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

July 1, 1992 - June 30, 1993

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

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

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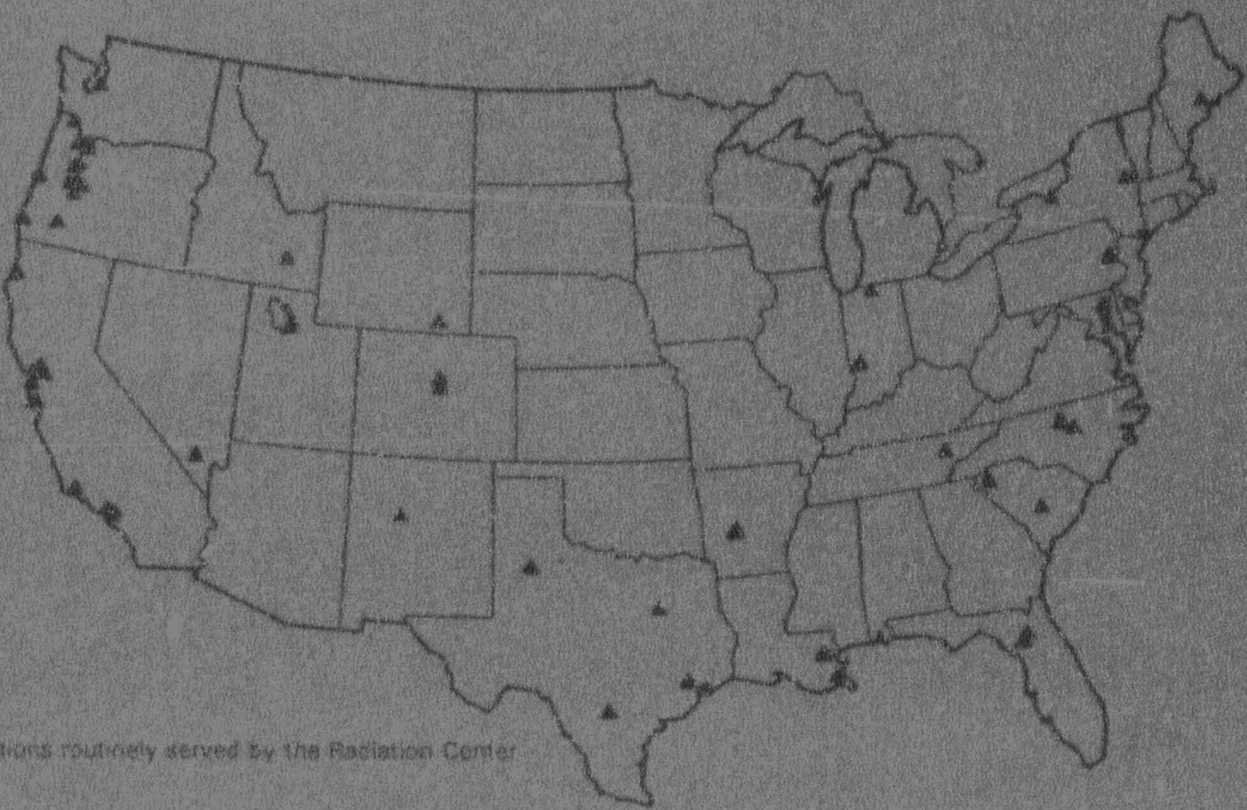
PART I

OVERVIEW



Institutions routinely served by the Radiation Center

PART I
OVERVIEW

A. Acknowledgements

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

In a special note of gratitude, the staff would also like to highlight the talents and the tolerance of our secretarial personnel, particularly Jennie Smith, who performed admirably during the preparation of this report.

B. Executive Summary

This 1992-93 executive summary highlights the Radiation Center's most noteworthy achievements during the reporting period. In preparing such a summary, one is required to compile key performance data for the past year, and with this effort comes the temptation to examine the data in order to objectively determine whether or not the program is meeting its goals. While numbers alone do not tell the entire story, they are one way of conveying the growth and the high level of activity which continued to exist at the Radiation Center over this past year. In view of the current challenges faced by higher education in Oregon, all of us at the Center are very grateful that the program remains healthy and vigorous. We are committed to having it continue in this manner.

The staff at the Radiation Center also remain very sensitive to the fact that our success is closely tied to the important support we receive from many different individuals and organizations. Therefore, before we summarize our achievements, we would like to express our appreciation to everyone who contributed to our program. In particular, we wish to thank the university's administration for their continued financial and administrative support and for their encouragement. We are also most grateful to the U.S. Department of Energy for their very valuable support through the University Reactor Sharing Program and for their financial assistance in helping us modernize equipment essential to the operation of the university's reactor. We would also like to extend our appreciation to the many other organizations who funded research and technical services carried out at the Center. The resources obtained through all of these channels continue to create valuable opportunities for numerous students and researchers who use the unique facilities present at the Radiation Center.

One of the Center's most visible and important programs is the TRIGA research reactor. Once again we are delighted to report that the reactor remained very busy and showed increases in essentially all operating parameters, including total operating hours, total hours at full power, the number of Irradiation Requests processed (+11%) and the number of samples irradiated (+61%). In addition, the staff's efforts to improve efficiency by encouraging simultaneous use of the reactor by more than one researcher resulted in a record (+412%) number of occasions when the reactor accommodated four users during a single reactor run, while use by two or three experimenters during a single reactor run continued near last year's record highs.

Participation in teaching activities is also one of the most important functions of the Radiation Center. Evidence of this is provided by the fact that during the past year use of Radiation Center facilities for teaching once again reached an all-time high. In this period, a record 78 OSU classes were accommodated at the Center. Additionally, about 40% of these classes used the reactor and about 30% of the reactor's total use hours were in direct support of such classes.

Growth in the volume of research performed at the Radiation Center was also prominent again this year. The number of individual projects accommodated by the Center as well as the number of faculty and students using the facilities remained high, while the number of times the Center's facilities were used by these individuals increased 13%. Research over the past year once again involved the many applications of neutron activation analysis, while other research programs focused on different nuclear technologies. For example, the Center's program with Oregon Health Sciences University involving use of the reactor's thermal column to develop a new cancer therapy technique continued to be very active, and construction of the new facility for testing the Westinghouse AP600 reactor system was nearly finished. In addition, the AP600 project experienced a major increase in its scope with an accompanying increase in total funding up to approximately $4 million. Besides these projects, several new research programs were initiated which directly support Oregon's interests in emergency response to radiological accidents and seventy-two shipments of radioactive material were made from the Radiation Center to researchers at other locations.

The Center's cobalt-60 gamma irradiators continued to be a valuable part of our research capability. As expected, the newer irradiator containing approximately 5300 curies of cobalt-60 enabled the Radiation Center to perform considerably higher dose gamma irradiations in much shorter time intervals. Use of this facility showed a large increase (+38%) in the number of irradiations performed, and totalled 1352 hours of irradiations (a 44% increase) which would have been virtually impossible with the older irradiator. However, because the gamma radiation levels in the older irradiator are now lower, it meets a unique requirement that cannot easily be met with the new device. Consequently, the older irradiator was still used for 97 individual irradiations.

Scholarly publications involving a contribution by the Radiation Center totalled 80, and there were 66 presentations at professional meetings where the Center supported the development of the research data being reported. Considering the publications currently in print, those presently submitted for publication and those in the final stages of preparation, there were 129 total articles generated during the 1992-93 reporting period which involved a contribution by the Radiation Center. In addition, 23 graduate student theses were completed and 8 are currently in preparation using data obtained with Radiation Center assistance.

As a result of this past year's performance, we believe that the OSU Radiation Center has again strengthened its image as a regionally and nationally recognized instructional and research facility. We are pleased that the number of institutions using the Center continues to remain high. While such use is definitely good, it is very important to note that our participation in research and teaching with other institutions did not reduce the availability of any Radiation Center facilities, particularly the reactor, to OSU students or researchers.

Other services offered by the Radiation Center, such as tours, where we hosted a record high 1,552 visitors; forensic support for law enforcement programs; emergency response and other technical assistance to State of Oregon agencies; and instrument repair and calibration for OSU and other schools within the state system of higher education, continued to be heavily used. Regarding the latter activity, the Radiation Center calibrated and/or repaired a total of 430 instruments during the past year, and we are especially pleased to be able to offer this support since these calibrations are both a state and federal license requirement and are unavailable to OSU anywhere else in Oregon.

As a final note, we feel that it is very important to point out that there were no items of regulatory noncompliance and no emergencies or security events relating to the Radiation Center during this reporting period. Furthermore, all of the increased use of the Radiation Center and reactor was accomplished with no increase in personnel radiation exposure or any impact on the environment. The comprehensive radiation protection program at the Radiation Center once again showed that the Center and the reactor can be operated safely and within the international goal of keeping personnel doses and releases of radionuclides as low as reasonably achievable (ALARA).

C. Introduction

The current annual report of the Oregon State University Radiation Center and TRIGA Reactor follows the usual format by including information relating to the entire Radiation Center rather than just the reactor. However, the information is still presented in such a manner that data on the reactor may be examined separately if desired. It should be noted that all annual data given in this report cover the period from July 1, 1992 through June 30, 1993. 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, 1993. For a summary of data on the reactor's original 20% enriched core the reader is referred to Table IV.A.2 in Part IV of this report, or to the 1976-77 annual report if a more comprehensive review is needed.

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

D. Overview of the Radiation Center

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

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

A recent major addition to the Radiation Center is the one-quarter scale thermal hydraulic 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. The test facility at the Radiation Center will operate at pressures of up to 400 psia and temperatures up to 450°F using electrical heaters instead of nuclear fuel. All major components of the AP600 are included in the test facility and all systems are appropriately scaled to enable the experimental measurements to be used for safety evaluations and licensing of the

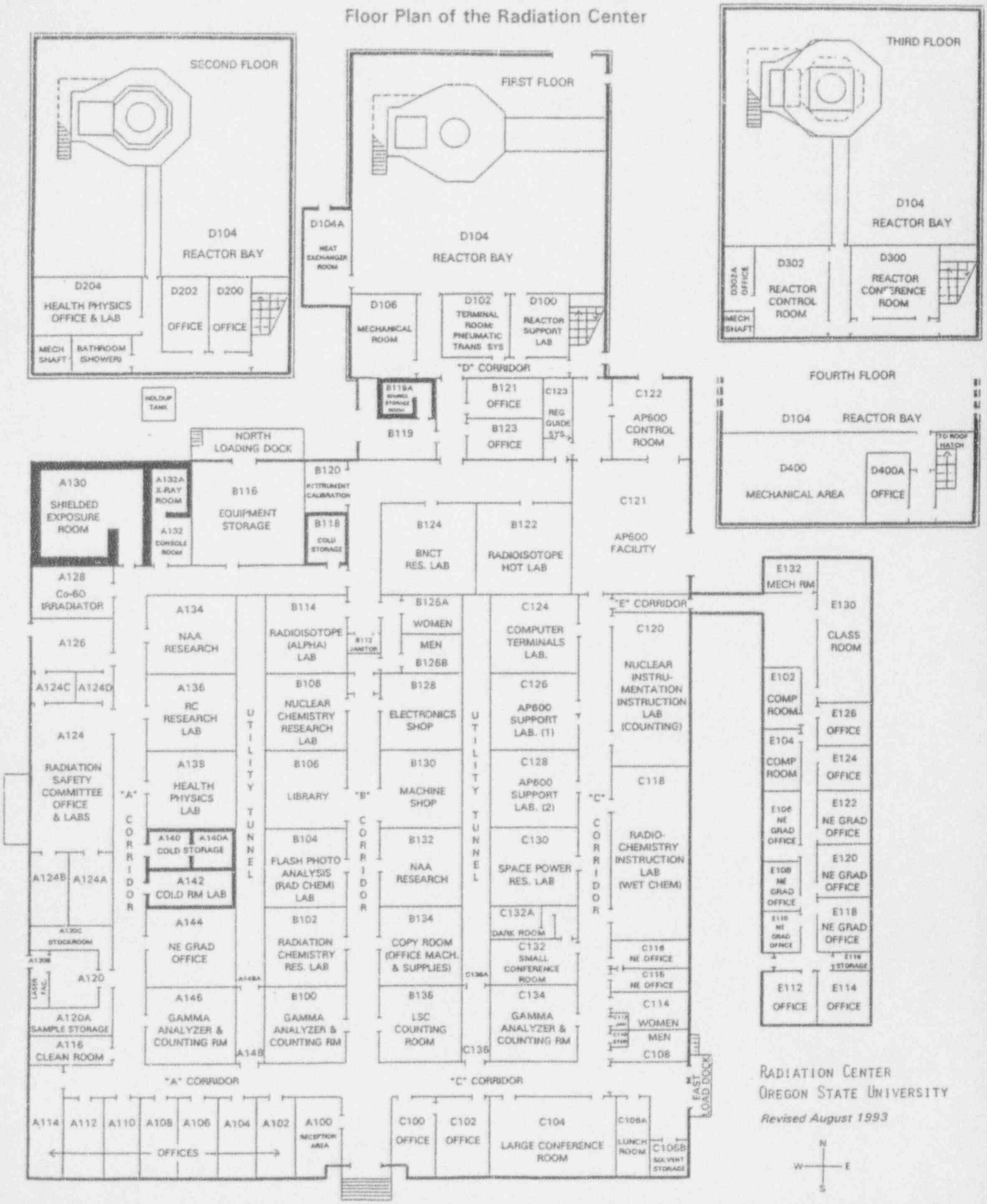
full scale plant. This world-class facility meets exacting quality assurance criteria to provide assurance of safety as well as validity of the test results.

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

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

Figure I.D.1

Floor Plan of the Radiation Center



E. Summary of OSTR Environmental and Radiation Protection Data

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

a.	Total estimated quantity of radioactivity released (to the sanitary sewer)[1][2]	$\leq 6.45 \times 10^{-5}$ Curies
b.	Detectable radionuclides in the liquid waste	^{3}H, ^{60}Co
c.	Estimated average concentration of released radioactive material at the point of release	$\leq 4.19 \times 10^{-6}$ μCi/cc
d.	Percent of applicable MPC for released liquid radioactive material at the point of release	0.10%[3] 0.004%[4]
e.	Total volume of liquid effluent released, including diluent[5]	4072 gallons
	(1) OSTR contribution	0[6] gallons

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(1) OSU has implemented a policy to reduce the absolute minimum radioactive wastes disposed to the sanitary sewer. Although no radioactive wastes have been disposed to the sanitary sewer in this reporting period, a trace of residual activity remains in the waste discharge system.

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

(3) Based on values listed in 10 CFR 20, Appendix B to 20.1-20.601, Table 2, Column 2.

(4) Based on values listed in 10 CFR 20, Appendix B to 20.1-20.601, Table 1, Column 2, applicable to sewer disposal.

(5) Total volume of effluent plus diluent does not take into consideration the additional mixing with the over 7,500,000 gallons per year of liquids and sewage normally discharged by the Radiation Center complex into the same sanitary sewer system.

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

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

a.	Total estimated quantity of radioactivity released	3.06 Curies
b.	Detectable radionuclides in the gaseous waste(1)	^{41}Ar ($T^{½}$ = 1.83 hr)
c.	Estimated average atmospheric diluted concentration of argon-41 at the point of release	2.0×10^{-8} μCi/ml
d.	Percent of applicable MPC for diluted concentration of argon-41 at the point of release	0.5%
e.	Total estimated release of radioactivity in particulate form with half-lives greater than 8 days(2)	None

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

a.	Total amount of solid waste packaged and disposed of	30 ft^3
b.	Detectable radionuclides in the solid waste	^{46}Sc, ^{51}Cr, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{95}Zr, ^{124}Sb, ^{125}Sb, ^{131}I, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce, ^{152}Eu, ^{154}Eu, ^{210}Pb
c.	Total radioactivity in the solid waste	9.3×10^{-4} Curies

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

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

4. Radiation Exposure Received by Personnel (See Table V.C.1)[1]

a.	Facility Operating Personnel	(mrem)
(1)	Average whole body	18
(2)	Average extremities	49
(3)	Maximum whole body	110
(4)	Maximum extremities	190
b.	Key Facility Research Personnel	
(1)	Average whole body	0
(2)	Average extremities	5
(3)	Maximum whole body	0
(4)	Maximum extremities	60
c.	Physical Plant Maintenance Personnel	
(1)	Average whole body	<1
(2)	Maximum whole body	4
d.	Laboratory Class Students	
(1)	Average whole body	0
(2)	Average extremities	0
(3)	Maximum whole body	0
(4)	Maximum extremities	0
e.	Campus Police and Security Personnel	
(1)	Average whole body	0
(2)	Maximum whole body	0
f.	Visitors	
(1)	Average whole body	<1
(2)	Maximum whole body	7

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

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

a. Facility Survey Data

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

(a)	Beta-gamma dosimeter measurements	136
(b)	Neutron dosimeter measurements	48

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

b. Environmental Survey Data

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

(a)	Onsite monitoring	
	-- OSU TLD monitors	108
	-- Radiation Detection Co. TLD monitors	72
	-- Monthly μR/hr measurements	108
(b)	Offsite monitoring	
	-- OSU TLD monitors	264
	-- Radiation Detection Co. TLD monitors	104
	-- Monthly μR/hr 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.
July 1964	Transfer of the 0.1 W AGN 201 reactor to the Radiation Center. This reactor was initially housed in the Mechanical Engineering Department and first went critical in January of 1959.
Oct. 1966	Completion of the second phase of the Radiation Center, consisting of 9,956 square feet of space for the TRIGA reactor and associated laboratories and offices.
March 1967	Initial criticality of the Oregon State TRIGA Reactor (OSTR). The reactor was licensed to operate at a maximum steady state power level of 250 kW, and was fueled with 20% enriched fuel.
August 1969	OSTR licensed to operate at a maximum steady state power of 1 MW, but could do so only for short periods of time due to lack of cooling capacity.
June 1971	OSTR cooling capacity upgraded to allow continuous operation at 1 MW.
April 1972	OSTR Site Certificate issued by the Oregon Energy Facility Siting Council.
Sept. 1972	OSTR area fence installed.
Dec. 1974	AGN-201 reactor permanently shut down.
March 1976	Completion of 1600 square feet of additional space to accommodate the rapidly expanding nuclear engineering program.
July 1976	OSTR refueled with 70% enriched FLIP fuel.
July 1977	Completion of a second 1600 square feet of space to bring the Radiation Center complex to its current total of 45,553 square feet.
Jan. 1980	Major upgrade of the electronics in the OSTR control console.

