastern-Most Russia.
Jon Nauert	MS	Geological Sciences	Gans	Volcanism in the Eldorado Mountains, Southern Nevada.
Jaime Toro	Not Known	Geological Sciences	Gans	Cretaceous and Tertiary History of Alaska's Brooks Range and Russia's Chukotka Peninsula.
University of Florida				
Ann Heatherington	Post-Doc	Geology	Mueller	Crustal Evolution Along the Western Boundary of the Wyoming Crater.
Stephanie Jenkins	MS	Geology	Mueller	Age and Origin of the Albermarle Group, Carolina State Belt.
University of New Orleans				
Judy Wilson	MS	Geology and Geophysics	Johnson	Evolution of the South Sister Magmatic System

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
Judy Wilson	MS	Geology and Geophysics	Johnson	Volcanic Hazards in the Cascade Range.
University of Wisconsin-Madison				
Mercedes Hernandez	PhD	Mineralogy	Singer	Petrology and Geochronology of the Catalan Coastal Ranges Batholith, NE Spain.
Robert Marschick	PhD	Mineralogy	Singer	Cretaceous Cu (-Fe) Mineralization in the Punta del Cobre Belt, Northern Chile.
Osman Parlak	PhD	Mineralogy	Singer	Geochemistry and Geochronology of the Merson Ophiolite within the Eastern Mediterranean Tectonic Frame.
Thao Ton-That	MS	Mineralogy	Singer	Ar-40/Ar-39 Dating of Basaltic Lava Flows and the Geology of the Lago Buenos Aires Region, Santa Cruz Province, Argentina.
Yann Vincze	MS	Mineralogy	Singer	Ar-40/Ar-39 Incremental Heating Studies of Latest Pleistocene and Holocene Lava and Tephra: Implications for the Last Glaciation in the Southern Andes.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Degree	Academic Department	Faculty Advisor	Thesis Topic
University of Wyoming				
Robert Kirkwood	MS	Geology and Geophysics	Murphy	
Andrew Leier	MS	Geology and Geophysics	Murphy	

Table VI.C.3

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
321	Murphy	University of Wyoming	Fission Track Dating	Thermal column irradiations of apatite and zircon samples for fission track production to determine rock age.	Geophysics, U of Wyoming
335	Kowallis	Brigham Young University	Fission Track Dating	Dating of natural rocks and minerals via fission track methodology.	National Science Foundation
444	Duncan	Oregon State University	Ar-40/Ar-39 Dating of Oceanographic Samples	Production of Ar-39 from K-39 to measure radiometric ages on basaltic rocks from ocean basins.	Oceanography, OSU
481	Winans	Oregon Health Sciences Univ.	Instrument Calibration	Calibration of radiation survey instruments.	Oregon Health Sciences University
488	Farmer	Oregon State University	Instrument Calibration	Calibration of portable radiation survey instruments for radiation users on OSU campus.	Radiation Center, OSU
519	Livingstone	U.S. EPA	Instrument Calibration	Calibration of portable radiation survey meters using the standard RC protocol.	USEPA-Corvallis
521	Vance	University of Washington	Fission Track Studies	Thermal column irradiation of zircon and other samples to induce fission tracks in catcher foils for dating.	University of Washington

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
547	Boese	EPA - Newport	Survey Instrument Calibration	Calibration of GM and other portable survey meters as per standard OSU protocol.	USEPA, Cincinnati, OH
664	Higginbotham	Oregon State University	Instrument Calibration	Calibration of radiation survey instruments.	Radiation Center, OSU
665	Higginbotham	Oregon State University	Instrument Calibration	Calibration of radiation survey instruments.	Radiation Center, OSU
708	Reyes	Oregon State University	AP600 Long-Term Cooling Test	Fabricate and test scale model of section of Westinghouse AP600 reactor cooling system.	US Nuclear Regulatory Commission
815	Morrell	Oregon State University	Sterilization of Wood Samples	Sterilization of wood samples to 2.5 Mrads in Co-60 irradiator for fungal evaluations.	Forest Products, OSU
920	Becker	Berkeley Geochronology Center	Ar-39/Ar-40 Age Dating	Production of Ar-39 from K-39 to determine ages in various anthropologic and geologic materials.	Berkeley Geochronology Center
930	McWilliams	Stanford University	Ar-40/Ar-39 Dating of Geological Samples	Irradiation of mineral grain samples for specified times to allow Ar-40/Ar-39 dating.	Geophysics, Stanford University

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
931	Kerkvliet	Oregon State University	TCDD Effects on T-Cell Activation	Co-60 irradiation of spleen cells from mice to study the effects of TCDD on T-cell activation using T-h cell clones.	OSU Environmental and Molecular Toxicology
932	Dumitru	Stanford University	Fission Track Dating	Thermal column irradiation of geological samples for fission track age-dating.	Geology, Stanford University
995	Bottomley	Oregon State University	Herbicide Mineralization in Agricultural Soils	Soil sterilization in the Co-60 irradiator.	Crop and Soil Science, OSU
1002	Singer	University of Wisconsin-Madison	Ar-40/Ar-39 Dating of Young Geological Materials	CLICIT irradiation of geological materials such as volcanic rocks from sea floor, etc. for Ar-40/Ar-39 dating.	University of Geneva
1018	Gashwiler	Occupational Health Lab	Calibration of Nuclear Instruments	Calibrate radiation survey meters.	Occupational Health Laboratory
1020	Gans	Univ. of California, Santa Barbara	Tectonic Studies in Eastern-Most Russia	Irradiation for Ar-40/Ar-39 dating using the CLICIT or dummy fuel element.	National Science Foundation
1072	Rasmussen	Army Corps of Engineers	Instrument Calibration	Calibration of radiation detection instruments.	U.S. Army Engineer District, Portland.