July 1980	AGN-201 reactor decommissioned and space released for unrestricted use.
June 1982	Shipment of the original 20% enriched OSTR fuel to Westinghouse Hanford Corporation.
Dec. 1988	AGN-201 components transferred to Idaho State University for use in their AGN-201 reactor program.
Dec. 1989	OSTR licensed power increased to 1.1 MW.
June 1990	Installation of a 7000 Ci ^{60}Co Gammacell irradiator.
March 1992	25th anniversary of the OSTR initial criticality.
Nov. 1992	Start of AP600 plant construction.

PART II

PEOPLE

PART II

PEOPLE

PART II

PEOPLE

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

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

A. Faculty

*Johnson, Arthur G.
Director, OSU Radiation Center
Director, OSU Institute of Nuclear Science and Engineering
Professor of Nuclear Engineering and Radiation Health

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

Bilich, Dan K.
Research Assistant
College of Veterinary Medicine

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

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

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*Reactor users for research and/or teaching.

*Conrady, Michael R.
Research Assistant
Neutron Activation Analysis Specialist

*Cordell, Sharon M.
Research Assistant
Radiation Protection Technologist

Daniels, Malcolm
Professor of Chemistry

*Dodd, Brian
Reactor Administrator
Professor of Nuclear Engineering

Freier, Timothy A.
Research Associate
College of Veterinary Medicine

Groome, John T.
Research Assistant
AP600 Test Engineeer
Nuclear Engineering

Hart, Lucas P.
Research Associate
Chemistry

Haytas, John J.
Research Assistant
AP600 Facility Operator
Nuclear Engineering

*Higginbotham, Jack F.
Senior Health Physicist
Associate Professor of Nuclear Engineering

King, John B.
Instructor of Nuclear Engineering

Klein, Andrew C.
Associate Professor of Nuclear Engineering

Kulas, Mary M.
Assistant Professor of Nuclear Engineering

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*Reactor users for research and/or teaching.

Lafi, Abd Y.
Research Associate
AP600 Theoretical Models Group Leader
Nuclear Engineering

Lee, Deanna
Research Assistant

*Liu, Yun-Gang
Research Associate
Chemistry

*Loveland, Walter D.
Professor of Chemistry

MacVicar, Robert
President Emeritus, OSU

*Maki, Leonard M.
Professor of Nuclear Engineering (Visiting)

*Martsolf, Steven W.
Research Assistant
Nuclear Engineering

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

*Pastorek, Christine
Instructor of Chemistry

Popovich, Milosh
Vice President Emeritus, OSU

*Pratt, David S.
Research Assistant
Health Physicist

Reyes, José N.
AP600 Principal Investigator
Associate Professor of Nuclear Engineering

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

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*Reactor users for research and/or teaching.

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

*Schmitt, Roman A.
Professor of Chemistry

Srivastava, Alok
Research Associate
Chemistry

Wachenheim, Daniel E.
Research Associate
College of Veterinary Medicine

*Walker, Robert J.
Research Assistant
Geochemist

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

Willis, David L.
Professor Emeritus
General Science, OSU

Young, Roy A.
Professor Emeritus, OSU

Yundt, Michael S.
Research Assistant
AP600 Calibration Technician
Nuclear Engineering

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*Reactor users for research and/or teaching.

B. Visiting Scientists and Special Trainees

Name	Field (Affiliation)	Advisor or Research Program Director
Behkami, Aziz N.	Visiting Scientist Chemistry (Iran)	W. D. Loveland
Gallagher, Brandon J.	Saturday Academy Mentorship Program, Churchill High School (Eugene, Oregon)	R. J. Walker
Glass, Jason E.	Oregon State University Space Grant Program (Vassar College, New York)	A. C. Klein
Ham, Neal	Saturday Academy Mentorship Program, Pasco High School (Pasco, Washington)	W. D. Loveland
*Liedtke, James D.	Visiting Associate Professor (Portland Community College)	A. G. Johnson
Yanez, Ricardo	Chemistry (Sweden)	W. D. Loveland

*Reactor users for research and/or teaching.

C. OSU Graduate Students

Name	Degree Program	Field	Advisor
Abdul-Hamid, Shahab A.	MS	Nuclear Engr.	A. C. Klein
Ahn, Harry	MS	Nuclear Engr.	J. F. Higginbotham
Al-Baroudi, Homan	PhD	Nuclear Engr.	A. C. Klein
Al-Kheliewi, Abdullah S.	PhD	Nuclear Engr.	A. C. Klein
Ala, Abbas	PhD	Nuclear Engr.	S. E. Binney
*Bae, Jung Soo	MS	Radiation Health	J. F. Higginbotham
Betts, Curt M.	MS	Nuclear Engr.	M. M. Kulas
Cantaloub, Michael	MS	Nuclear Engr.	J. N. Reyes
*Day, Travis D.	PhD	Chemistry	W. D. Loveland
Dickinson, Jeffrey W.	MS	Nuclear Engr.	A. C. Klein
Fishburn, Mark R.	MS	Radiation Health	B. Dodd
*Fitz, Christopher K.	MS	Radiation Health	B. Dodd
Franz, Scott C.	MS	Nuclear Engr.	J. N. Reyes
Fu, Yingxian	PhD	Chemistry	M. Daniels
Fundak, Robert	MS	Nuclear Engr.	A. C. Klein
Gulshan-Ara, Zubaida	MS	Nuclear Engr.	A. C. Klein
Guymon, III, Vernon M.	MS	Nuclear Engr.	S. E. Binney
*Hamoudi, Ali K.	MS	Radiation Health	J. F. Higginbotham
*Johnson, Jennifer E.	MS	Radiation Health	S. E. Binney
*Kellar, Marvin	MS	Radiation Health	B. Dodd
Kiestler, William C.	MS	Nuclear Engr.	A. C. Klein
Lee, Hsing H.	PhD	Nuclear Engr.	A. C. Klein
Ma, Chang Chun	MS	Nuclear Engr.	J. N. Reyes
*Martin-Bandin, Fernando	MS	Radiation Health	J. F. Higginbotham
*Martsolf, Steven W.	MS	Radiation Health	S. E. Binney
*Merritt, Patrick A.	MS	Nuclear Engr.	A. C. Klein
Potter, Nathan K.	MS	Radiation Health	B. Dodd
*Pratt, David	MS	Radiation Health	J. F. Higginbotham
*Shepherd, Stephen H.	PhD	Nuclear Engr	J. C. Ringle
Snuggerud, Ross D.	MS	Nuclear Engr.	A. C. Klein
Stevens, Owen L.	MS	Nuclear Engr.	J. N. Reyes
*Streck, M.	PhD	Geosciences	A. Grunder
Vostmyer, Chris	MS	Radiation Health	S. E. Binney
Wang, Yi	MS	Nuclear Engr.	J. N. Reyes
Wu, Renpo	MS	Radiation Health	B. Dodd
Zhou, Liansheng	MS	Nuclear Engr.	M. M. Kulas

*Reactor users for research and/or teaching.

D. Business, Administrative and Clerical Staff

Director, Radiation Center	A. G. Johnson
Business Manager	S. C. Campbell
Administrative Assistant	D. K. Dalton
Office Specialists	J. F. Hopkins
	C. L. Phillips
	J. R. Smith
Custodian	M. L. Benad
Office Coordinator (Nuclear Engineering)	D. L. Cramer
Word Processing Technician (Nuclear Engineering)	R. A. Keen
Word Processing Technician (AP600 - Nuclear Engineering)	T. L. Culver

E. Reactor Operations Staff

Principal Security Officer	A. G. Johnson
Reactor Administrator, Senior Reactor Operator	B. Dodd
Reactor Supervisor, Senior Reactor Operator	T. V. Anderson
Senior Reactor Operators	S. E. Binney
	A. D. Hall
	J. F. Higginbotham

F. Radiation Protection Staff

Senior Health Physicist	J. F. Higginbotham
Health Physicist	D. S. Pratt
Radiation Protection Technologist	S. M. Cordell
Health Physics Monitors (Students)	D. Calaba
	M. Cunningham
	D. Fisher
	M. Hackworth
	D. King
	J. Robbins
	E. Rockett
	O. Stevens
	B. Tharakan

G. Scientific Support Staff

Senior Neutron Activation Analyst . . . . R. A. Schmitt
Neutron Activation Analysis Specialist . . . . M. R. Conrady
Geochemists . . . . M. J. Streck
E. G. Torne
R. J. Walker
Neutron Activation Analysis Technicians (Students) . . . . J. MacLean
D. Maher
D. Princehouse
I. Ryu
C. Schneider
J. Templeton
K. Wiese
L. Zhang
Scientific Instrument Technician . . . . S. P. Smith
Computer Specialist (Student) . . . . J. Estabrook
Nuclear Instrumentation Support . . . . J. Bae

H. OSU Radiation Safety Office Staff

Radiation Safety Officer . . . . R. H. Farmer
Radiation Specialists . . . . D. L. Harlan
E. F. Forrer
Secretary . . . . K. L. Miller
Student Technicians . . . . A. Arevalo
J. Dominick
S. Naguib
R. Sitsler

I. Committees

1. Reactor Operations Committee

Name	Affiliation
S. E. Binney, Chair	Nuclear Engineering
D. L. Amort	Electrical and Computer Engineering
T. V. Anderson	Radiation Center
B. Dodd	Radiation Center and Nuclear Engineering
J. F. Higginbotham	Radiation Center and Nuclear Engineering
A. G. Johnson	Radiation Center and Nuclear Engineering
J. C. Ringle	Nuclear Engineering and Graduate School
A. H. Robinson	Nuclear Engineering
R. A. Schmitt	Chemistry and Radiation Center
W. H. Warnes	Mechanical Engineering

2. Radiation Safety Committee (OSU)

Name	Affiliation
C. Rivin, Chair	Botany and Plant Pathology
R. Farmer, Secretary & RSO	Radiation Safety Office
H. Carpenter	Fisheries and Wildlife
R. Collier	Oceanic and Atmospheric Sciences
T. Dreher	Agricultural Chemistry
J. Higginbotham	Radiation Center and Nuclear Engineering
D. Keszler	Chemistry
P. McFadden	Biochemistry/Biophysics
C. Schreck	Fisheries and Wildlife
T. Wolpert	Botany and Plant Pathology

3. Radiation Center Safety Committee

Name	Affiliation
W. D. Loveland, Chair	Chemistry
T. V. Anderson	Radiation Center
S. C. Campbell	Radiation Center
M. R. Conrady	Radiation Center
J. F. Higginbotham	Radiation Center and Nuclear Engineering
A. G. Johnson	Radiation Center and Nuclear Engineering
S. P. Smith	Radiation Center

4. Radiation Center TQM Teams

Team No. 1	Affiliation
B. Dodd, Team Leader	Radiation Center and Nuclear Engineering
T. V. Anderson	Radiation Center
S. C. Campbell	Radiation Center
M. R. Conrady	Radiation Center
D. S. Pratt	Radiation Center
R. J. Walker	Radiation Center

Team No. 2

S. Cordell, Team Leader	Radiation Center
B. Dodd, Facilitator	Radiation Center
A. Hall	Radiation Center
J. Higginbotham	Radiation Center

PART III

FACILITIES

PART III

FACILITIES

PART III
FACILITIES

A. Research Reactor

1. Description

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

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

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

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

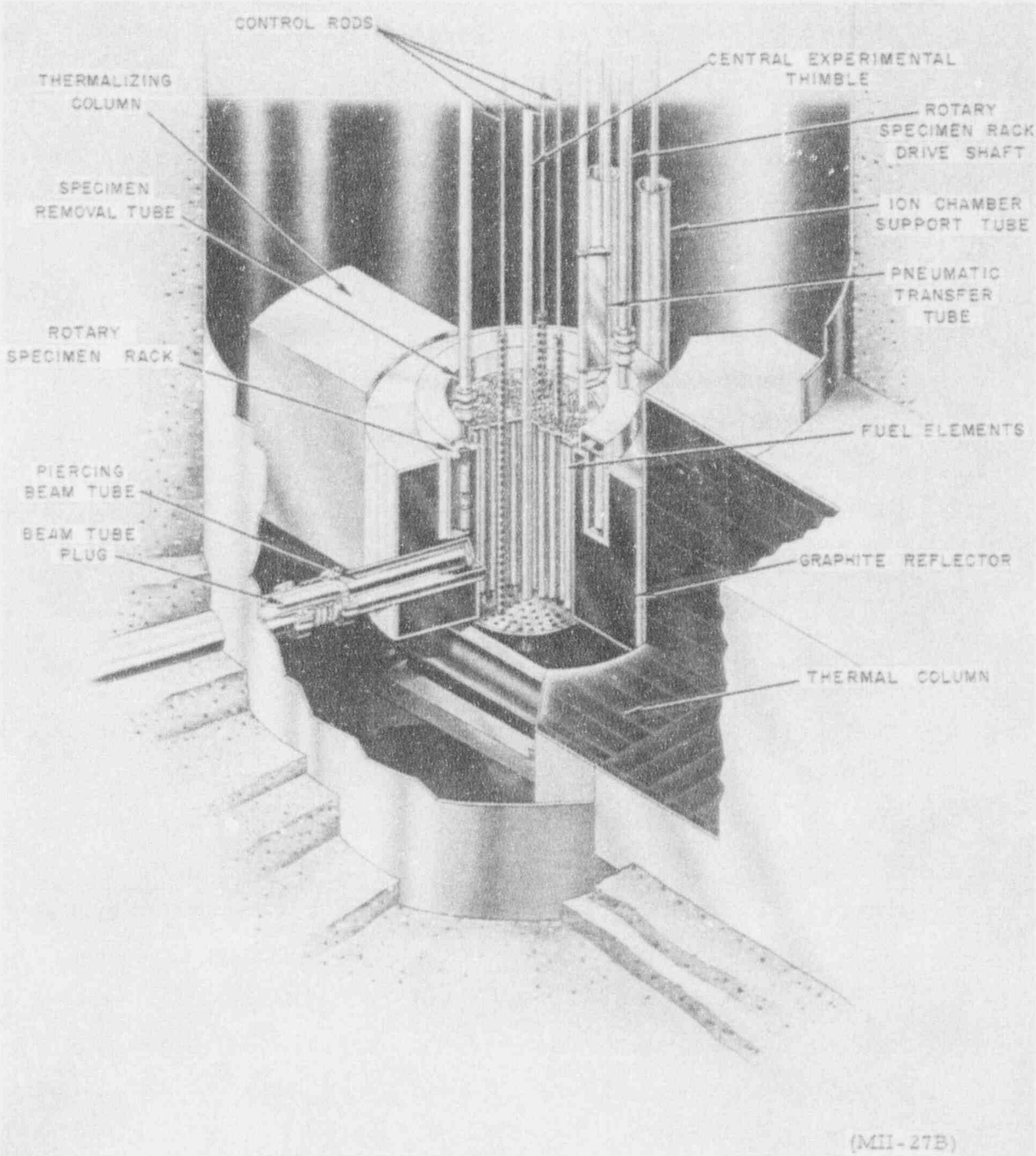


Fig. III.A.1 Cutaway View of Standard TRIGA Mark II Core Arrangement

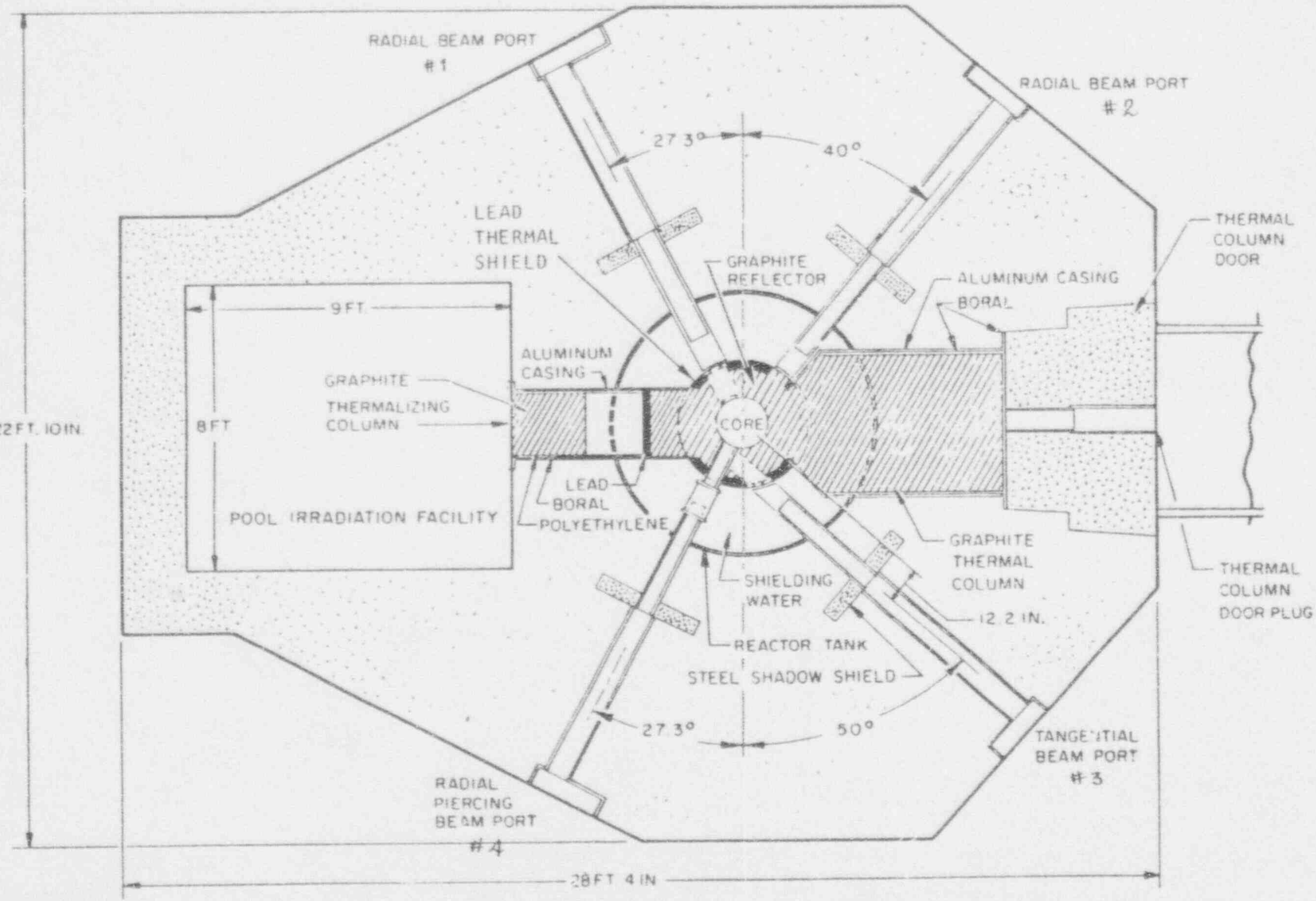


Fig. III.A.2 Horizontal Section of TRIGA Mark II Reactor

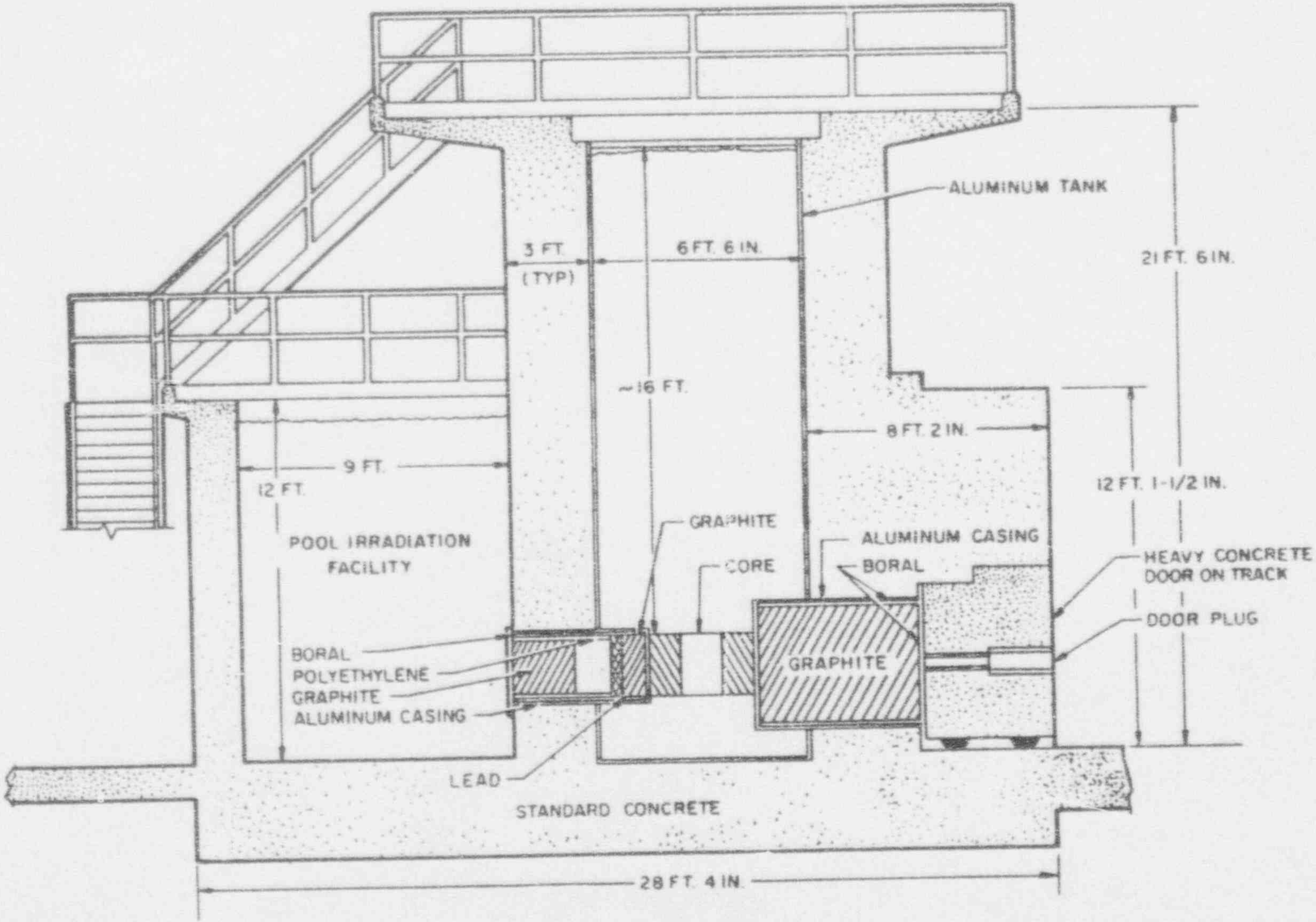


Fig. III.A.3 Vertical Section of TRIGA Mark II Reactor

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

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

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

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

2. Utilization

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

a. Instruction

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

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

During this reporting period the OSTR accommodated 30 different OSU academic classes. In addition, portions of classes from other Oregon universities were also supported by the OSTR. The OSU teaching programs utilized 816 hours of reactor time. Tables III.A.1 and III.A.2 as well as Table III.E.1 provide detailed information on the use of the OSTR for instruction and training.

b. Research

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

Table III.A.1

OSU Courses Using the OSTR

Course Number	Course Name
NE 111	Introduction to Nuclear Engineering
NE 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 457	Nuclear Reactor Laboratory
NE 479	Individual Design Projects (Nuclear Engineering)
NE 480	Field Practices in Radiation Protection (Undergraduate)
RHP 480	Field Practices in Radiation Protection (Undergraduate)
NE 484	Applied Radiation Safety
RHP 484	Applied Radiation Safety
NE 503	Thesis (Nuclear Engineering)
RHP 503	Thesis (Radiation Health Physics)
NE 549W	Selected Topics/Radioactive Waste: Technical & Social Issues
NE 580	Field Practices in Radiation Protection (Graduate)
RHP 580	Field Practices in Radiation Protection (Graduate)
CH 219	General Chemistry Laboratory
CH 222	General Chemistry for Science Majors
CH 419	Radioactive Tracer Methods
CH 462	Experimental Chemistry II
CH 503	Thesis (Chemistry)
CH 505	Reading and Conference (Activation Analysis)
CH 515	Selected Topics in Inorganic Chemistry
CH 519	Advanced Radioactive Tracer Methods
CH 576	Activation Analysis
GEO 503	Thesis (Geosciences)
OC 503	Thesis (Oceanography)
Asia University, America Office (OSU)	Japanese Class
Saturday Academy	Visiting Students
SMILE Program	Teacher's Short Course

Table III.A.2

OSTR Teaching Hours

Description	Annual Values (hours)		Cumulative Values for FLIP Core (hours)
Departmental		734	4,232
Nuclear Engineering	654		
Chemistry	72		
Geosciences[1]			
Oceanic and Atmospheric Sciences[1]			
Physics[1]			
Asia University (OSU)	4		
Saturday Academy	2		
SMILE Program	2		
Special Classes and Projects[2]		82	763
Total Teaching Hours[3,4,5]		816	4,995

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

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

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

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

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

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

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

During this reporting period, the OSTR accommodated 93 funded research projects which utilized 777 hours of reactor time, and 11 unfunded research projects which utilized 44 hours of reactor time. Details of the reactor's use specifically for research are given in Table III.A.3. Additional information regarding reactor use for research, thesis and service can be found in Tables VI.C.1 through VI.C.3. In these tables OSTR use is indicated with an asterisk.

Table III.A.3

OSTR Research Hours

Types of Research	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
OSU Research	250	6,980
Off-Campus Research	512	5,763
Total Research Hours[(1)(2)]	762	12,743

(1) Total research hours statistics:

(a) 94% (718 hours) of the total research hours were user-funded by federal, state, or other organizations.

(b) 6% (44 hours) of the total research hours were user-unfunded studies in support of graduate thesis research or other academic investigations. Reactor costs for this research were absorbed (funded) by the OSU Radiation Center.

(2) OSTR use hours in support of OSU teaching and research programs equal approximately twice the hours the OSTR operated for off-campus research projects. Of the off-campus research hours OSTR recorded, approximately 27 hours were in direct support of research being conducted at the University of Oregon.

B. Analytical Equipment

1. Description

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

2. Utilization

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

Table III.B.1

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

Room	System	Rel. Effic. (%)
B100	Adcam 1, 8k Ortec, Ortec HP Ge	26.8
B100	Adcam 2, 8k Ortec, Ortec HP Ge	29.9
B100	Adcam 3, 8k Ortec, Canberra Ge(Li)	16.6
B100	Adcam 4, 8k Ortec, Ortec HP Ge	28.8
D102	Adcam 5, 8k Ortec, PGT Ge(Li)	13.0
C120	Ace 1, 4k Ortec, NaI(Tl) 3x3	N/A
C123	Ace 2, 4k Ortec, PGT Ge(Li)	18.7
A138	H.P. Scaler, NaI(Tl) 2x2	N/A
A146	Ace, 4k Ortec, Ortec HP Ge	30.0
A146	Ace, 4k Ortec, Ortec Ge(Li)	27.0
C134	Adcam MCA, PGT Ge(Li)	16.2
C134	Adcam MCA, PGT Ge(Li)	19.3
C134	Adcam MCA, PGT LEP	N/A
C134	Adcam MCA, Ortec LEP	N/A
C120	Ace 3, 4k Ortec, 576A Alpha Spectrometer	N/A

Table III.B.2

Radiation Center Liquid Scintillation Counting Systems

Room	System
C120	Beckman, Betamate
C120	Beckman, Betamate
C120	Beckman, Betamate
C120	Beckman, Betamate
B136	Beckman, LS 7500
B136	Searle, Delta 300

Table III.B.3

Radiation Center Proportional Counting Systems

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

Table III.B.4

Thermoluminescent Dosimeter Systems

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

C. Radioisotope Irradiation Sources

1. Description

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

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

2. Utilization

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

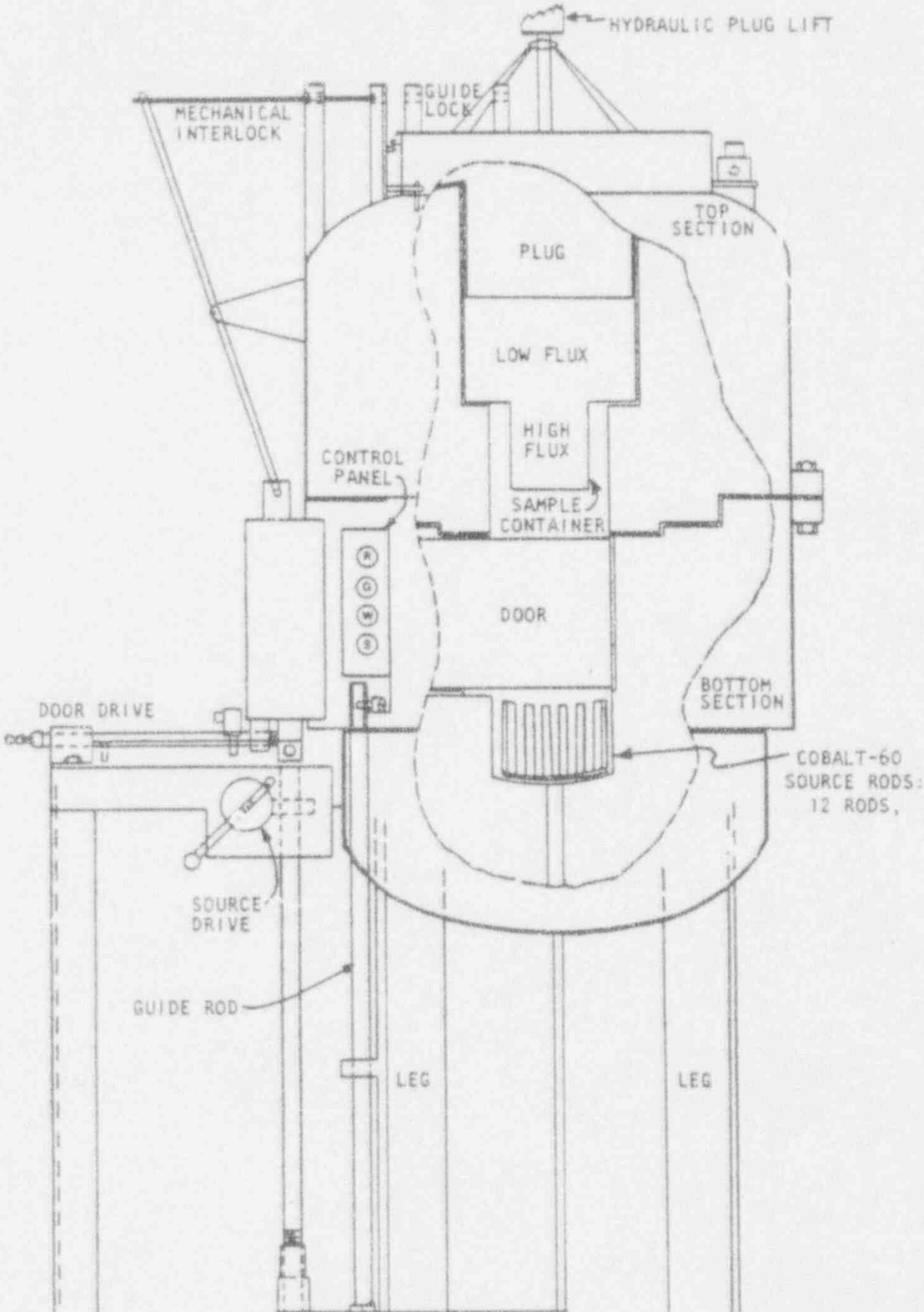


Fig. III.C.1 Budd ^{60}Co Irradiator (Vertical Section)