INAA = Instrumental Neutron Activation Analysis

REE = Rare Earth Elements

Table VI.C.3

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
1073	Pringle	Scottish Univ. Res. & Rx Centre	Argon 40/39 Dating of Rock Minerals	Age dating of various materials using the Ar-40/Ar-39 ratio method.	Scottish Universities Research and Reactor Centre
1074	Wijbrans	Faculty of Earth Sciences	40Ar-39 Ar Dating of Rocks and Minerals	40Ar-39Ar dating of rocks and minerals.	Vrije Universiteit, Amsterdam
1075	Lederer	Univ. of California Energy Institute	Activation Analysis Experiment for NE Class	Irradiation of small, stainless steel discs for use in a nuclear engineering radiation measurements laboratory.	UC Berkeley
1098	Loveland	Oregon State University	Fusion Enhancement with n-rich Projectiles	Measurement of fusion enhancements with n-rich stable and radioactive projectiles.	Chemisty, OSU
1118	Larson	Oregon State University	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 scintilation counting.	Forest Resources, OSU
1125	Streck	Portland State University	Crystallization in Ignimbrite E, Gran Canary	Determination of mobility of trace elements during cooling of tuff E using INAA.	GEOMAR Inst. Germany

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Table VI.C.3

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
1191	Vasconcelos	Department of Earth Sciences	Ar-39/Ar-40 Age Dating	Production of Ar-39 from K-39 to determine ages in various anthropologic and geologic materials.	Earth Sciences, University of Queensland
1206	Hughes	Idaho State University	Chemical Correlation of Volcanic Units on INEEL	NAA of basaltic rocks obtained from drill core and surface locations to evaluate the local and regional stratigraphy beneath various facilities on the INEEL to determine the geometry of the aquifer system.	Idaho Water Resources Research Inst.
1225	Roden-Tice	Plattsburgh State University	Fission Track Analysis of Apatite and Zircon	Analysis of the thermal history of Triassic basins in Connecticut using fission track age dating methods.	Radiation Center, OSU
1267	Hemming	Columbia University	Geochronology by Ar/Ar Methods	Three sub-projects: (i) Sanidine phenocrysts from the Snake river plain to evaluate volcanic stratigraphy. (ii) Sandine and biotite phenocrysts from a late Miocene ash, Mallorca to more accurately constrain the stratigraphic horizon (iii) Hornblends and feldspar from the Amazon to assess climatic changes and differences in Amazon drainage basin provenance.	Columbia University

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1270	Higley	Oregon State University	Multiple Mode Radiography	Investigation of long-lived radionuclide migration through soils using a variety of techniques, including thin-section neutron radiography.	Radiation Center, OSU
1288	DiPietro	Southern Indiana University	Geochemistry of Plutonic Rocks from Pakistan	Study evaluating the petrogenesis and evolution of plutonic rocks in active tectonic settings.	NSF Collaborative Research Project
1300	Buckovic	Oregon State University	Geochemical Assay of Co, Ni, and Mn in Laterite Soil	Determination of the geochemical variability of cobalt, nickel, and manganese in laterite soils of Southeastern Cameroon.	Geovic, Ltd.
1302	Niles	Oregon Office of Energy	Calibration of Emergency Response Instruments	Routine calibration of radiological monitoring instruments associated with the Oregon Office of Energy's programs supporting HazMat and other emergency response teams.	Oregon Office of Energy
1311	Schafer	Goodyear Tire Company	Evaluation of Tin Content in Rubber	Analysis of rubber samples to determine the tin content using INAA.	Goodyear Tire Company

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1323	Roden-Tice	Plattsburgh State University	Fission Track Reseach in Several Geological Areas	Determination of the thermal exhumation histories of: the Triassic basins of CT and MA,; the Adirondack Mtns., NY and estimation of regional strain of Northern Walker Lane, NV using fission track analysis.	USDOE (Reactor Sharing)
1324	Mueller	University of Florida	Proterozoic Crustal Evolution	Examination of the distribution of Proterozoic crust in the Rocky Mountains of Montana and in the Appalachians by geochemical and geochronologic studies of young granitoids and silicic volcanic rocks.	USDOE (Reactor Sharing)
1328	Hughes	Idaho State University	Neutron Activation Analysis of Geologic Materials	INAA of a variety of geologic materials for use in graduate courses in activation analysis and quantitative geochemistry.	USDOE (Reactor Sharing)
1329	Davidson	UCLA	Trace Element Distribution Coefficients in Rocks from Irano, Iran	Determination of trace element concentrations in mineral phases from rocks collected from Damavand Volcano in Iran to model magma differentiation processes.,	USDOE (Reactor Sharing)

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1330	Garver	Union College	Fission Track Studies of Detrital Apatite and Zircon	Determination of the cooling age of single crystals of detrital apatite and zircon applied to sediment provenance in order to evaluate the evolution of source regions with time.	USDOE (Reactor Sharing)
1331	Feeley	Montana State University	Geochemistry of Intrusions from Yellowstone National Park	Examination of model variations in chemical compositions of lavas and related co-genetic intrusions on Sepulchur Mountain and Electric Peak in Yellowstone National Park to provide insight into magma chamber dynamic processes.	USDOE (Reactor Sharing)
1336	Johnson	Texas Tech. University	Petrology and Geochemistry of the Wallowa Batholith	Detailed investigation of the Wallowa batholith in the Blue Mountains of northeastern Oregon to provide information about the timing of accretion and the change in nature of magma source regions with time.	USDOE (Reactor Sharing)
1337	Smith	Trinity University	Petrology and Geochemistry of the Aquacate Volcanics, Costa Rica	Analysis of Aquacate Volcanic rocks to constrain processes important in the genesis and evolution of magmas in order to gain a better overall understanding of the evolution of the Central volcanic arc in Costa Rica.	USDOE (Reactor Sharing)

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
1338	Reynolds	Central Oregon Community College	Tephra and Rock Samples from Paulina Lake, OR	Trace element characterization of tephra and rock samples from Paulina Lake, Newberry volcano to correlate them with surrounding summit tephra and lavas that are not submerged. This will enable a detailed reconstruction of the past several thousand years of geologic history at the summit of the active Newberry volcano.	USDOE (Reactor Sharing)
1339	Nelson	Brigham Young University	Unita Mountains Fibrous Calcite	INAA of calcite vein material in an area of a reported emerald discovery to compare with similar calcite veins in known emerald deposits.	USDOE (Reactor Sharing)
1340	Johnson	University of New Orleans	Evolution of Magmatic System beneath the South Sister, OR	Preliminary evaluation of the magma chamber beneath the South Sister Volcano in the Oregon Cascades to develop a volcanic hazard assessment.	USDOE (Reactor Sharing)
1341	Schmitt	Oregon State University	INAA of Deep Sea Drilling Project samples		USDOE (Reactor Sharing)

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

Project	User(s) Name	Organization Name	Project Title	Description	Funding
1342	Lutes	ARCADIS Geraghty & Miller	Bromide determination in pine needles	The purpose of this project is to characterize the bromide concentration in biological material that will be incinerated. Bromide is present from natural sources and fumigation with bromomethane. The analysis is needed for an environmental impact statement.	ARCADIS Geraghty & Miller
1343	Garver	Union College	Fission Track Dating of Minerals for Thermochronology & Provenence Analysts	Fission track anylysts of zircon and apatite to determine the thermotectonic evolution of orogenic systems. Fission track analysts of detrital zircon and apatite to evaluate the provenance of sedimentary sequences and to understand the evolution of orogenic systems.	USDOE (Reactor Sharing)
1344	Barnes	Texas Tech University	Geochemistry of Middle Proterozoic Igneous Rocks from eastern New Mexico and west Texas	The purpose of this project is to determine the minor and trace element composition of of I- and A-type rhyolites collected from the subsurface ofeastern New Mexico and west Texas.	USDOE (Reactor Sharing)
1345	Tollo	George Washington University	Petrology of Grenville-age basement, Shenandoah National Park, Blue Ridge Province, Virginia	The objective of this project is to determne rare earth element and high field strength element concentrations in charnockite.	USDOE (Reactor Sharing)

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1348	Barnes	Texas Tech University	Granite Petrogenesis in the Ruby Mtn. Area, Nevada	Development of an understanding of the relationship between tectonism and granitic magmatism in a metamorphic core complex. In particular, to show that the Late Cretaceous granites in the Lamoille Canyon area were derived from deep-seated crustal source rocks whereas middle Tertiary granites were derived from sources at shallower levels.	USDOE (Reactor Sharing)
1350	Vergin	Oregon State University	Sterilization of Micropipets and Labware	Irradiation of micropipets and other laboratory equipment used in the study of DNA.	Microbiology Dept., OSU
1351	Dalrymple	Oregon State University	Age Dating of Lunar Samples	Use of Ar-40/Ar-39 ratio methodology to date lunar rock samples about 4 billion years old.	Oceanography Dept., OSU
1352	Niles	Oregon Office of Energy	General Consultation	Radiological and radioactive material transport consulting services	Oregon Office of Energy
1353	Kamp	The University of Waikato	Fission Track Thermochronology of New Zealand	Determination of the history and timing of denudation of basement terranes in New Zealand as well as the thermal history of late Cretaceous-Cenozoic sedimentary	University of Waikato

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1354	Paris	Radiation Protection Services	Radiological Instrument Calibration	Routine calibration of radiological monitoring instruments.	Oregon Health Division
1357	Krane	Oregon State University	Neutron Cross Section Measurements	Irradiation and gamma spectrometry of germanium, gadolinium, and other elements in order to determine the thermal capture cross sections of certain radionuclides.	Radiation Center, OSU
1359	Niles	Oregon Office of Energy	State Laboratory Support	Maintenance of state radiological monitoring support capability. This involves quality assurance, counting standards and calibrations of gamma spectrometer systems suitable for measuring low levels of radioactivity in various environmental and foodstuffs samples.	Oregon Office of Energy
1362	Mueller	University of Florida	Proterozoic Crustal Evolution	Examination of the distribution of Proterozoic crust in the Rocky Mountains of Montana and in the Appalachians by geochemical and geochronologic studies of young granitoids and silicic volcanic rocks.	University of Florida

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1365	Schütfort	Oregon State University	Quality Assurance Program	Irradiation of various samples for quality assurance purposes. This involves irradiations of solutions of Au and Mn both with and without cadmium covers to determine neutron flux ratios.	Radiation Center, OSU
1366	Scaillet	Universite Paris-Sud	Ar-Ar Geochronology	Determination of geological samples via Ar-Ar radiometric dating.	Universite Paris-Sud
1367	Siddoway	Colorado College	Geochemical Discrimination of "A-type" and "I-type" granites	INAA of two granitic samples from a dredge haul collected in a glacier trough offshore Marie Byrd Land, Antarctica, in order to verify or disprove a correlation of these materials with the on-land granite exposures.	Colorado College
1368	Buckovic	Oregon State University	Determination of Cobalt Leach Rates in Sulfurous Acid	Determination of cobalt leach rates as a function of time, temperature, and grain size of ore minerals using sulfur dioxide through an aqueous laterite ore slurry.	Geovic Ltd.