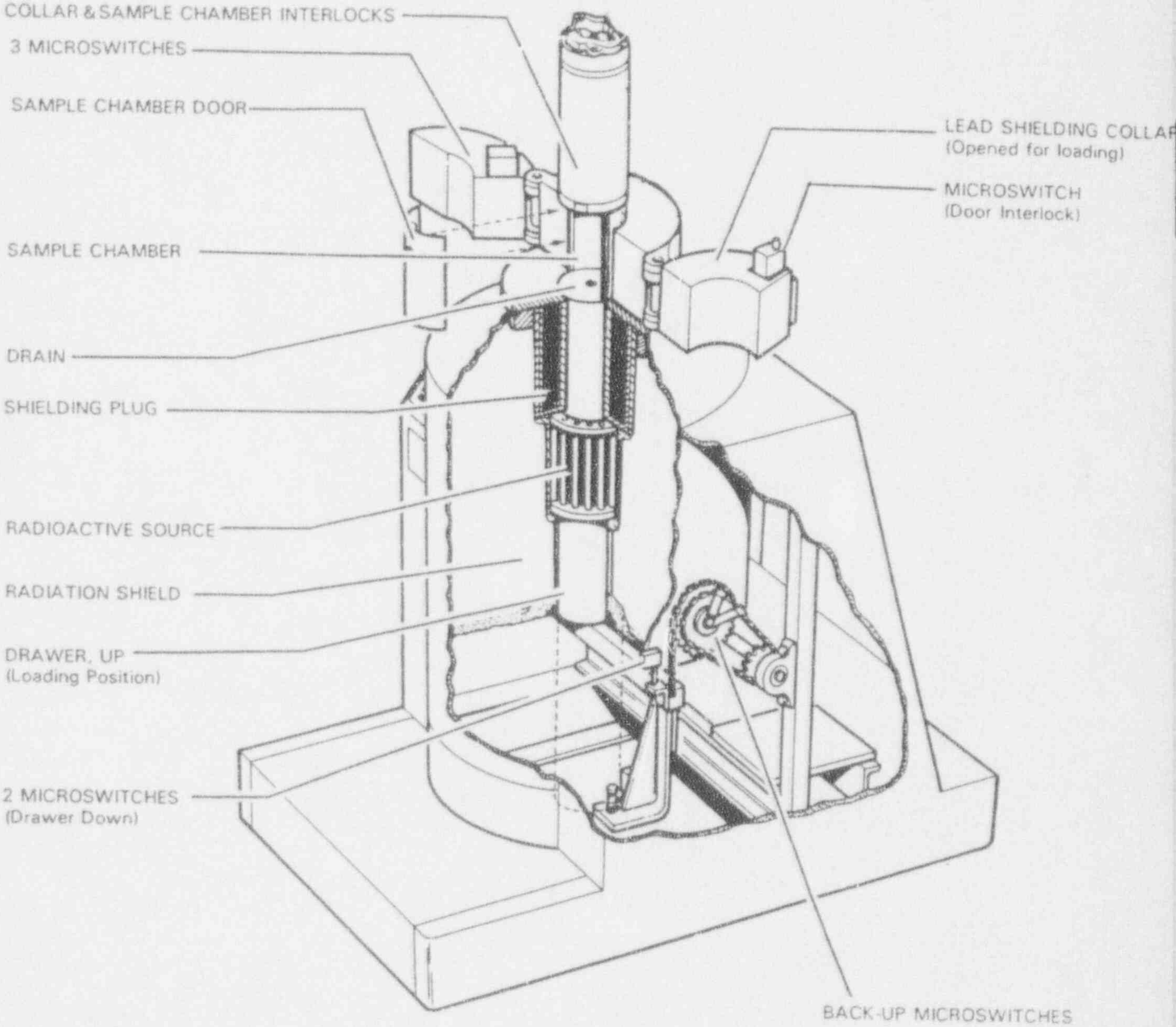


Fig. III.C.2 Gammacell 220 ^{60}Co Irradiator

Table III.C.1

Budd ^{60}Co Irradiator Use
(69 Ci: 7/1/92)

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Biological Studies	Cells, cell culture, mouse cells, fish cells, mice, hamsters	1.0×10^2 to 2.5×10^3	33	13
Botanical Studies	Dill seeds	2×10^3 to 2.0×10^4	4	9
Dosimeter Analysis	TLDs, other dosimeters	$< 5.0 \times 10^1$ to 3.0×10^4	60	87
TOTALS	---	---	97	109

Table III.C.2

Gammacell 220 ^{60}Co Irradiator Use
(5340 Ci: 7/1/92)

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Sterilization	Bacteria, talc, blood serum, wood, IUDs, latex poly-styrene, soil	2.5×10^6 to 1.0×10^7	86	835
Material Evaluation	Gemstones, resins	1.58×10^6 to 6.0×10^7	4	515
Botanical Studies	Bean seeds	2.5×10^3 to 8.0×10^4	23	2
Biological Studies	Murine cells, fish cells, spleen cells, cells	3.0×10^3 to 1.0×10^4	11	<1
TOTALS	---	---	124	1,352

D. X-Ray Machine

1. Description

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

2. Utilization

The X-ray machine continued to be used as a radiation source where students could perform state-required radiation surveys of a fixed X-ray machine installation and carry out other safety checks required for such a facility. In addition, the X-ray machine was used four times (5.7 hours) for a Ph.D. research project.

E. Laboratories and Classrooms

1. Description

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

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

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

There are two classrooms in the Radiation Center which are capable of holding about 16 and 35 students. In addition, there are two smaller conference rooms 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 major developments in the Radiation Center's thermal hydraulics laboratory. This laboratory is being used by a member of the nuclear engineering faculty to accommodate the construction of a one-quarter scale model of the Westinghouse AP600 reactor. The Westinghouse AP600 is a next-generation reactor which features simplicity, passive safety and standardization in its design. Construction of this multi-million dollar facility continued at a rapid

pace during 1992-1993 with initial testing planned to begin in early 1994. The fully scaled, integral model facility will use electrical heating elements to simulate the fuel elements, will operate at 450°F and 400 psia and will respond at twice real time. Upon completion, it will be the only facility of this type in the world and will be used by Westinghouse, the U.S. Nuclear Regulatory Commission and other organizations to test the safety systems and provide licensing data.

2. Utilization

All of the laboratories and classrooms are used extensively during the academic year. For example, a listing of 77 courses accommodated at the Radiation Center during this reporting period along with their enrollments is given in Table III.E.1. Table III.A.1 gives a separate listing of the 30 classes specifically accommodated by the reactor during the reporting period.

Table III.E.1

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

Course	Credit	Course Title	Number of Students			
			Fall 1992	Winter 1993	Spring 1993	Summer 1993
Nuclear Engineering Courses						
NE 111*	3	Introduction to Nuclear Engineering	30	--	--	--
NE 112*	3	Introduction to Nuclear Engineering	--	30	--	--
NE 113*	3	Introduction to Nuclear Engineering	--	--	27	--
NE 231	3	Nuclear & Radiation Physics	21	--	--	--
NE 232	3	Nuclear & Radiation Physics	--	19	--	--
RHP 232	3	Nuclear & Radiation Physics	--	3	--	--
NE 233*	3	Nuclear Radiation Detection & Instrumentation	--	--	17	--
RHP 233*	3	Nuclear Radiation Detection & Instrumentation	--	--	3	--
NE 361	3	Nuclear Reactor Systems	--	17	--	--
NE 381	3	Principles of Radiation Safety	15	--	--	--
RHP 381	3	Principles of Radiation Safety	4	--	--	--
NE 406	1-16	Projects	1	1	2	--
RHP 406	1-16	Projects	1	--	--	1
NE 407	1	Nuclear Engineering Seminar	19	18	23	--
NE 414	3	Nuclear Rules & Regulations	--	--	26	--
RHP 414	3	Nuclear Rules & Regulations	--	--	8	--
NE 454	3	Nuclear Reactor Analysis	11	--	--	--
NE 455	3	Nuclear Reactor Analysis	--	11	--	--
NE 456	3	Nuclear Reactor Analysis	--	--	11	--
NE 457**	3	Nuclear Reactor Laboratory	--	--	12	--
NE 467	4	Nuclear Reactor Thermal Hydraulics	13	--	--	--
NE 471	3	Nuclear Power Systems Design	12	--	--	--
NE 472	3	Nuclear Power Systems Design	--	12	--	--
NE 473	3	Nuclear Reactor Design	--	--	12	--
NE 479**	1-4	Individual Design Project	4	4	2	5
RHP 480*	1-3	Field Practices in Radiation Protection	2	2	1	6
NE 484**	3	Applied Radiation Safety	--	15	--	--
RHP 484**	3	Applied Radiation Safety	--	4	--	--
NE 486	3	Radiation Dosimetry	--	--	14	--
RHP 486	3	Radiation Dosimetry	--	--	4	--
NE 501	1-16	Research	2	--	1	--
NE 503**	1-16	Thesis	5	5	4	3
RHP503**	1-16	Thesis	5	5	6	1

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

Table III.E.1 (Continued)

Course	Credit	Course Title	Number of Students			
			Fall 1992	Winter 1993	Spring 1993	Summer 1993
NE 505	1-16	Reading & Conference	1	--	--	2
RHP 505	1-15	Reading & Conference	--	--	--	1
NE 506	1-16	Projects	--	1	--	1
RHP 506	1-16	Projects	2	--	--	--
NE 507	1	Seminar	3	5	5	--
NE 510	1-12	Internship	1	--	--	--
NE 514	3	Nuclear Rules & Regulations	--	--	5	--
RHP 514	3	Nuclear Rules & Regulations	--	--	6	--
NE 526	3	Computational Methods for Nuclear Reactors	--	7	--	--
NE 537	3	Applications of Nuclear Techniques	--	4	--	--
RHP 537	3	Applications of Nuclear Techniques	--	5	--	--
NE 539	3	ST/Neutron Particle Physics	7	--	--	--
NE 549H	1	ST/Radioactive Waste: Technical and Social Issues	--	--	--	7
NE 549L	3	ST/Low Level Radioactive Waste Management	2	--	--	--
RHP 549L	3	ST/Low Level Radioactive Waste Management	8	--	--	--
NE 549W*	3	ST/Radioactive Waste: Technical and Social Issues	--	--	--	11
NE 554	3	Advanced Nuclear Reactor Analysis	2	--	--	--
NE 555	3	Advanced Nuclear Reactor Analysis	--	1	--	--
NE 556	3	Advanced Nuclear Reactor Analysis	--	--	1	--
NE 567	4	Advanced Nuclear Reactor Theory	3	--	--	--
NE 571	3	Advanced Nuclear Power Systems Design	2	--	--	--
NE 572	3	Advanced Nuclear Power Systems Design	--	2	--	--
NE 573	3	Advanced Nuclear Power Systems Design	--	--	2	--
NE 580*	1-3	Advanced Field Practice Radiation Health	1	--	--	--
RHP 580*	1-3	Field Practices in Radiation Protection	1	--	3	1
RHP 584	3	Applied Radiation Safety	--	4	--	--
NE 586	3	Advanced Radiation Dosimetry	--	--	2	--
RHP 586	3	Advanced Radiation Dosimetry	--	--	3	--
NE 601	1-16	Research	--	1	--	--
NE 603	1-16	Thesis (Nuclear Engineering)	4	7	7	1
NE 605	1-16	Reading and Conference	--	1	--	--
NE 607	1	Nuclear Engineering Seminar	--	2	--	--
NE 651	3	Nuclear Reactor Dynamics and Control	--	--	5	--
NE 656	3	Advanced Particle Physics for Reactors	--	--	5	--

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

Table III.E.1 (Continued)

Course	Credit	Course Title	Number of Students			
			Fall 1992	Winter 1993	Spring 1993	Summer 1993
Chemistry Courses						
CH 219*	2	General Chemistry Lab	66	--	--	--
CH 222*	5	General Chemistry (Science Majors)	--	380	--	--
CH 419*	4	Radioactive Tracer Methods	5	--	--	--
CH 462*	3	Experimental Chemistry II Laboratory	--	14	--	--
CH 503*	1-16	Thesis (Chemistry)	2	2	2	--
CH 505*	1	Reading and Conference (Activation Analysis)	--	--	4	--
CH 519**	4	Advanced Radioactive Tracer Methods	5	--	--	--
CH 576**	4	Activation Analysis	--	11	--	--
Other Courses						
GEO 503*	1-16	Thesis (Geosciences)	3	3	3	--
OC 503*	1-16	Thesis (Oceanography)	1	1	1	--

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

F. Instrument Repair and Calibration Facility

1. Description

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

2. Utilization

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

G. Libraries

1. Description

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

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

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

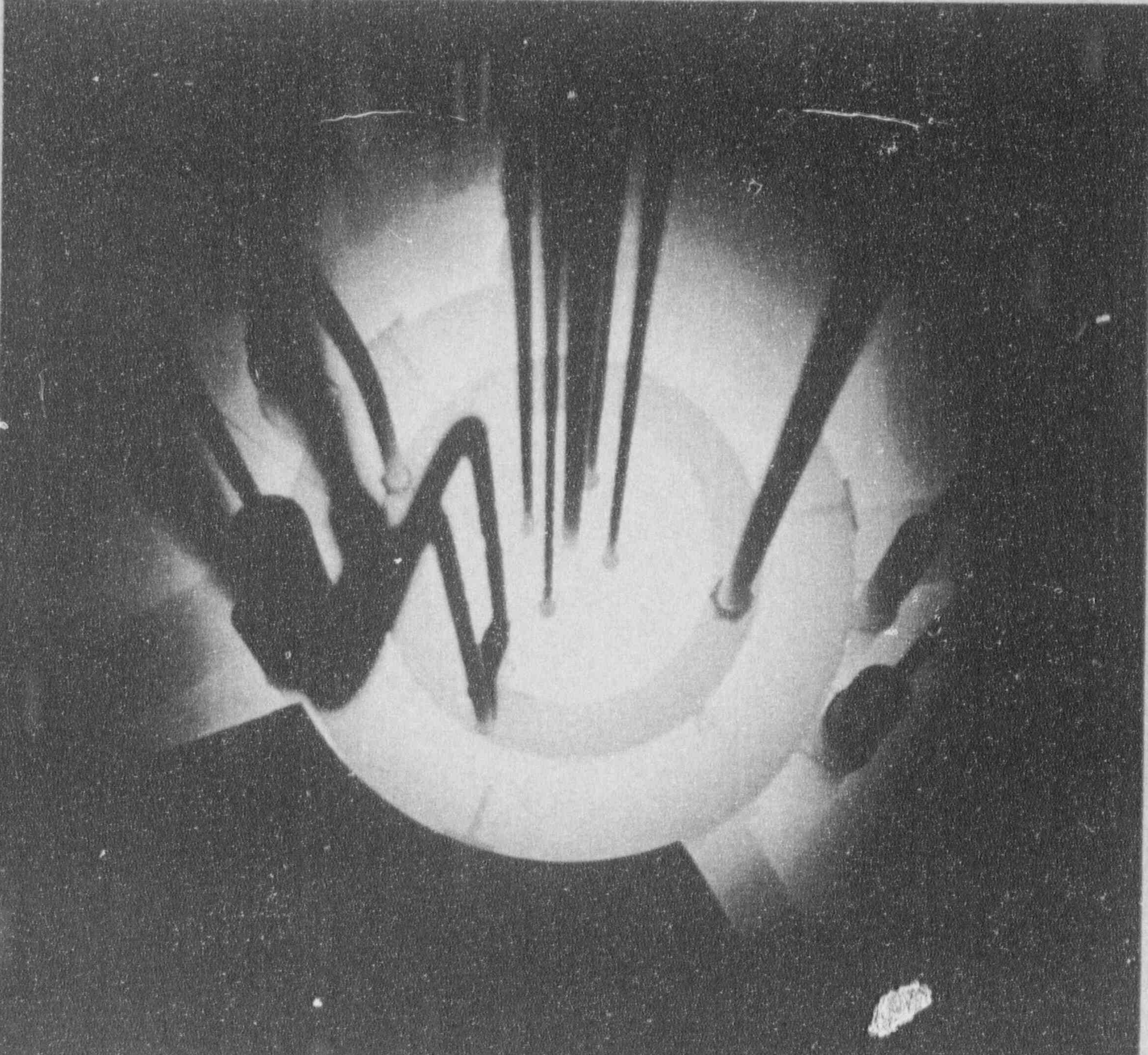
The Radiation Center videotape library has over one hundred tapes on nuclear engineering, radiation protection and radiological emergency response. In addition, the Radiation Center uses videotapes for most of the technical orientations which are required for personnel working with radiation and radioactive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

2. Utilization

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

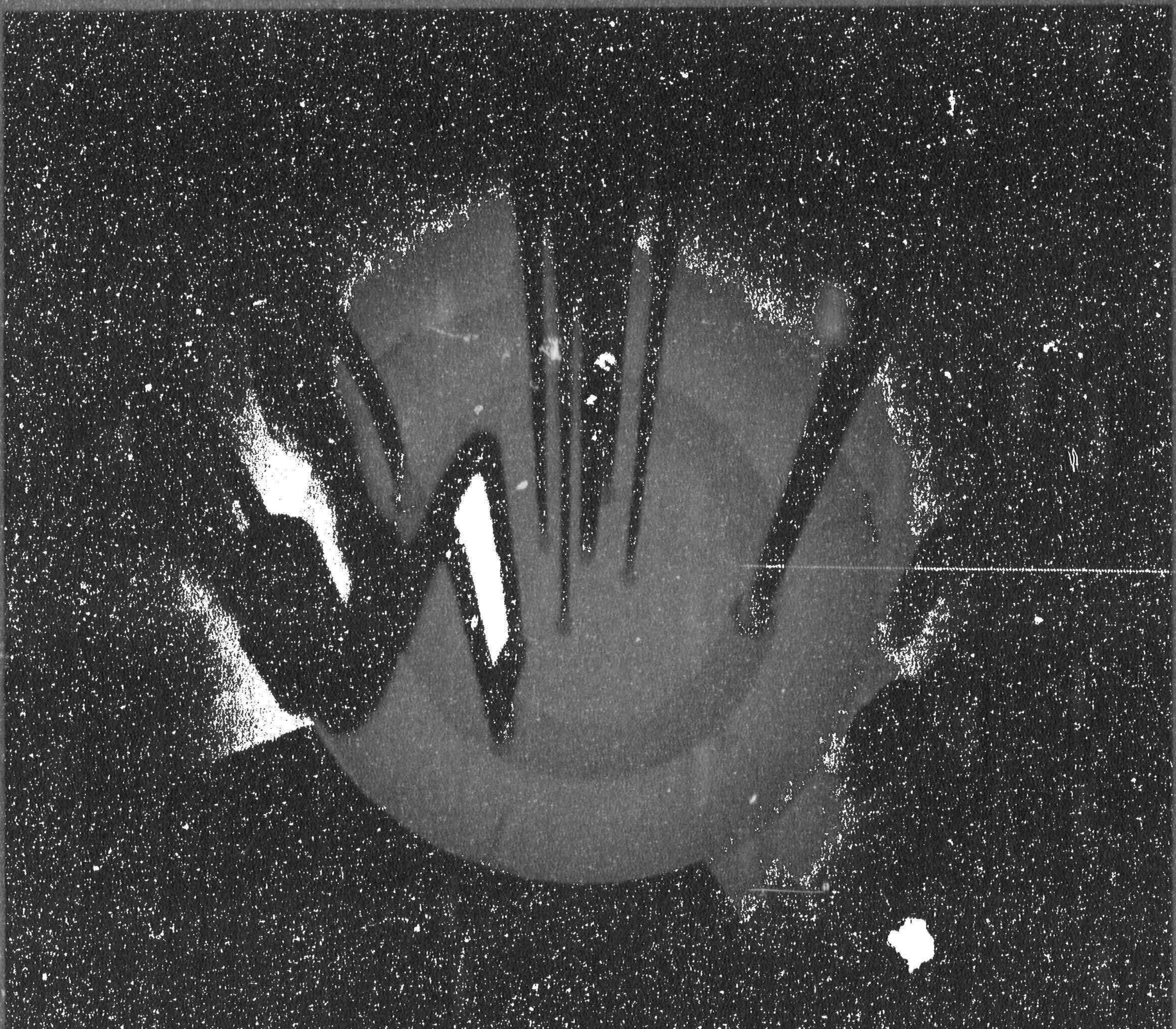
PART IV

REACTOR



PART IV

REACTOR



PART IV
REACTOR

A. Operating Statistics

For the current reporting period, the operating statistics for the OSTR continued a steady 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 42.7 megawatt days (MWD). The cumulative thermal energy generated by the FLIP core now totals 609.5 MWD from August 1, 1976 through June 30, 1993. Reactor use time averaged approximately 87% of the normal nine-hour, five-day per week schedule. Tables IV.A.3 through IV.A.5 detail the operating statistics applicable to this reporting period.