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1370	Tollo	George Washington University	Petrology of Grenville-Age Charnockites, Blue Ridge Provice, VA	Formulation of a rigorous geological model of magmatic activity and metamorphism associated with Grenville orogenesis in the Blue Ridge province of the central Appalachians.	George Washington University
1371	Griffith	Agricultural Research Service	Liquid Scintillation Ccounting of C-14 Smears	Analysis of smears for decommissioning of a radioactive materials laboratory at the National Forage Seed Research Center.	Agricultural Research Service
1372	Slavens	DOE/Albany Research Center	Liquid Scintillation Counting for Thorium Content	Identification of thorium content in TIMET filter waste system by using the liquid scintillation counter.	DOE/Albany Research Center
1373	Haggerty	Oregon State University	Diffusion in Geologic Materials	Use of the Radiation Center facilities to research the diffusion of water through geologic materials. Tritium will be used to evaluate the diffusion along with the liquid scintillation counter.	Radiation Center, OSU

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1374	Ream	Oregon State University	Ancient DNA	The purpose of the project is to extract DNA from archaeological artifacts. Irradiation is done to destroy the DNA that is not ancient. Objects to be irradiated include gloves and gelatin.	OSU Microbiology
1375	Gardner	Oregon State University	PAC spectroscopy of W_2ZrO_8	Activation of Hafnium in W_2ZrO_8 crystal in order to perform perturbed angle correlation spectroscopy.	OSU Radiation Center
1376	Proebstring	Oregon State University Horticulture	Genetics of Peas	Produce deletion mutants of peas on the SN and NP genes	OSU Horticulture
1377	Williamson	Oregon State University	Bioremediation Bottle Sterilization	Destruction of Cells in Bioremediation Bottle Study	OSU Civil Engineering
1378	McBirney	University of Oregon	Petrology of the Skaergaard Intrusion, East Greenland	Determination of trace elements to evaluate the behavior of components during crystallization and differentiation of magmas at shallow depths of the earth's crust and mantle.	USDOE (Reactor Sharing)

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1379	Feeley	Montana State University	Petrogenesis of Shoshonitic Series Magmas: Evidence from the Type Locality	Examination and modeling of variations in rare earth element concentrations of Shoshonitic series magmas from the Eocene Sunlight volcano, Wyoming to serve as a reference point for comparison to other areas that have erupted Shoshonitic series magmas, particularly those in the back-arc regions of active subduction zones.	USDOE (Reactor Sharing)
1380	Barnes	Texas Tech University	Correlation of Cretaceous and Tertiary granites in a Nevadan core complex	Prior work in the Ruby Mountains and the East Humboldt Range in Nevada identified an exportable set of field relations which show late Cretaceous and Oligocene ages of granite generation. Detailed sampling of similar rocks in the structurally deepest levels of the East Humboldt Range provides a basis for geochemical analysis and statistical testing of correlation between the ranges. Results will permit basement age theories, structure, and current concepts of granite generation in the region to be tested.	USDOE (Reactor Sharing)

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1381	Fodor	North Carolina State University	Hawaiian magmatism: geochemistry of basalt and gabbro xenoliths and their plagioclase	Evaluation of trace-element abundances in Hawaiian basaltic and gabbroic rocks that occur as xenoliths in Koolau and Mauna Kea volcanoes	USDOE (Reactor Sharing)
1382	Smith	Trinity University	Origin of silicic magmas in Costa Rica	Determination of the origin of the high-silica magmas that occur in Costa Rica	USDOE (Reactor Sharing)
1383	Hughes	Idaho State University	INAA of Geologic Materials to Support Graduate Level Courses and Thesis Research	Support of student research projects for Quantatative Geochemistry Laboratory and Neutron Activation Analysis graduate courses	USDOE (Reactor Sharing)
1384	Mueller	University of Florida	Origin of the Little Belt Mountains	Identification and geochemical characterization of Proterozoic rocks in the Little Belt Mountains in order to better constrain the time nature of the collision between these two cratons	USDOE (Reactor Sharing)
1385	Roden-Tice	Plattsburgh State University	Apatite and Zircon Fission Track Dating	Apatite and zircon fission track dating to determine the thermal and uplift histories of the Adirondack . Mountains, NY and the Olympic Mts., WA.	USDOE (Reactor Sharing)

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1386	Johnson	Texas Tech. University	Geochemistry of the Late Jurassic Wallowa batholith, Blue Mountains,	Characterization of the Blue Mountains province of northeastern Oregon to evaluate the relative roles of the crust and mantle in the generation of the pre-accretion magmas	USDOE (Reactor Sharing)
1387	Fleischer	Union College	Nuclear Tracks in Solids	(1) Characterization of U and Th distributions in South American and upstate New York lake core samples using solid state plastic track detectors. (2) Measurement of neutron fluence at Hiroshima from fission tracks in glass.	USDOE (Reactor Sharing)
1388	Hawkins	The Colorado College	Petrology, geochemistry of Silurian bimodal metavolcanic and subvolcanic rocks, Vinalhaven Island ME	INAA of Silurian age volcanic rocks from Vinalhaven Island, ME to determine tectonic setting.	Keck Consortium
1389	Michalek	Umpqua Research Company	PVC with Glass Wool and 35 ml Sorbent Material	PVC pipe with glass wool and sorbent material	Umpqua Research Company
1390	Bottomley	Oregon State University	Soil Study	Soil Study	OSU Crop and Soil Science

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1391	Hawkins	The Colorado College	Stratigraphic record of Vinalhaven granite, coastal Maine	INAA of samples for a Stratigraphic record of replenishment, mixing, crystallization and wall-rock collapse in the magma chamber of the Vinalhaven granite, coastal Maine.	Keck Consortium
1392	Hawkins	The Colorado College	Basaltic pillow mounds in the Vinalhaven granite, coastal Maine	INAA of Vinalhaven granite to determine hybrization processes.	Keck Consortium
1393	Hawkins	The Colorado College	Mafic replenishments into the Vinalhaven granite, coastal Maine	INAA of Vinalhaven granite to understand geochemical line between cross-cutting basaltic bodies & closely associated layers of cumulate gabbros; understand hybridization of mafic layers	Keck Consortium
1394	Hawkins	The Colorado College	Petrologic and geochemical relations of mafic and felsic dikes of Vinalhaven Island	INAA of mafic and felsic dikes from Vinalhaven Island Maine for correlation and understanding of events which created granitic-gabbroic complex	Keck Consortium
1395	Hawkins	The Colorado College	Geology of Elkhorn Mountains, NE Oregon	INAA of volcanic rocks to characterize the petrography and geochemical composition	Keck Consortium

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1396	Hawkins	The Colorado College	Tectonic Investigation of Basalts in the Southern Nicoya Peninsula,Costa Rica	INAA of basalts to determine geochemical consistency of northern Nicoya basalts & intrusives	Keck Consortium
1397	Buckley	Oregon Medical Laser Institute C/O OHSU	Sterilization of pig arteries and vessel transections	Sterilization of pig arteries and vessel transections for St. Vincents Hospital, Portland	Oregon Medical Laser Institute
1398	Barnes	Texas Tech University	Correlation of Cretaceous and Tertiary granites in a Nevadan core complex	Prior work in the Ruby Mountains and the East Humboldt Range in Nevada identified an exportable set of field relations which show late Cretaceous and Oligocene ages of granite generation. Detailed sampling of similar rocks in the structurally deepest levels of the East Humboldt Range provides a basis for geochemical analysis and statistical testing of correlation between the ranges. Results will permit basement age theories, structure, and current concepts of granite generation in the region to be tested.	Texas Tech University

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1399	Olander	U.C. Berkeley	Volatilization of uranium in the presents of organic material	Depleted uranium is loaded on a resin and heated to high temperatures in a reducing atmosphere. Products in the resulting vapor are irradiated. U-235 in the vapor deposits will fission and U-238 will absorb neutrons. Gamma ray spectrometry will determine the amount of uranium volatilized.	University of California Berkeley
1400	Moody	M. Pulse Technology	MPT Stabilization of Contamination	Characterization and stabilization of S-90 contaminated soils in the Hanford 100 area.	
1401	Orsborn	Private Citizen	Determination of Origin of Material	Determination of Fe, Ni and Cr in possible meteoritic or smelter material.	Public service
1402	Clayton	Private Citizen	Determination of Origin of Material	A unusual occurrence of a rock specimen was observed by Mr. Clayton on his property. Mr. Clayton suspects the sample to be of meteoritic origin.	Public service
1403	Klingensmith	Univ California at Santa Barbara	Testing of Metal Specimens	Testing of activated metal specimens for full range of isotopes.	Univ California Santa Barbara
1404	Riera-lizarau	Oregon State University	Evaluation of wheat DNA	Gamma irradiation of wheat seeds	

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1405	Pastorek	Oregon State University	CH 462 - Integrated Laboratory Program	The integrated laboratory program uses an INAA experiment to determine the abundance of sodium, aluminum and potassium in zeolite.	
1406	Pate	Tracerco	Production of Argon-41	Production of Argon-41 for various field uses	Tracerco
1407	Roden-Tice	Plattsburgh State University	Apatite and Zircon Fission Track Dating	Apatite and zircon fission track dating to determine the thermal and uplift histories the Hartford Basin sedimentary rocks and Bronson Hill terrane crystalline rocks, CT.	Plattsburgh State University
1408	Gerdemann	USDOE Albany Research Center	Analysis of titanium powder	Measurement of sodium and chlorine in titanium powder.	USDOE Albany Research Center
1409	Keith	Brigham Young University	Characterization of Bingham Porphyry System, UT	Characterization of Bingham porphyry Cu-Au-Mo deposit, Utah	USDOE (Reactor Sharing)
1410	Johnson	University of New Orleans	Evolution of magma chamber beneath South Sister Volcano, OR	Trace element and isotopic study to evaluate recent magma chamber processes. Development of a volcanic hazard report	USDOE (Reactor Sharing)
1411	Hughes	McBirney High School	Irradiation of Carrot Seeds		