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

Table IV.A.1

OSTR Operating Statistics (Using the FLIP Fuel Core)

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

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

Table IV.A.1 (continued)

OSTR Operating Statistics (Using the FLIP Fuel Core)

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

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

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

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

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

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

Table IV.A.1 (continued)

OSTR Operating Statistics (Using the FLIP Fuel Core)

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

Table IV.A.2

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

Operational Data for 20% Enriched Core	Mar 8, 67 Through Jun 30, 68 (1)	Jul 1, 68 Through Jun 30, 69	Jul 1, 69 Through Mar 31, 70 (2)	Apr 1, 70 Through Mar 31, 71 (3)	Apr 1, 71 Through Mar 31, 72	Apr 1, 72 Through Mar 31, 73	Apr 1, 73 Through Mar 31, 74	Apr 1, 74 Through Mar 31, 75	Apr 1, 75 Through Mar 31, 76	Apr 1, 76 Through Jul 26, 76 (4)	TOTAL: March 67 Through July 76
Operating Hours (critical)	904	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; 250 kW). Note: This period length is 1.33 years as initial criticality occurred in March of 1967.

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

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

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

Table IV.A.3

Present OSTR Operating Statistics

Operational Data for FLIP Core	Annual Values	Cumulative Values for FLIP Core
MWH of energy produced	1,026	14,627
MWD of energy produced	42.7	609.5
Grams ^{235}U used	53.6	765.2
Number of fuel elements added to (+) or removed from (-) the core	0	82 + 3 FFCR(1)
Number of pulses	6	1,192
Hours reactor critical	1,180	18,714
Hours at full power (1 MW)	1,000	14,268
Number of startup and shutdown checks	257	4,280
Number of irradiation requests processed(2)	329	6,213
Number of samples irradiated	4,103	71,231

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

(2) Each irradiation request could authorize from 1 to 120 samples. The number of samples per irradiation request averaged 12.5 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)	816	4,995
OSU research(2)	250	6,980
Off-campus research(2)	512	5,763
Forensic services	0	160(3)
Reactor preclude time	778	12,089
Facility time(4)	539	6,035
Visitor demonstration(5)	14	271
Total reactor use time	2,909	36,293

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

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

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

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

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

Table IV.A.5

OSTR Multiple Use Time[1]

Number of Users	Annual Values (hours)	Cumulative Values for FLIP Core (hours)
Two	127	1,814
Three	69	563
Four	41	201
Five	0	42
Six	0	31
Seven	0	10
Total multiple use time	237[2]	2,661[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 20% of the total hours the reactor was critical during this reporting period.

(3) This represents 14% of the total hours the reactor was critical since startup with FLIP fuel in August of 1976.

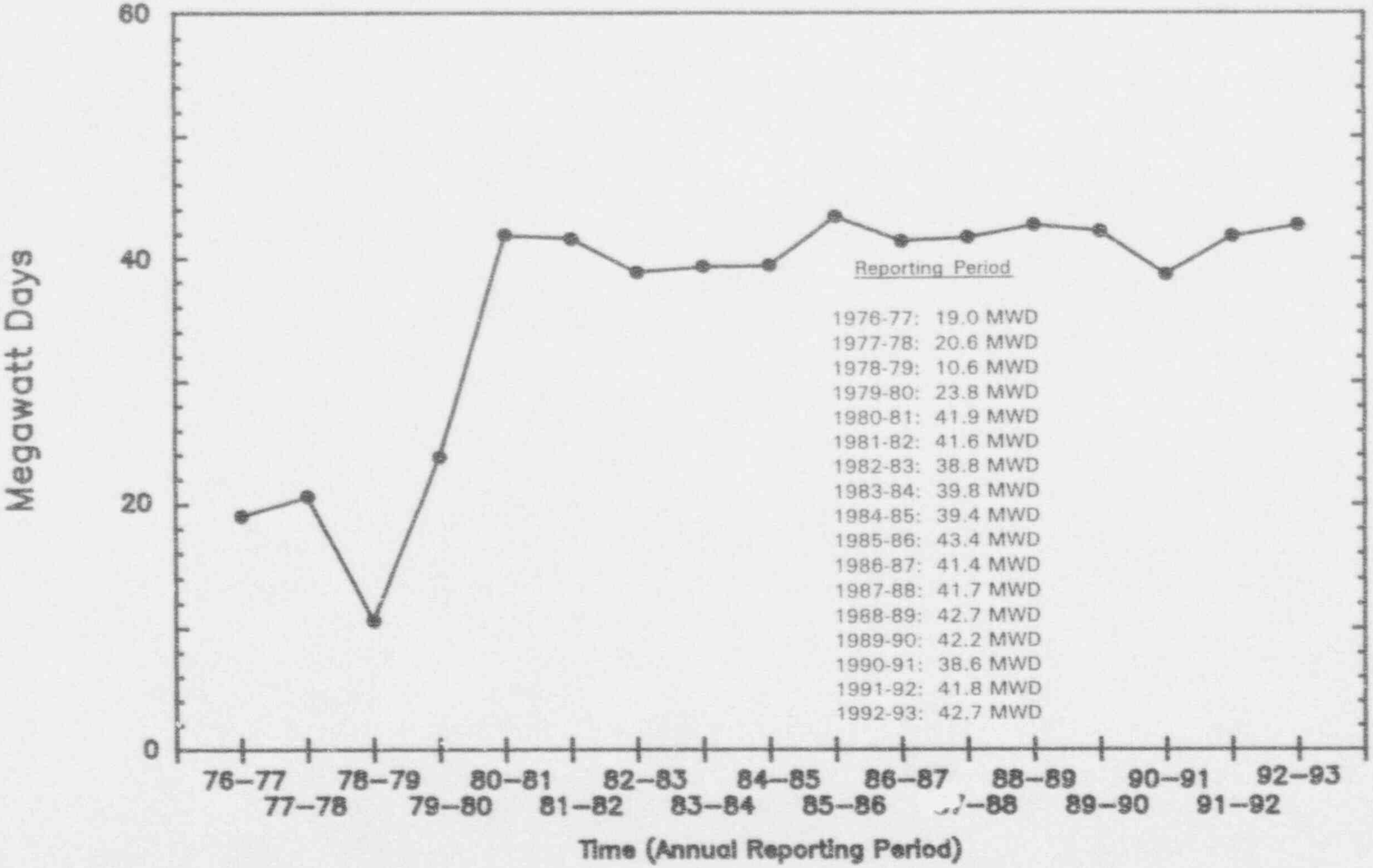


Figure IV.A.1 OSTR Annual Energy Production Vs. Time (Annual Reporting Period)

B. Experiments Performed

1. Approved Experiments

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

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

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

Table IV.B.1

Use of OSTR Reactor Experiments[1]

Reactor Experiment Number[2]	Research	Teaching	Facility Time[3]	TOTAL
A-1	N/A	32	117	149
B-3	103	33	N/A	136
B-11	10	0	N/A	10
B-12	3	0	N/A	3
B-23	30	1	N/A	31
TOTAL	146	66	117	329

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

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

A-1 Normal TRIGA Operation
B-3 Irradiation of Materials in the Standard OSTR Irradiation Facilities
B-11 Irradiation of Materials Involving Specific Quantities of Uranium and Thorium in the Standard OSTR Irradiation Facilities
B-12 Exploratory Experiments
B-23 Studies Using the TRIGA Thermal Column

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

2. Inactive Experiments

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

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

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

C. Unplanned Shutdowns

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

Table IV.C.1

Unplanned Reactor Shutdowns and Scrams

Type of Event	Number of Occurrences	Cause of Event
Manual Scram	1	Commercial power failure. Commercial power was restored in about one-half hour and reactor operation was resumed.
Manual Scram	2	Stack monitor filter failure alarm. The filter was replaced and operation was resumed.
Safety Channel Power Scram	1	Operator was in the process of shutting the reactor down. Instead of pushing the "IN" button for the control rod, he pushed the "OUT" button. The safety channel scrammed the reactor at its trip point of 1.06 MW.
Manual Scram	1	"VENTILATION DAMPERS CLOSED" annunciator. Air pressure to the damper pneumatic motors was restored and operation resumed.

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

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

1. 10 CFR 50.59 Changes to the Reactor Facility

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

a. REPLACEMENT AND RELOCATION OF SELECTED AREA RADIATION MONITORS

(1) Description

The reactor operations staff and health physics staff removed all of the existing Tracerlab area radiation monitors (ARMs), relocated one of the Nuclear Measurements Corporation (NMC) ARMs, and installed five new Eberline ARMs. The locations, ranges, alarm set points and new identification numbers for the ARMs are given in Table IV.D.1.

The old Tracerlab ARMs were removed completely as they had approached the end of their useful lifetime.

An NMC ARM which was located near the sample handling area in the reactor bay was moved to a point midway between beam port #2 (BP2) and the thermal column. Detector mounts were installed over BP2 and on the wall just to the north of the thermal column door. The

Table IV.D.1

Locations, Ranges, Alarm Set Points and New Numbers for the ARM System

No.	Type	Location	Range (mR/h)	Intermed. Alarm (mR/h)	High Alarm (mR/h)
1	NMC	Beam Port #1	0-10,000	50	100
2	NMC	Beam Port #2/Thermal Column	0-10,000	50	100
3	NMC	Beam Port #3	0-10,000	50	100
4	Eberline	Beam Port #4	0-10,000	50	100
5	Eberline	Control Room	0-10,000	10	100
6	NMC	Reactor Top	0-10,000	750	1000
7	Eberline	Reactor Top	0-10,000	750	1000
8	NMC	Fuel Storage Pits	0-10,000	10	20
9	Eberline	Sample Handling Area	0-10,000	50	100
10	NMC	Pneumatic Transfer Terminal	0-10,000	50	100
11	Eberline	Demin. System Filter	0-10,000	50	100
12	NMC	Demineralizer Column	0-10,000	50	100
	Eberline	Spare	0-10,000		

detector is positioned in one of these two mounts depending on the work being performed. Due to the higher level of use currently associated with the thermal column, the detector was initially placed by the thermal column door. A new Eberline ARM was located near the sample handling area.

A new Eberline ARM was also positioned outside the control room on the south reactor bay wall to the west of the third floor bridge. An additional readout for this ARM was located in A100, which provides a dose rate indication only, i.e., it does not have any alarms associated with it.

Other new Eberline ARMs replaced the old Tracerlab ARMs near beam port #4, on the reactor top, and near the demineralizer system filter. Finally, one Eberline ARM was kept as a spare to enable quick response to any future ARM failures. All other ARMs remained unchanged.

Several procedures required changing as a result of the removal of the Tracerlab ARMs and the installation of the Eberline ARMs. Most of the changes were minor and merely allowed for differences between the Tracerlab ARMs and the Eberline ARMs and the revised ARM numbers and locations. However, one change was more significant, and arose because the Eberline ARMs do not have an electronic method for testing their audible and visual alarms. Therefore, the quarterly functional check procedure was changed to add the use of an actual radiation source to initiate the alarms. This new method is now used for both the NMC and Eberline ARMs.

(2) Safety Evaluation

The Tracerlab ARMs had reached the end of their useful lifetime and were replaced by the new Eberline ARMs. This will increase reliability and thereby increase radiation safety.

The opportunity was taken to rearrange some of the ARMs in order to position them in locations consistent with current uses of the reactor and its facilities; however, all of the previous locations are still covered.

Additional areas are covered by the new ARM arrangement and increase radiological safety by monitoring dose rates in locations which may be occupied by Radiation Center staff. These locations include: (a) the thermal column near the controls for opening its door; and (b) accessible areas just outside the reactor control room.

The addition of a new ARM outside the control room with a dose rate readout in A100 will be very useful in the event of an emergency requiring evacuation of the reactor building. With the new A100 ARM readout capability, it will be possible to determine the dose rate in the reactor bay near the control room without sending in an entry team. This remote ARM readout will also provide necessary information to help determine whether or not the EOC could be relocated to the reactor control room. In view of the above, we believe that this measure increases radiological safety by reducing potential personnel exposure.

The Technical Specifications for the OSTR require only one ARM and, therefore, the new ARM arrangement more than adequately meets this need.

The use of an actual radiation source for the quarterly alarm checks of the ARMs will potentially involve a small increment of personnel dose, but it is felt that such a check is necessary to assure proper operability of these alarms. The source activity will be in the low millicurie range and the source itself will be attached to a long rod in order to minimize personnel exposure.

b. REPLACEMENT RELAYS FOR THE LEFT-HAND DRAWER OF THE OSTR CONSOLE

(1) Description

Occasionally, some of the dry-reed relays in the left-hand drawer of the reactor console fail, or become erratic, and require replacement. The relays of concern here are used for many of the ranging functions on the console. In the past, these relays have been replaced by identical relays supplied by the console manufacturer, General Atomics; however, these can no longer be obtained. The Scientific Instrument Technician determined that the relay manufacturer (Magnacraft) makes a replacement relay which is electrically equivalent. In the future, as the original dry-reed relays fail, they will be replaced by the new type. This 50.59 safety evaluation is necessary due to the fact that the new relays are not identical to the original equipment.

(2) Safety Evaluation

The new relays have identical electrical characteristics when compared to the original relays and are recommended as replacements by the manufacturer. The only difference between the old and new relays is in the mounting and appearance. The different mounting will not cause a problem during replacement. It is expected that the new relays will perform at least as well as the old ones and will likely have a lifetime equal to or longer than the original equipment. Typically, newer designs are more reliable than old and, therefore, it is expected that failures will be few. Therefore, replacing the old relays with the new ones on an as-needed basis will not introduce any unreviewed safety questions.

c. REPLACEMENT OF THE DETECTOR IN THE STACK MONITOR PARTICULATE CHANNEL

(1) Description

The GM tube detector in the particulate channel of the stack monitor reached the end of its useful life. Because it was becoming very

difficult to find equivalent replacement GM tubes, the staff replaced the GM detector with a new detector using a beta scintillator and photomultiplier tube. No modifications to the detector power supply were required because the high voltage is fully adjustable and was easily set to the appropriate voltage for the new detector. However, it was necessary to make some changes to the detector housing in order to make the new detector fit.

(2) Safety Evaluation

Beta scintillators are often used as detectors for air particulate monitoring channels, and in fact function better than GM tubes because the sensitivity to background gamma radiation is reduced and the beta counting efficiency is usually much higher than that obtainable with GM tubes. Therefore, this change increases safety by replacing an aging detector with a more modern, more sensitive, and more efficient detector. The new detector system was fully tested and calibrated prior to use.

d. CHANGE TO THE HOLD UP TANK (HUT) WATER LEVEL INDICATOR SYSTEM

(1) Description

The Scientific Instrument Technician changed the water level indicator system for the HUT. The HUT's original water level indicator was based on a float and rod mechanism which was designed to trip a series of four microswitches as the float rose. As each microswitch was tripped, it turned on a water level indicating light located on the right hand side-cabinet of the reactor console. Manual switches were associated with these level indicating lights which could be set to either an on or off position. If a switch was set on, then as that light illuminated audible and visual alarms would occur on the reactor control room annunciator panel indicating "high water level in the HUT" and "green light off."