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1412	Chilcote	Benton County Sheriff's Office	Forensic Analysis of Shotgun Pellets	Forensic analysis of shotgun pellets	Benton County Sheriff's Office
1413	Webb	University of Geneva	Argon Geochronology	Radiometric dating of rock materials based on the natural decay of potassium and conversion of K-39 to Ar-39 of pure mineral and whole rock separates irradiation. Measurement of relative proportions of Ar isotopes with a noble gas mass spectrometer to determine the age.	University of Geneva
1414	Weigand	Cal. State University, Northridge	Petrology of volcanic rocks associated with the Miocene San Onofre Breccia, southern California	Characterization and comparison of volcanic rocks in the Miocene San Onofre Breccia on Santa Cruz Island and the San Onofre Breccia on Santa Catalina Island.	USDOE Reactor Sharing
1415	McGinness	ESCO Corporation	Calibration of Instruments	Instrument calibration	ESCO Corporation
1416	Rowan	Colorado State University	Tracer Studies in Trout	Irradiate to activate Cs-133	USDOE Reactor Sharing
1417	Loveland	Oregon State University	Production of Radionuclides for LBNL	Various radionuclides will be produced for research to be conducted at LBNL.	OSU Chemistry/Loveland DOE

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1418	Hinton	University of Georgia -Savannah River Ecology Lab.	Determination of Cesium in Fish Mussle and Lake Flora	Determination of the cesium concentration in freeze-dried and ashed fish mussel and plant samples from Pond #4 of the Savannah River Site.	RUS
1419	Krane	Oregon State University	Nuclear Structure of N=90 Isotones	Study of the structure of the N=90 isotones (Sm-152, Gd-154, Dy-156) from the decays of Eu-152, Eu-152m, Eu-154, Tb-154, and Ho-156 . Samples will be counted at LBNL.	OSU Physics
1420	Binney	Oregon State University	Class Project NE 457	Determination of components in mineral dietary supplements.	OSU Radiation Center
1421	Krane	Oregon State University	Measurement of Pb-208 capture cross section	Measurement of the Pb-208 capture cross section by the activation technique by looking at the beta decay of Pb-209.	OSU Physics
1422	Harnish	Colorado School of Mines	Actinide Studies	Actinide studies of sediment samples	Colorado School of Mines
1423	Turrin	Lamont-Doherty Earth Observatory	40Ar/39Ar Analysis	Petrology and geochemical evolution of the Damavand trachyandesite volcano in Northern Iran.	Columbia University

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Project	User(s) Name	Organization Name	Project Title	Description	Funding
1424	Yasinko	Tru-Tec	Argon 41 Production	Irradiation of argon gas to produce argon 41.	Tru-Tec
1425	Gardner	Oregon State University	Measuring Impurity Levels in ZrO_2	INAA of pure, undoped zirconium oxide to measure oxygen vacancies which affects ionic conductivity.	OSU Radiation Center

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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	
Alpha Detectors	4
Civil Defense Detectors	0
GM Detectors	45
Ion Chambers	9
Micro-R Meters	3
Personal Dosimeters	57
Support Agency Instruments	
Corvallis Fire Department	8
Good Samaritan Hospital (Corvallis, OR)	8
TOTAL	134

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	6
Animal Science	3
Biochemistry/Biophysics	7
Botany and Plant Pathology	9
Chemistry	2
Civil Engineering	2
Crop Science	3
Electrical and Computer Engineering	1
Entomology	0
Fisheries and Wildlife	3
Food Science and Technology	4
Forest Science	3
Horticulture	3
Linus Pauling Institute	0
Microbiology	6
Nutrition and Food Management	0
Oceanic and Atmospheric Sciences	4
Pharmacy	5
Physics	6
Radiation Safety Office	14
Veterinary Medicine	3
Zoology	3
OSU Departments Total	87
Non-OSU Agencies	
Army Corps of Engineers	3
Corvallis Fire Department	5
ESCO Corporation	5
Good Samaritan Hospital	9
Occupational Health Laboratory	1
Oregon Office of Energy	7
Oregon Department of Transportation	3
Oregon Health Sciences University	23
Oregon Public Utilities Commission	5
Oregon State Health Division	44
Rogue Community College	1
USDA Agricultural Research Service/Forest Service	3
U.S. Environmental Protection Agency	7
Non-OSU Agencies Total	116

Table VI.C.6

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

Date	Organization	Instrument	Calibrated ?	Nature of Repair
7/8/98	OHSU	Bicron 2000	No	Replace range switch
7/29/98	Oregon Health Division	Victoreen 471A #329	Yes	Replace function switch
8/19/98	Public Utilities Commission	Ludlum 6 S/N 35532	Yes	Replace meter scale
9/9/98	Public Utilities Commission	Ludlum 6 S/N 35563	Yes	Replace meter scale
9/9/98	Public Utilities Commission	Ludlum 6 S/N 44257	Yes	Replace meter scale
12/23/98	Physics	Technical Associates PUG-1 063111	Yes	Replace GM tube
3/2/99	Good Samaritan Hospital	Technical Associates TBM-15	Yes	Replace connector
3/2/99	Oregon Health Division	Victoreen 471A	Yes	Replace meter
3/15/99	Oregon Health Division	Ludlum 18 34280	Yes	Replace meter bezel
3/15/99	Oregon Health Sciences University	Ludlum 3 27930	No	Replace meter movement
6/21/99	ESCO Corporation	Ludlum 12S 11821	Yes	Replace meter movement
Total Number of Repairs			**11**	