The modified system provides a more modern method for monitoring the HUT water level. One specific design improvement was to include a direct readout of the HUT water level in inches. The existing float is still used, but it is now attached to a thin wire which passes around a pulley system and rotates a multi-turn potentiometer. The resulting voltage signal (which is proportional to the water level) is amplified, converted to a digital signal, and displayed in the control room. Adjustments in the amplifier enable the signal to display digits which correspond to the inches of water in the HUT (<u>to the nearest tenth of an inch</u>).

The high water alarm setpoint is adjusted in the control room by dialing in a digital value on a thumb-wheel unit. A comparator is used to monitor the water level signal and the alarm set point. If the water level signal becomes greater than the set point, then the high water level alarm is activated. This alarm includes audible and visual alarms on the control room annunciator panel exactly the same as the old one. In addition, the old back-up high water level float and alarm system was slightly modified to enable it to also give audible and visual alarms on the control room annunciator panel. These alarms are the same as the alarms initiated by the primary level indicator for the HUT.

(2) Safety Evaluation

The circuitry for the new HUT water level indicator system is completely separate from reactor console and reactor safety circuits, and therefore there are no unfavorable safety implications from this standpoint. The control room part of the system is located in the right hand side cabinet.

The new level indicating system increases safety by providing a more accurate indication of the water level in the HUT. With the old system, the water level indicated in the control room at any given time would be somewhere between two points about 18 inches apart. Although

a reasonable approximation of the water level could be made by looking at the float level in the HUT room, a much more precise indication will now be available in the control room. Furthermore, the new digital HUT high water level alarm can easily be set to any value and will normally be only a few inches above the actual current water level. In this way, any inadvertent filling of the HUT (such as from a water tap left running) will soon be detected.

As indicated, the new digital readout shows the water level down to a tenth of an inch. Tenths of inches were included on the digital readout to provide an indication that the system is functioning correctly. This function check is based on the fact that the tenth-inch digit will normally fluctuate due to wave action, especially when water is draining into the tank. If, for some reason, the drive wire for the potentiometer should break or the float should become separated from the drive wire then the digital readout would become steady and unchanging. The reactor operator would notice this reading abnormality when making the normal log entries. In addition, safety has been further enhanced by attaching the back-up float alarm (which is not dependent on the drive wire mechanism) to the same alarm circuits as the primary level system. There are now two separate systems available to provide warning of a filling HUT at any time of the day or night.

Corrosion is not a problem in the HUT building due to the thermostatically controlled heaters in the building. They seem to keep the room acceptably dry.

e. CLICIT CAP MODIFICATION

(1) Description

The reactor operations staff modified the cap of the cadmium-lined in-core irradiation tube (CLICIT). The modification involved boring and tapping a hole in the top of the cap. The hole is large enough to allow thermocouple leads to exit the CLICIT. When leads are used with the cap, a seal around the leads is maintained with material such as duct seal. When the hole is not needed, then it is sealed by screwing in a short bolt with a recessed head for an allen wrench.

(2) Safety Evaluation

The modification does not change the existing safety considerations for the CLICIT. As before, the tube remains sealed with a slight suction on it during operation. It is just the method of obtaining the seal which has changed in order to allow greater flexibility in the use of the CLICIT.

2. 10 CFR 50.59 Changes to Reactor Procedures

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

a. MINOR REVISIONS TO THE RADIATION CENTER AND TRIGA REACTOR EMERGENCY RESPONSE PLAN

(1) Description

As a result of the annual emergency response drill and emergency plan review, a number of minor changes to the emergency plan were made. These changes are detailed below:

2.0 DEFINITIONS

The following definitions were added:

ANNUAL

Every 12 months, with an interval not exceeding 15 months.

BIENNIAL

Every 24 months, with an interval not exceeding 30 months.

MONTHLY

Every four weeks, with an interval not to exceed six weeks.

QUARTERLY

Every three months, with an interval not exceeding four months.

SEMI-ANNUAL

Every six months, with an interval not exceeding seven and one-half months.

8.2.1.b.iii:

"The 14-channel area radiation monitoring system ....." was changed to "The multi-channel area radiation monitoring system ....."

8.4.b.

The typographical error in the spelling of "communication" was corrected.

Figure A-2

The map was updated by adding the new Corvallis bypass.

Figure A-3

The map of the Radiation Center floor plan was upd ted.

Appendix B

B.2.b.

This was changed to:

b) Corvallis Fire Department (HAZMAT Team #5 Vehicle), Boxes Numbered 1 - 5

The Inventory Checklists were replaced with new, updated ones.

(2) Safety Evaluation

Adding the definitions with respect to frequencies made the emergency response plan consistent with the OSTR Technical Specifications and

ANSI/ANS 15.1. It further clarified exactly what is meant by annual, etc., in the emergency plan, and provides the operational flexibility necessary to schedule routine actions required by the plan.

Changing the very specific "14-channel" ARMs description to the more general "multi-channel" concept allows for the fact that the ARM systems were replaced by newer, more up-to-date equipment, and accommodates the fact that the exact number of ARMs will change from time to time. There are still about 10-12 systems operational, which more than adequately provides good area coverage. Safety will be increased because the new ARMs will be more reliable than the old ones.

Correction of typographical errors and updating the maps and floor plan have no reactor safety significance. They just keep the plan current and correct.

The Corvallis Fire Department is now the lead department in HAZMAT Region #5 in Oregon. They have a new HAZMAT vehicle and the opportunity was taken to revise and repack Radiation Center emergency equipment and supplies normally kept at the fire department. The new system allows equipment to be accessed more easily and, therefore, increases safety.

The Inventory Checklists are revised from time to time to keep them current. Replacing them with the latest lists just keeps the plan up-to-date. There were no safety-related changes to the inventories.

b. REVISION TO OSTROP 6 CONCERNING THE REACTOR BAY ACCESS POLICY FOR PERSONS UNDER THE AGE OF 18 YEARS

(1) Description

The previous reactor bay access policy for minors, as stated in OSTROP 6, prohibited all access to the reactor bay for persons under the age of 18. Occasionally, a freshman member of the nuclear engineering orientation class or a student intern at the Radiation Center is not quite 18 but has a need to enter the reactor bay. The staff of the OSTR could see no reason to prevent such people from entering the reactor bay; therefore, the Senior Health Physicist revised section 6.7.B.6 of OSTROP 6, Administrative and Personnel Procedures. The amended section now reads as follows:

> "Access to the reactor bay will be kept to a minimum. No persons under 18 years of age will be admitted to the reactor bay unless such access is required as a part of the activities of an OSU class or access is specifically approved by a person on Access List A.
>
> It is also the policy of the OSU Radiation Center to prohibit access to the reactor bay for the purpose of routine tours unless access is specifically approved by a person on Access List A."

(2) Safety Evaluation

While the reactor bay access policy was relaxed slightly, it was because the previous policy was unnecessarily restrictive. From a regulatory viewpoint, persons under the age of 18 are subject to the same radiation dose limits as members of the general public, and members of the public are allowed into the reactor bay with specific permission. Therefore, this does not represent a new situation with respect to dose limitation. It is highly unlikely that anyone entering the reactor bay will receive a dose approaching the public dose limit. Even

doses received by *occupationally exposed* workers who routinely enter the reactor bay are significantly below the limits for members of the general public.

All existing access control procedures remain in place, thus ensuring appropriate authorization and escort of all personnel entering the reactor bay.

c. REVISION OF OSTROP 6

(1) Description

The Radiation Center Director revised the job descriptions of the Senior Health Physicist and Health Physicist which are included in OSTROP 6.

(2) Safety Evaluation

The revisions involved changes of detail, language and layout only. There were no actual changes in the duties, responsibilities or authorities associated with these two positions, and therefore, there is no impact on reactor safety. This safety analysis is necessary only because OSTROP 6 states that all changes to this procedure will be reviewed in this manner.

d. REACTOR OPERATION WITH A REDUCED NUMBER OF AREA RADIATION MONITORS

(1) Description

In order to implement part of a previously approved 10 CFR 50.59 safety analysis which addressed an upgrade to the OSTR area radiation monitors (ARMs), it was necessary to disconnect the wiring for all of the old Tracerlab ARMs and the one Nuclear Measurements Corporation (NMC) ARM channel located near the sample handling area. The length of time required to remove the old ARMs and install the new Eberline ARMs was such that it was necessary to operate the reactor with only the remaining six NMC ARMs in an operational state. These

were positioned at the following locations: reactor top, beam port #1, beam port #3, fuel storage pits, pneumatic transfer terminal, and the demineralizer column.

(2) Safety Evaluation

While there were fewer ARMs in operation for a short period of time, this did not constitute an unreviewed safety question. First of all, a number of the Tracerlab ARMs being removed were duplicated by the NMC ARMs. In addition, all of the areas of potential high radiation associated with reactor operations were still covered by the NMC ARMs. Finally, the OSTR Technical Specifications require only one ARM on the reactor top. Thus, there were no safety issues and no conflicts with the Technical Specifications.

3. <u>10 CFR 50.59 Changes to Reactor Experiments</u>

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

E. <u>Surveillance and Maintenance</u>

1. <u>Non-Routine Maintenance</u>

Aug. 13, 1992	Repaired the fractured cooling tower fan shaft.
Oct. 5, 1992	Replaced the cooling tower rubber grommets for lateral headers.
Oct. 19, 1992	Changed the holdup tank level indicator to a digital readout.
Dec. 22, 1992	Replaced the area radiation monitor (ARM) cabling with new wire for the new ARM system.
Jan. 20, 1993	Replaced the stack monitor particulate GM detector with a plastic scintillator.
Mar. 18, 1993	Replaced the D100 fan bearing.
Mar. 25, 1993	Performed a special facility inspection following a mild earthquake at about 0535 hours. All OK.
Mar. 30, 1993	Replaced the cooling tower float valve.
June 10, 1993	Installed a new electrical circuit in the heat exchanger room to accommodate the transfer pump.

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 was one reportable occurrence during the reporting period. This occurrence involved a semi-annual surveillance and maintenance (S&M) item that exceeded the due date by nine calendar days (four working days). The item involved was the semi-annual pulse comparison specified by Technical Specification 4.3.1.e. The occurrence was addressed in detail in a report to the NRC dated February 1, 1993.

Figure IV.E.1

Monthly Surveillance and Maintenance (Sample Form)

OSTROP 13 SURVEILLANCE & MAINTENANCE FOR THE MONTH OF ______

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

* License Requirement.

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

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Figure IV.E.2

Quarterly Surveillance and Maintenance (Sample Form)

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

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

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

12 OPERATOR LOG

NAME	LIMITS	a) TIME	b) OPERATING EXERCISE			
	a) ≥4 hours: at console (RO) or as Rx. Sup. (SRO) b) Complete Operating Exercise					

* License Requirement

‡ Physical Security Plan Requirement

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

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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
13 CHECK FILTER TAPE SPEED ON STACK MONITOR	1"/HR ± 0.2					
14 INCORPORATE 50.59 & ROCAS INTO DOCUMENTATION	QUARTERLY					
15						
16 FUNCTIONAL CHECK OF EVACUATION ALARMS	ALL FUNCTIONAL					
*17 SUBMISSION OF SAFEGUARDS LOG BY P.S.O. FOR ____/____/____ QUARTER	SUBMIT IF NEW ENTRIES					
18 STACK MONITOR ALARM CIRCUIT CHECKS	ALARM ON CONTACT					
19 ALARM TESTING OF VITAL AREA DOUBLE DOORS	FUNCTIONAL					

* License Requirement.

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

Figure IV.E.3

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15

SEMI-ANNUAL SURVEILLANCE AND MAINTENANCE FOR ____________

No.	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 7 ½ months.

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Figure IV.E.3 (Continued)

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15 (continued)

SEMI-ANNUAL SURVEILLANCE AND MAINTENANCE FOR ____________

SURVEILLANCE & MAINTENANCE TO BE PERFORMED			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
13								
14	STANDARD CONTROL ROD MOTOR CHECKS			OILED _____				
15	FLUKE FUEL TEMPERATURE INSTRUMENT "D" CELL CHECK		TEST POSITION READ >800°C					
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 18.0 — 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 15.0					
		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.

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					

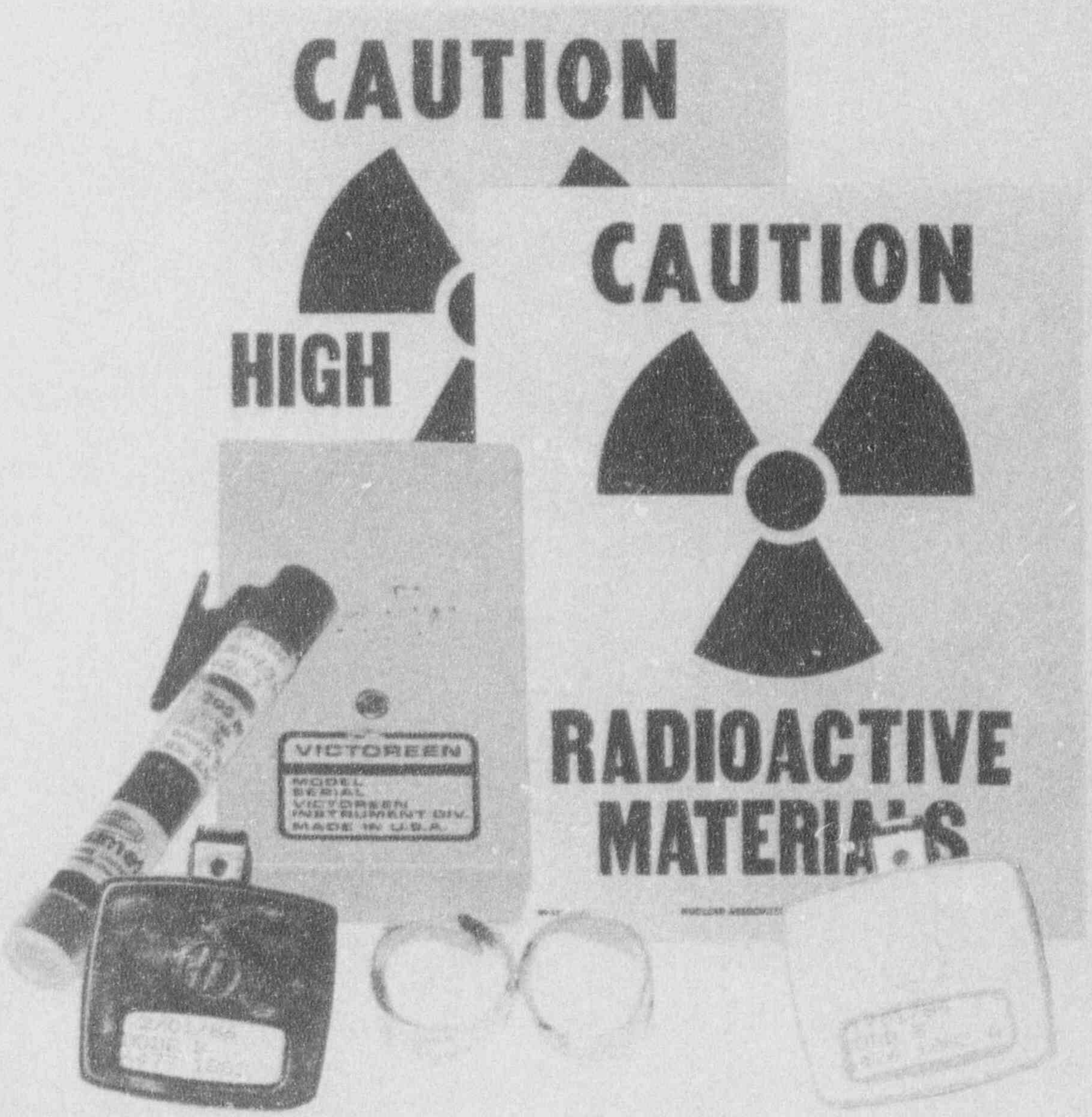
*19	REACTOR OPERATOR LICENSE CONDITIONS	ANNUAL				BIENNIAL		EVERY 6 YEARS				
		REQUALIFICATION				MEDICAL		NRC REQUAL EXAM		LICENSE		
		WRITTEN EXAMINATIONS		OPERATING TEST		DUE DATE	DATE COMPLETED	DUE DATE	DATE PASSED	APPLICATION		EXPIRATION DATE
	NAME	DUE DATE	DATE PASSED	DUE DATE	DATE PASSED					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, B4, 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				