Table VI.F.1

Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
July 9, 1998	2	R. Zyromski and L. Zyromski
July 9, 1998	20	Major Crime Squad
July 13, 1998	15	Adventures in Learning, Forensic Class
July 13, 1998	15	Adventures in Learning, Forensic Class
July 14, 1998	20	Adventures in Learning
July 15, 1998	20	Adventures in Learning
July 16, 1998	20	Adventures in Learning
July 22, 1998	15	Chemistry Class/PCC
July 28, 1998	2	John Mandler and Bob Gehrke, INEEL
July 29, 1998	1	Mike Shivers
August 5, 1998	3	Daniel Boehm, Hagen Schorfield, Thorsten Nahl
August 11, 1998	4	Greg, Troy, Tory Jr., and Jordan Strawn
August 12, 1998	7	SMILE program High School
August 12, 1998	1	Hongbin Xhao
August 13, 1998	6	National Science Foundation Sponsored Research for Undergraduates
August 19, 1998	28	Japanese Engr Students
August 20, 1998	2	Carl Demitropolis, Hatfield Marine Science Center
August 21, 1998	2	Stephanie Antoine, Mike Corwin
August 31, 1998	3	Bill Buckovic, Norman Rose, Dan Sanders - Geovic
September 3, 1998	4	DAIDO Institute of Technology - Japan
September 10, 1998	6	Sean Williams and Family
September 11, 1998	12	Ag Extension Retirees and wives
September 14, 1998	2	Sarah Lyons, Jeff Cosek

Table VI.F.1

Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
September 16, 1998	1	Ann Peltier - Linn County Health Department
September 18, 1998	5	Dr. Ron Guenther
September 22, 1998	2	Toby Hayes, Mary Nunn
September 30, 1998	21	NE 111 Class
October 2, 1998	1	Eric Leber
October 6, 1998	1	Dr. John Westall
October 12, 1998	1	Melanie Barnes
October 19, 1998	2	Richard Stout, Jan Stout
October 19, 1998	1	Isaac Jones
October 21, 1998	40	Woodburn High School
October 23, 1998	2	Donna West, Linda James
October 28, 1998	2	Kelley Moss, Nancee Beckett
October 30, 1998	2	Amy Beach, Tabby Groff
November 6, 1998	30	Loren Anderson - Corvallis Water Deptartment
November 6, 1998	3	Ian Davis and Grandparents
November 9, 1998	1	Don Pettit - NASA
November 10, 1998	20	Cauthorn RA
November 14, 1998	10	Beaver Open House
November 16, 1998	15	Finley Hall residents
November 17, 1998	12	OSU Bioresource Engineering
November 20, 1998	1	Fazlur Rahman - IAEA
November 24, 1998	2	Harold and Fran Orsborn
November 24, 1998	20	LBCC GS105 General Science
November 24, 1998	20	LBCC GS105 General Science

Table VI.F.1
Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
November 25, 1998	2	Jeff and Deanna Binney
December 4, 1998	1	Tom Baird
December 23, 1998	4	Dr. Martin Rice, Dr. Cox and 2 children
January 7, 1999	13	CH 462 class
January 12, 1999	4	CH 462 class
January 21, 1999	4	CH 462 class
January 25, 1999	24	CH 225H class
January 26, 1999	24	CH 225H class
January 27, 1999	3	Student Tour
January 28, 1999	24	CH 225H class
February 4, 1999	11	Honors Writing for Engineers
February 6, 1999	127	Dad's Weekend
February 9, 1999	1	Dennis Honeywell
February 11, 1999	4	Nate Carstens and family
February 17, 1999	47	Dr. King/Fluids Class
February 19, 1999	14	NE 112 class
February 22, 1999	8	Naval Engineering
February 22, 1999	6	Naval Engineering
February 22, 1999	7	Corvallis Fire Department
February 23, 1999	10	Environmental Scientists
February 23, 1999	9	Corvallis Fire Department
February 24, 1999	7	Corvallis Fire Department
February 24, 1999	1	Travis Kunkle
March 2, 1999	11	CH 222 class

Table VI.F.1
Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
March 2 1999	19	CH 222 class
March 2, 1999	20	CH 222 class
March 2, 1999	23	CH 222 class
March 2, 1999	21	CH 222 class
March 4, 1999	21	CH 222 class
March 4, 1999	21	CH 222 class
March 4, 1999	20	CH 222 class
March 4, 1999	22	CH 222 class
March 8, 1999	5	Physic Undergraduates
March 9, 1999	19	CH 222 class
March 9, 1999	17	CH 222 class
March 9, 1999	19	CH 222 class
March 9, 1999	14	CH 222 class
March 9, 1999	1	Jennifer Tanner, PNNL
March 10, 1999	17	CH 222 class
March 10, 1999	18	CH 222 class
March 11, 1999	18	CH 222 class
March 11, 1999	20	CH 222 class
March 11, 1999	23	CH 222 class
March 11, 1999	23	CH 222 class
March 12, 1999	19	SMILE
March 24, 1999	1	Vincent Remcho
March 24, 1999	3	KVAL/TV
March 29, 1999	1	Student

Table VI.F.1
Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
April 1, 1999	2	Larry Posey/Sandia National Laboratory
April 2, 1999	26	8th grade TAG Students
April 6, 1999	11	Linfield Engineering/Orientation Class
April 9, 1999	5	Sophia and Dale Atkinson and Family
April 9, 1999	19	SMILE Tour
April 21, 1999	1	Pat Newport
April 22, 1999	1	Dr. William Johnson
April 23, 1999	5	Vanlang University
April 23, 1999	1	Finley Hall Student
April 23, 1999	3	OSU Film Crew
April 27, 1999	12	OSU Film Crew
April 30, 1999	2	Mark and Stacee Taft
May 1, 1999	63	Mom's Weekend
May 3, 1999	1	Dr. Samuel Glover
May 6, 1999	1	Dr. Carson Riland
May 7, 1999	4	Bruce Young
May 7, 1999	8	Geosciences 633 class
May 11, 1999	2	Oregon State Police
May 12, 1999	10	SMILE
May 13, 1999	22	LBCC Nuclear Engineering Class
May 24, 1999	1	Dr. David D. Breshears
May 25, 1999	1	PNNL
May 27, 1999	2	Paul Strathers and Peter Oake
May 28, 1999	24	Held College