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

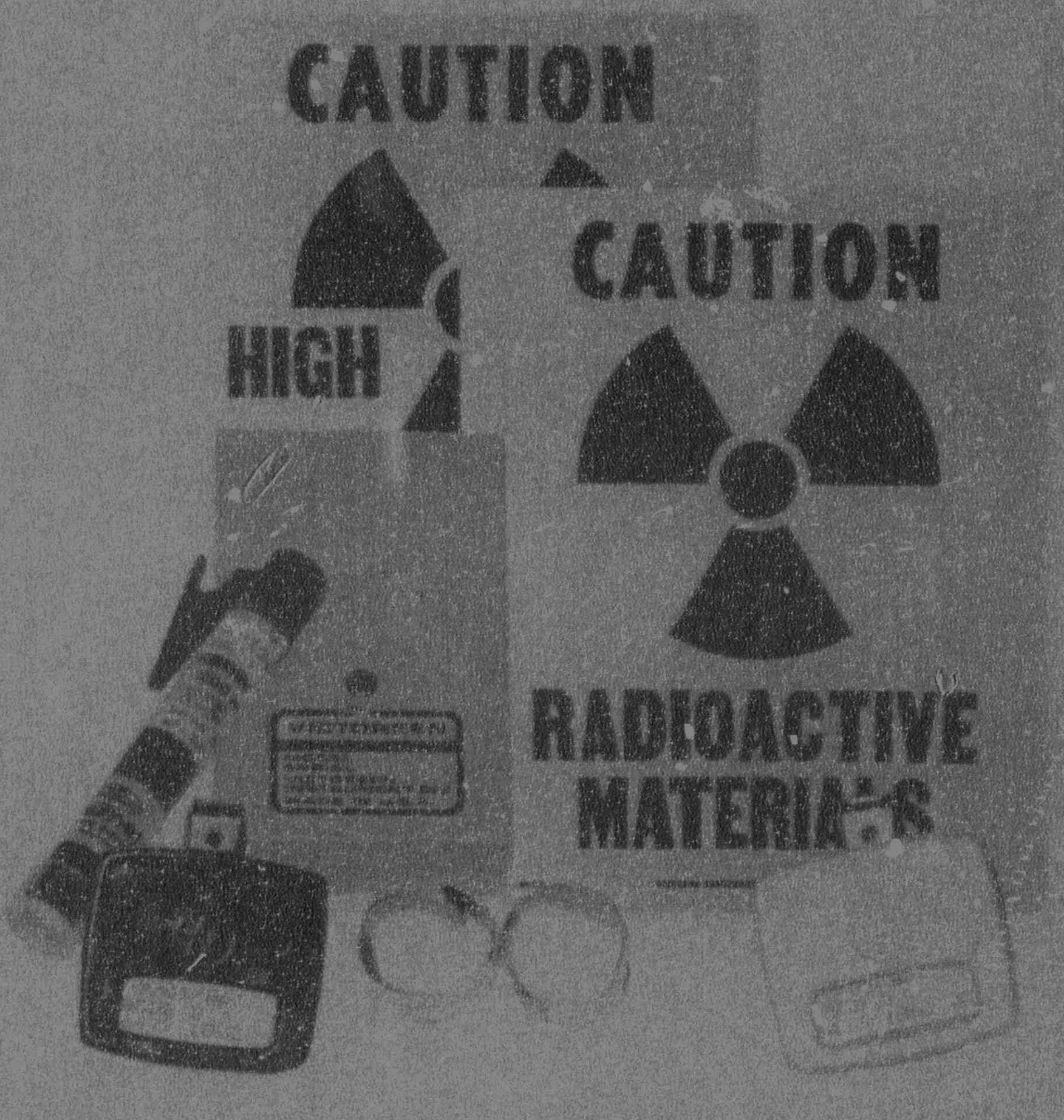
PART V

PROTECTION



PART V

PROTECTION



PART V
PROTECTION

A. Introduction

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

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

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

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

Table V.A.1

Radiation Protection Program Requirements and Frequencies

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

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

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 generated from decontamination of TRIGA tubes and glassware is now absorbed and disposed of as radioactive solid waste. 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 this release are contained in Table V.B.1. While no radioactive liquids were discharged to the holdup tank during this reporting period, it can be seen that there remains a small amount of residual activity in the system.

Table V.B.1

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

Date of Discharge (Month & Year)	Total Quantity of Radioactivity Released (Curies)	Detectable Radionuclides in the Waste	Specific Activity For Each Detectable Radionuclide in the Waste, Where the Release Concentration Was $>1 \times 10^{-7}$ μCi/cc (μCi/cc)	Total Quantity of Each Detectable Radionuclide Released in the Waste (Curies)	Average Concentration of Released Radioactive Material at the Point of Release (μCi/cc)	Percent of Applicable MPC for Released Radioactive Material (%)	Total Volume of Liquid Effluent Released Including Diluent[3] (gal)
October 92 **(No OSTR Contribution)**	3.58×10^{-5}	^{3}H ^{60}Co	3.77×10^{-6} ----	3.11×10^{-5} 2.33×10^{-7}	4.34×10^{-6}	0.18%[4] 0.007%[5]	2180
May 93 **(No OSTR Contribution)**	$<2.87 \times 10^{-5}$ [6]	None	Not Applicable	Not Applicable	<LLD (95%) of 4.01×10^{-6} [6]	Not Applicable	1892
Annual Total for Radiation Center **(No OSTR Contribution)**	$\leq 6.45 \times 10^{-5}$	^{3}H ^{60}Co	Not Applicable	3.11×10^{-5} 2.33×10^{-7}	$\leq 4.19 \times 10^{-6}$	0.10%[4] 0.004%[5]	4072

(1) OSU has implemented a policy to reduce to the absolute minimum radioactive wastes disposed to the sanitary sewer. Although no radioactive wastes have been disposed to the sanitary sewer in this reporting period, a trace of residual activity remains in the waste discharge system. This will continue to be monitored at the point of release. There were no liquid effluent releases during months not listed.

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

(3) The total volume of liquid effluent plus diluent does not take into consideration the additional mixing with the over 7,500,000 gallons per year of liquids and sewage normally discharged by the Radiation Center complex into the same sanitary sewer system.

(4) Based on values listed in 10 CFR 20, Appendix B to 20.1-20.601, Table 2, Column 2.

(5) Based on values listed in 10 CFR 20, Appendix B to 20.1-20.601, Table 1, Column 2, which are applicable to sewer disposal.

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

2. Airborne Effluents Released

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

a. Gaseous Effluents

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

b. Particulate Effluents

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

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

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

3. Solid Waste Released

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

Table V.B.2

Monthly Summary of Gaseous Effluent Releases[1]

Date of Discharge (Month & year)	Total Estimated Radioactivity Released (Curies)	Total Estimated Quantity of Argon-41 Released[2] (Curies)	Estimated Average Atmospheric Diluted Concentration of Argon-41 at Point of Release (Reactor Stack) (μCi/ml)	Percent of the Applicable MPC for Diluted Concentration of Argon-41 at Point of Release (Reactor Stack) (%)
July 92	0.22	0.22	1.6×10^{-8}	0.4%
August 92	0.18	0.18	1.3×10^{-8}	0.3%
September 92	0.25	0.25	2.0×10^{-8}	0.5%
October 92	0.29	0.29	2.2×10^{-8}	0.6%
November 92	0.19	0.19	1.4×10^{-8}	0.4%
December 92	0.22	0.22	1.7×10^{-8}	0.4%
January 93	0.22	0.22	1.6×10^{-8}	0.4%
February 93	0.35	0.35	3.0×10^{-8}	0.7%
March 93	0.41	0.41	3.1×10^{-8}	0.8%
April 93	0.24	0.24	2.0×10^{-8}	0.5%
May 93	0.23	0.23	1.8×10^{-8}	0.4%
June 93	0.26	0.26	2.1×10^{-8}	0.5%
ANNUAL VALUE	3.06	3.06	2.0×10^{-8}	0.5%

(1) Airborne effluents from the OSTR contained no detectable particulate radioactivity resulting from reactor operations, and there were no releases of <u>any</u> radioisotopes in airborne effluents in concentrations greater than 20% of the applicable MPC value. (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 (Cubic Feet)	Detectable Radionuclides in the Waste	Total Quantity of Radioactivity in Solid Waste (Curies)	Dates of Shipment to Allied Ecology Services, Inc.[1]
TRIGA Reactor Facility:				
Dry Solid	8	^{59}Fe, ^{60}Co, ^{46}Sc	1.0×10^{-5}	
Absorbed Liquid	7	^{60}Co, ^{65}Zn, ^{75}Se	9.1×10^{-5}	8/18/92 11/17/92 5/13/93
Dewatered Resin Beads	3	^{46}Sc, ^{51}Cr, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{95}Zr, ^{124}Sb, ^{125}Sb, ^{131}I, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce, ^{152}Eu, ^{154}Eu	5.2×10^{-4}	
Radiation Center Laboratories	12	^{14}Co, ^{46}Sc, ^{59}Fe, ^{60}Co, ^{90}Sr, ^{210}Pb	3.1×10^{-4}	8/18/92 11/17/92 5/13/93
TOTAL	30	See Above	9.3×10^{-4}	---

(1) All Radiation Center and OSTR solid radioactive waste is routinely transferred to the OSU Radiation Safety Office, where it is held on the University's State of Oregon radioactive materials license, along with other campus waste, prior to shipment to Allied Ecology Services, Inc. by the Radiation Safety Office.

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 their installation located near Richland, Washington.

C. <u>Personnel Doses</u>

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, physical plant 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 X-ray, beta, and gamma [Xβ(G)] film badges, quarterly track-etch/albedo neutron dosimeters, either monthly or quarterly TLD (finger) extremity dosimeters, and pocket ion chambers.

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

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

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

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

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

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

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

Table V.C.1

Annual Summary of Personnel Radiation Doses Received

Personnel Group	Average Annual Dose(1)		Greatest Individual Dose(1)		Total Person-mrem For the Group(1)	
	Whole Body (mrem)	Extremities (mrem)	Whole Body (mrem)	Extremities (mrem)	Whole Body (mrem)	Extremities (mrem)
Facility Operating Personnel	18	49	110	190	270	730
Key Facility Research Personnel	0	5	0	60	0	170
Physical Plant Maintenance Personnel	<1	N/A	4	N/A	87	N/A
Laboratory Class Students	0	0	0	0	0	0
Campus Police and Security Personnel	0	N/A	0	N/A	0	N/A
Visitors	<1	N/A	7	N/A	292	N/A

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

D. Facility Survey Data

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

1. Area Radiation Dosimeters

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

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

In certain instances, neutron doses were recorded in areas where neutrons would not normally be expected. In each case, further investigation failed to find any neutron contribution. It appears as if the neutron track etch dosimeters occasionally have a high background of scratches or other damage which is read as a neutron dose.

Figure V.D.1

TRIGA Facility and Radiation Center Area Dosimeter Locations

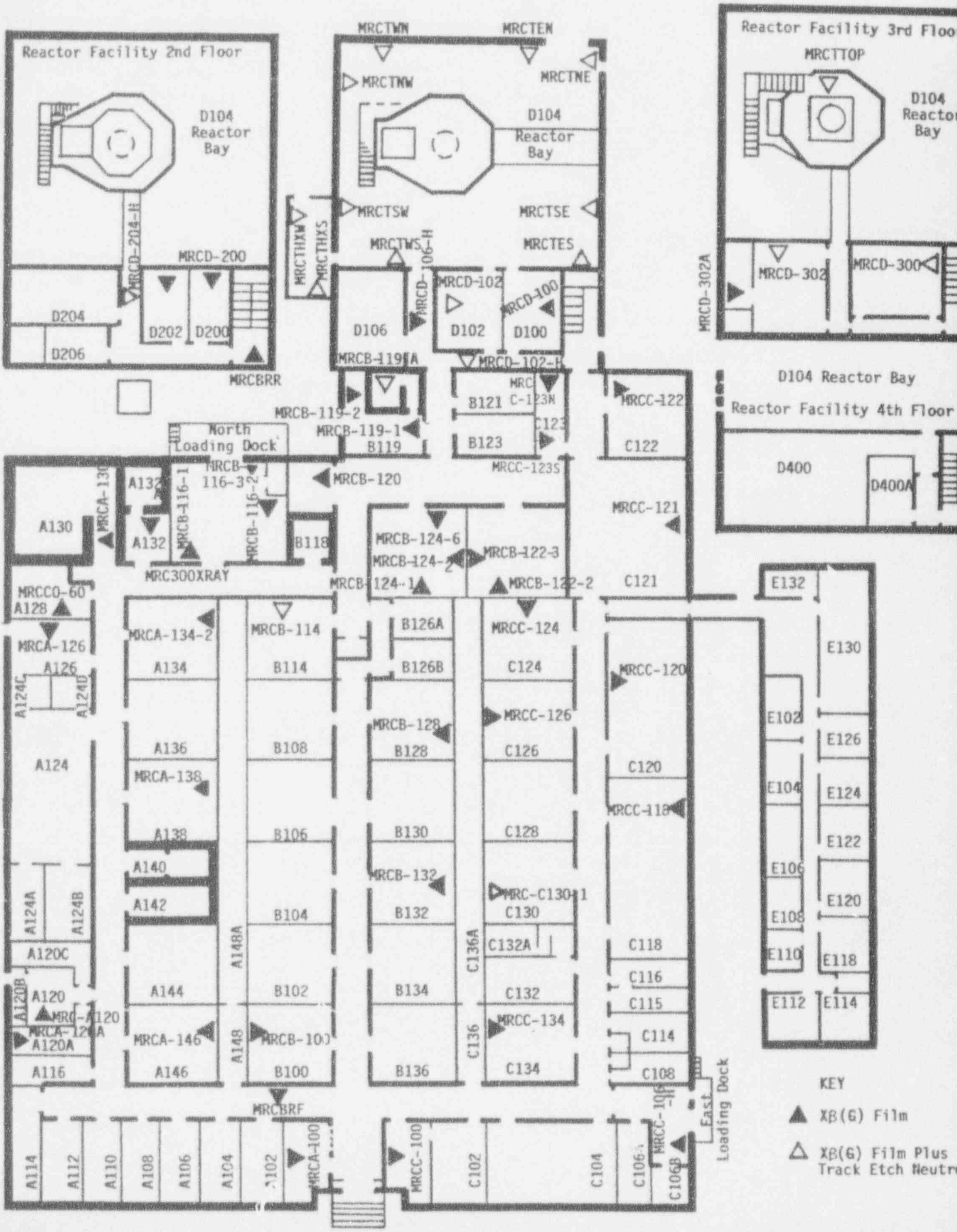


Table V.D.1

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

Monitor I.D.	TRIGA Reactor Facility Location (See Figure V.D.1)		Total Recorded Dose Equivalent[1][2]	
			xβ(G) (mrem)	Neutron (mrem)
MRCTNE	D104:	North Badge East Wall	20	0
MRCTSE	D104:	South Badge East Wall	0	0
MRCTSW	D104:	South Badge West Wall	80	0
MRCTNW	D104:	North Badge West Wall	20	0
MRCTWN	D104:	West Badge North Wall	20	0
MRCTEN	D104:	East Badge North Wall	125	0
MRCTES	D104:	East Badge South Wall	1030	0
MRCTWS	D104:	West Badge South Wall	430	55
MRCTTOP	D104:	Reactor Top Badge	515	0
MRCTHXS	D104A:	South Badge HX Room	515	160
MRCTHXW	D104A:	West Badge HX Room	30	0
MRCD-302	D302:	Reactor Control Room	190	0
MRCD-302A	D302A:	Reactor Supervisor's Office	25[3]	N/A

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

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

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

Table V.D.2

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

Monitor I.D.	Radiation Center Facility Location (See Figure V.D.1)		Total Recorded Dose Equivalent[1]	
			xβ(G) (mrem)	Neutron (mrem)
MRCA100	A100:	Receptionist's Office	0[2]	N/A
MRCBRF	A102H:	Frt Personnel Dosimetry Stor. Rack	0[2]	N/A
MRCA120	A120:	Stock Room	0[2]	N/A
MRCA120A	A120A:	NAA Temporary Storage	70[2]	N/A
MRCA126	A126:	Campus RSO's Isotope Receiving Lab	445[2]	N/A
MRCCO-60	A128:	^{60}Co Irradiator Room	1120[2]	N/A
MRCA130	A130:	Shielded Exposure Room	0[2]	N/A
MRC300XRAY	A132:	X-Ray Console Room	0[2]	N/A
MRCA134-2	A134:	NAA Research Office	130[2]	N/A
MRCA138	A138:	Health Physics Laboratory	0[2]	N/A
MRCA146	A146:	Gamma Analyzer Room (Storage Cave)	100[2]	N/A
MRCB100	B100:	Gamma Analyzer Room (Storage Cave)	85[2]	N/A
MRCB114	B114:	α Lab (^{226}Ra Storage Facility)	1960	110
MRCB116-1	B116:	Storage Rm (NAA Permanent Storage)	70[2]	N/A
MRCB116-2	B116:	Storage Rm (NAA Permanent Storage)	1980[2]	N/A
MRCB116-3	B116:	Storage Rm (NAA Permanent Storage)	0[2]	N/A
MRCB119-1	B119:	Source Storage Room	30[2]	N/A
MRCB119-2	B119:	Source Storage Room	1120[2]	N/A
MRCB119A	B119A:	Sealed Source Storage Room	3380	2160
MRCB120	B120:	Instrument Calibration Facility	100[2]	N/A
MRCB122-2	B122:	Radioisotope Storage Hood	0[2]	N/A
MRCB122-3	B122:	Radioisotope Research Laboratory	0[2]	N/A
MRCB124-1	B124:	Radioisotope Research Lab (Hood)	175[2]	N/A
MRCB124-2	B124:	Radioisotope Research Laboratory	0[2]	N/A
MRCB124-6	B124:	Radioisotope Research Laboratory	0[2]	N/A
MRCB128	B128:	Instrument Repair Shop	0[2]	N/A
MRCB132	B132:	Radioisotope Research Laboratory	90[2]	N/A
MRCC100	C100:	Radiation Center Director's Office	0[2]	N/A
MRCC106-H	C106H:	East Loading Dock	0[2]	N/A
MRCC118	C118:	Radiochemistry Laboratory	0[2]	N/A
MRCC120	C120:	Student Counting Laboratory	0[2]	N/A
MRCC121	C121:	AP600 Facility	0[2]	N/A
MRCC122	C122:	AP600 Control Room	0[2]	N/A

See footnotes next page.