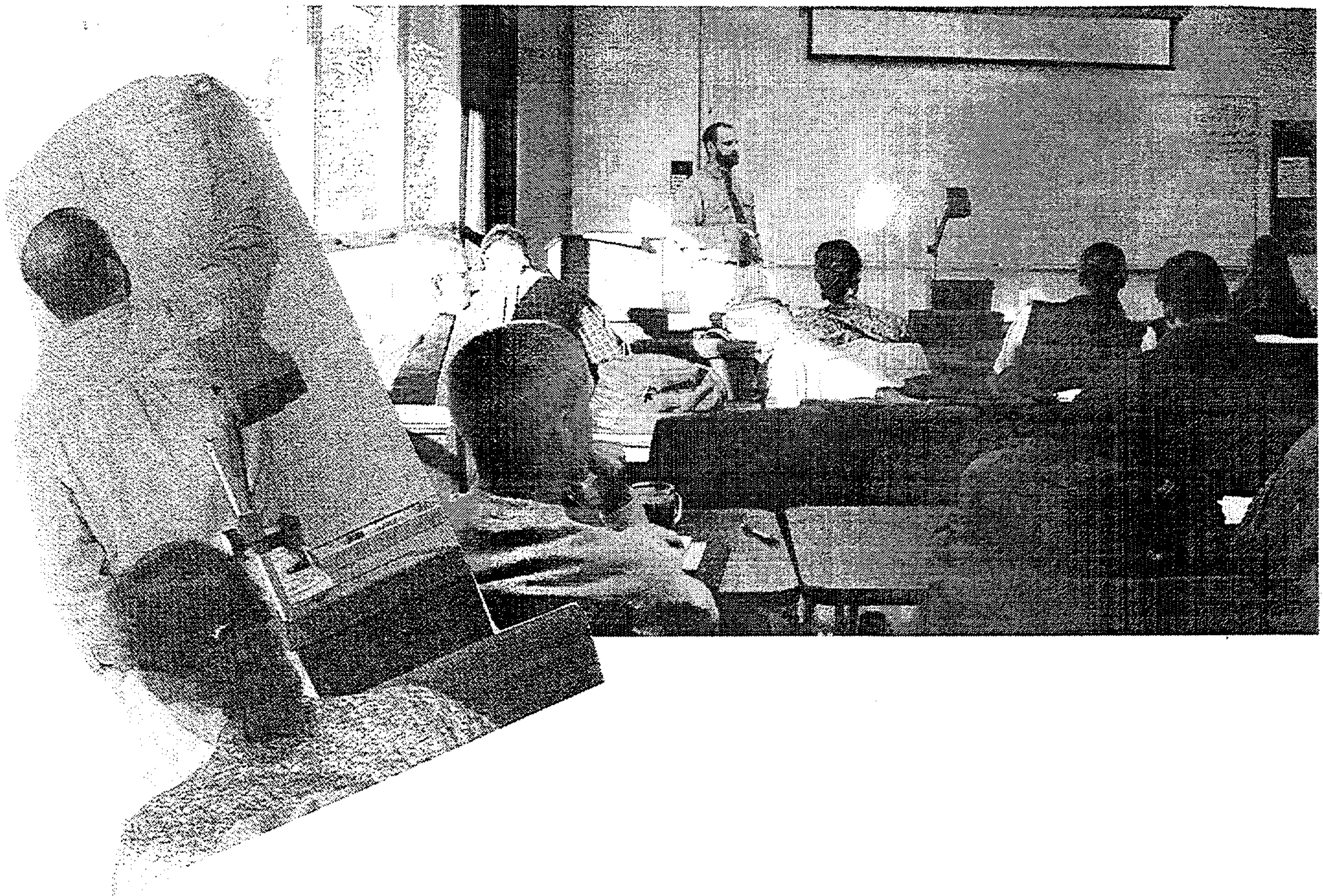
Table VI.F.1

Summary of Visitors to the Radiation Center

DATE	No. of Visitors	NAME OF GROUP
June 1, 1999	60	LBCC CH223 class
June 2, 1999	12	Eric Richardson and Cool Shoes Dance Group
June 14, 1999	1	Guest
June 24, 1999	10	Adventures in Learning
June 25, 1999	19	Adventures in Learning
June 28, 1999	11	Adventures in Learning
TOTAL	1326	

Part VII

WORDS



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*Ball, T. T., and G. L. Farmer (1998), "Infilling History of a Neoproterozoic Intracratonic Lasin: Nd isotope provenance studies of the Vinta Mountain Group, Western United States," *Precambrian Research*, 87:1-18.

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Iles, B. (1998), "How do Gamma Rays Affect the Mass, Growth Rate, Germination Rate, and Second Generation of Brassica Rapa?" Oregon Episcopal School, Portland, OR, http://www.teleport.com/~oeschem/ra98/iles.htm.

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*Feeley, T. C. and G. S. Winer, "Petrography and Geochemistry of Basaltic Lava Flows Erupted on St. Paul Island, Pribilof Islands, Alaska," *Lithos.*

*Fitzgerald, P. G., Baldwin, S. L., Miller, S. R., and G. Dingle, "Geologic and Thermochronologic Studies Along the Front of the Transantarctic Mountains near the Shackleton and Liv Glaciers," *Antarctic Journal of US.*

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* Indicates OSTR use.

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* Indicates OSTR use.