Table V.D.2 (continued)

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

Monitor I.D.	Radiation Center Facility Location (See Figure V.D.1)	Total Recorded Dose Equivalent[1]	
		$x\beta(G)$ (mrem)	Neutron (mrem)
MRCC123N	C123: Gamma Analyzer Room (Storage Cave)	75[2]	N/A
MRCC123S	C123: Gamma Analyzer Room	0[2]	N/A
MRCC124	C124: Student Computer Laboratory	0[2]	N/A
MRC126	C126: AP600 Office	0[2]	N/A
MRCC130-1	C130: Radioisotope Laboratory (Hood)	0[2]	N/A
MRCC134	C134: Gamma Analyzer Room (Storage Cave)	95	N/A
MRCD100	D100: Reactor Support Laboratory	80	N/A
MRCD102	D102: Pneumatic Transfer Terminal Lab	115	0
MRCD102-H	D102H: 1st Floor Corridor at D102	0	0
MRCD106-H	D106H: 1st Floor Corridor at D106	110[2]	N/A
MRCD200	D200: Senior Health Physicist's Office	155[2]	N/A
MRCD202	D202: Reactor Administrator's Office	195[2]	N/A
MRCBRR	D200H: Rear Personnel Dosimetry Storage Rack	0[2]	N/A
MRCD204-H	D204H: 2nd Floor Corridor at D204	0	0
MRCD300	D300: 3rd Floor Conference Room	20	240

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

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

2. Routine Radiation and Contamination Surveys

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

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

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

Table V.D.3

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

Accessible Location (See Figure V.D.1)	Whole Body Radiation Levels (mrem/hr)		Contamination Levels[1] (dpm/100 cm^2)	
	Average	Maximum	Average	Maximum
TRIGA Reactor Facility:				
Reactor Top (D104)	2	100	<500[2]	2250[2]
Reactor 2nd Deck Area (D104)	4	40	<500	<500
Reactor Bay SW (D104)	<1	5	<500	<500
Reactor Bay NW (D104)	<1	6	<500[2]	1913[2]
Reactor Bay NE (D104)	<1	2	<500[2]	1000[2]
Reactor Bay SE (D104)	<1	8	<500[2]	5250[2]
Class Experiments (D104,D302)	<1	3	<500	<500
Demineralizer Tank-- Outside Shielding (D104A)	<1	3	<500	<500
Particulate Filter-- Outside Shielding (D104A)	<1	4	<500	<500
Radiation Center:				
NAA Counting Rooms (A146,B100,C134)	<1	<1	<500	<500
Health Physics Laboratory (A138)	<1	4	<500	<500
^{60}Co Irradiator Room (A128)	<1	3	<500	<500
Radiation Research Labs (B114,B122,B124,B132)	<1	5	<500[2]	1000[2]
Radioactive Source Storage (B119A)	<1	4	<500	<500
Student Chemistry Laboratory (C118)	<1	<1	<500[2]	1560[2]
Student Counting Laboratory (C120)	<1	<1	<500	<500
Operations Counting Room (C123)	<1	<1	<500	<500
Pneumatic Transfer Laboratory (D102)	<1	<1	<500[2]	<500
TRIGA Tube Wash Room (D100)	<1	1	<500	<500

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

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

E. **Environmental Survey Data**

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

1. Gamma Radiation Monitoring

a. On-site Monitoring

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

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

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

Monthly measurements of the direct gamma exposure rate, in microroentgens per hour (μR/hr), were also made at each fence monitoring station. These measurements were made with an Eberline Instrument Company micro-R per hour survey meter containing a 1" x 1" NaI detector.

Figure V.E.1

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

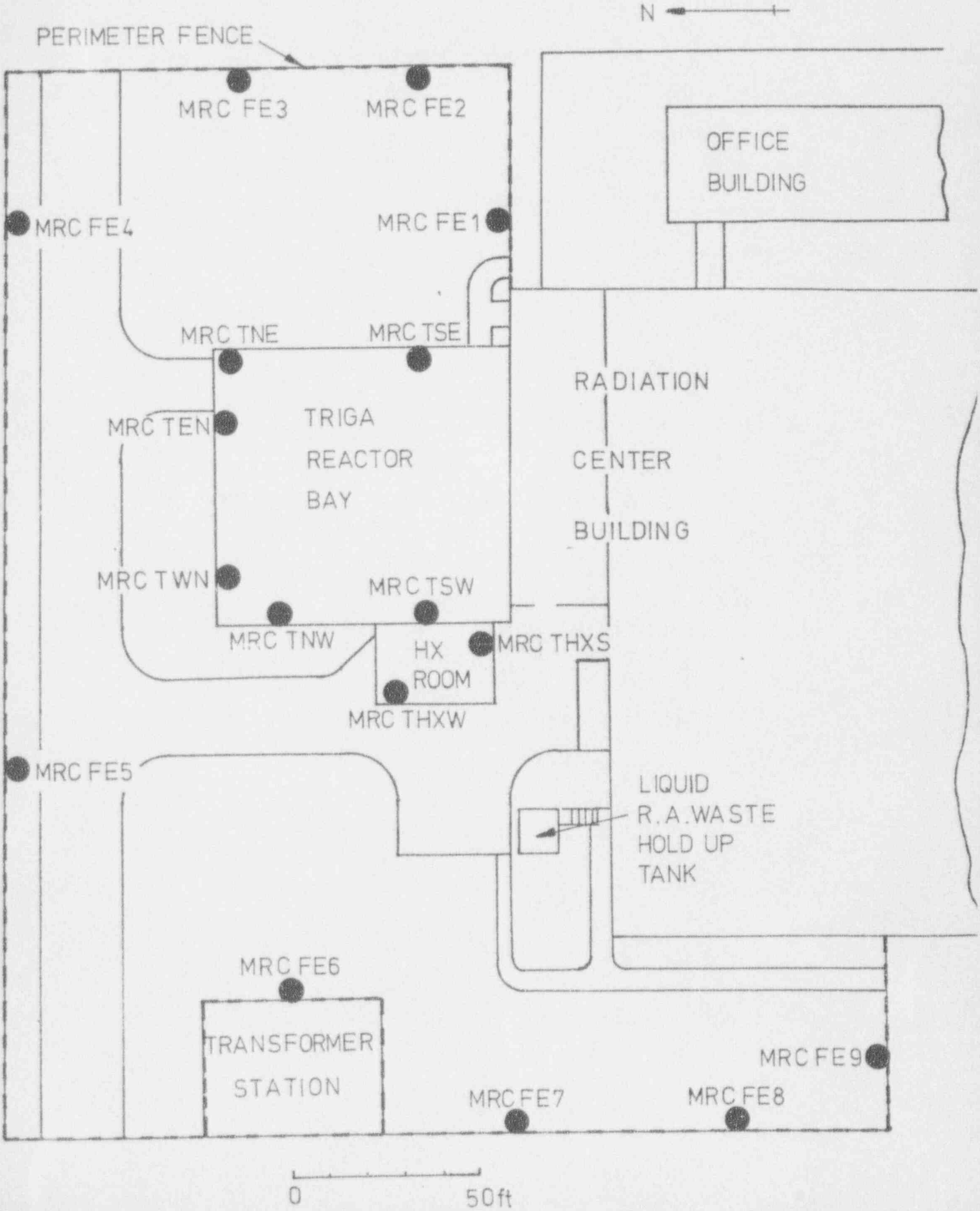


Table V.E.1

Total Dose Equivalent at the TRIGA Reactor Facility Fence

Fence Environmental Monitoring Station (See Figure V.E.1)	Total Recorded Dose Equivalent Based on R.D. Co. TLDs[1] (mrem)	Total Recorded Dose Equivalent Based on OSU TLDs[2][3] (mrem)	Total Calculated Dose Equivalent Based on the Annual Average μR/hr Exposure Rate[3] (mrem)
MRCFE-1	94	64 ± 4	81 ± 18
MRCFE-2	98	67 ± 4	85 ± 21
MRCFE-3	100	72 ± 2	84 ± 22
MRCFE-4	102	71 ± 3	91 ± 26
MRCFE-5	86	62 ± 3	74 ± 28
MRCFE-6	92	64 ± 4	78 ± 34
MRCFE-7	91	64 ± 6	75 ± 25
MRCFE-8	92	62 ± 4	75 ± 21
MRCFE-9	90	60 ± 6	71 ± 16

(1) Radiation Detection Company (R.D. Co.) TLD totals include their annual natural background contribution of 69 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 76 mrem for the same period.

(2) OSU fence totals include a measured natural background contribution of 54 ± 3 mrem.

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

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

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

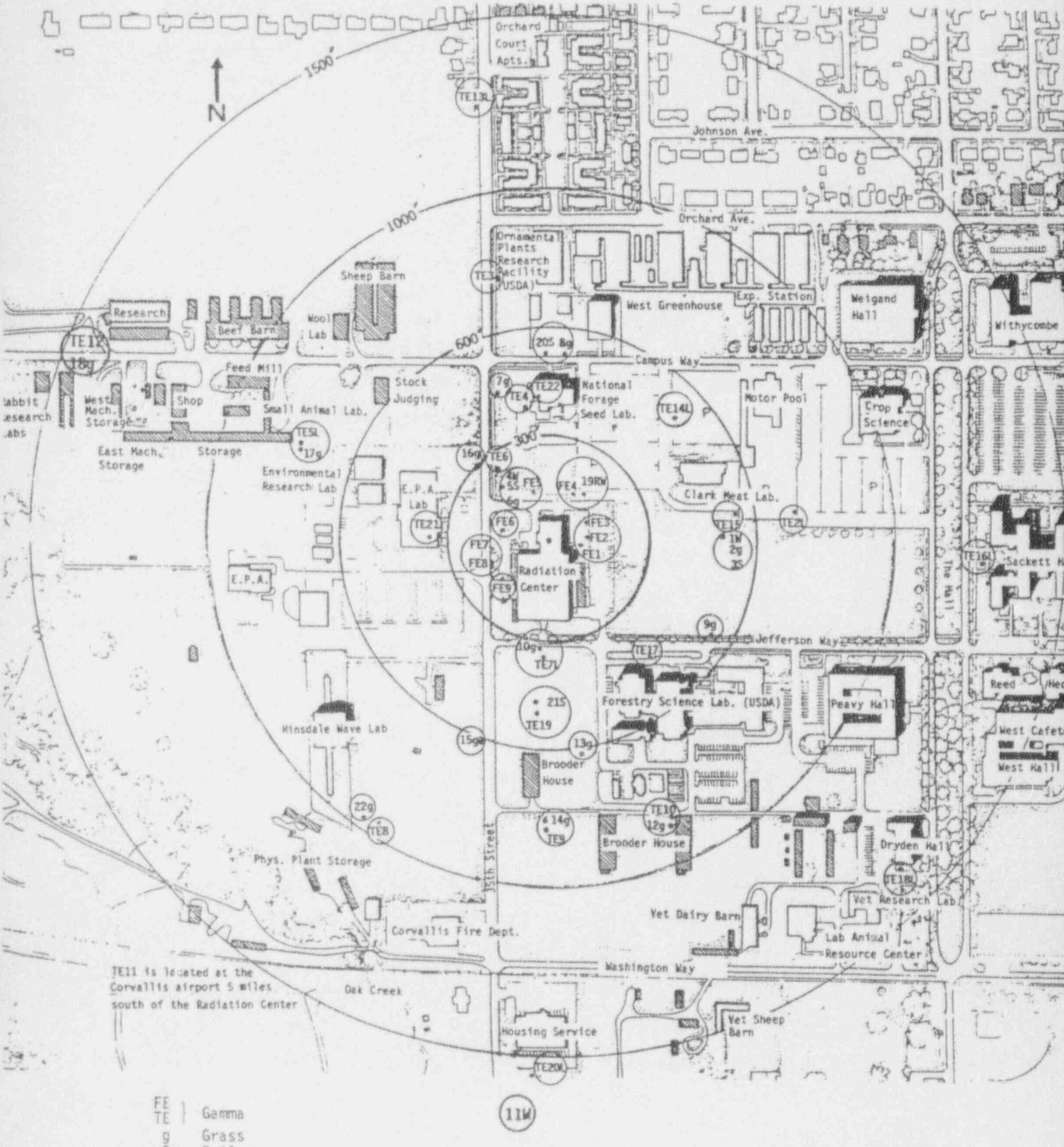
b. Off-site Monitoring

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

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

Figure V.E.2

Monitoring Stations for the OSU TRIGA Reactor



FE } Gamma
TE }
g Grass
S Soil
W Water
RW Rainwater

SCALE: 0 100 200 300

Table V.E.2

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

Off-Site Radiation Monitoring Station(1) (See Figure V.E.2)	Total Recorded Dose Equivalent Based on R.D. Co. TLDs(2) (mrem)	Total Recorded Dose Equivalent Based on OSU TLDs(3)(4) (mrem)	Total Calculated Dose Equivalent Based on the Annual Average μR/hr Exposure Rate(4) (mrem)
MRCTE-2L	---	55 ± 3	53 ± 15
MRCTE-3	97	63 ± 6	86 ± 12
MRCTE-4	89	55 ± 4	77 ± 16
MRCTE-5L	---	60 ± 7	84 ± 7
MRCTE-6	94	54 ± 19	89 ± 16
MRCTE-7L	---	55 ± 6	86 ± 12
MRCTE-8	98	61 ± 5	96 ± 17
MRCTE-9	98	55 ± 8	85 ± 16
MRCTE-10	86	53 ± 7	67 ± 13
MRCTE-11	87	53 ± 3	69 ± 9
MRCTE-12	97	62 ± 6	87 ± 12
MRCTE-13L	---	69 ± 5	84 ± 11
MRCTE-14L	---	55 ± 10	59 ± 14
MRCTE-15	87	65 ± 5	76 ± 11
MRCTE-16L	---	64 ± 12	85 ± 14
MRCTE-17	86	65 ± 6	72 ± 12
MRCTE-18L	---	67 ± 4	84 ± 13
MRCTE-19	99	72 ± 3	90 ± 11
MRCTE-20L	---	72 ± 6	80 ± 12
MRCTE-21	70	50 ± 3	46 ± 10
MRCTE-22	79	55 ± 3	62 ± 10

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

(2) Radiation Detection Company TLD totals include their annual natural background contribution of 69 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 76 mrem for the same period.

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

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

In a manner similar to that described for the on-site fence stations, monthly measurements of the direct gamma exposure rate in microroentgens per hour (μR/hr) are made at each of the twenty-one off-site radiation monitoring stations. As noted before, these measurements are made with an Eberline Instrument Company micro-R per hour survey meter containing a 1" x 1" NaI detector. A total of 252 μR/hr 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 μR/hr measurements, multiplying this average by 8760 hours per year, and then by converting microroentgens to millirem. A summary of this data is given in Table V.E.2.

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

2. <u>Soil, Water, and Vegetation Surveys</u>

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

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

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

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

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

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

Table V.E.3

Annual Average Concentration of the Total Net Beta Radioactivity (Minus ^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	[2][3]$2.69 \times 10^{-8} \pm 2.16 \times 10^{-9}$	µCi/cc
4-W	Water	[2][3]$2.69 \times 10^{-8} \pm 2.16 \times 10^{-9}$	µCi/cc
11-W	Water	[2]$2.70 \times 10^{-8} \pm 1.40 \times 10^{-9}$	µCi/cc
19-RW	Rainwater	[2]$2.70 \times 10^{-8} \pm 1.40 \times 10^{-9}$	µCi/cc
3-S	Soil	$1.07 \times 10^{-4} \pm 1.68 \times 10^{-5}$	µCi/gram of dry soil
5-S	Soil	$5.98 \times 10^{-5} \pm 1.50 \times 10^{-5}$	µCi/gram of dry soil
20-S	Soil	$1.30 \times 10^{-4} \pm 1.76 \times 10^{-5}$	µCi/gram of dry soil
21-S	Soil	$1.13 \times 10^{-4} \pm 1.48 \times 10^{-5}$	µCi/gram of dry soil
2-G	Grass	$2.80 \times 10^{-4} \pm 2.79 \times 10^{-5}$	µCi/gram of dry ash
6-G	Grass	$2.76 \times 10^{-4} \pm 3.75 \times 10^{-5}$	µCi/gram of dry ash
7-G	Grass	$4.07 \times 10^{-4} \pm 3.86 \times 10^{-5}$	µCi/gram of dry ash
8-G	Grass	$3.67 \times 10^{-4} \pm 3.59 \times 10^{-5}$	µCi/gram of dry ash
9-G	Grass	$2.38 \times 10^{-4} \pm 2.32 \times 10^{-5}$	µCi/gram of dry ash
10-G	Grass	$3.61 \times 10^{-4} \pm 3.62 \times 10^{-5}$	µCi/gram of dry ash
12-G	Grass	$3.38 \times 10^{-4} \pm 2.77 \times 10^{-5}$	µCi/gram of dry ash
13-G	Grass	$3.00 \times 10^{-4} \pm 3.10 \times 10^{-5}$	µCi/gram of dry ash
14-G	Grass	$1.82 \times 10^{-4} \pm 2.65 \times 10^{-5}$	µCi/gram of dry ash
15-G	Grass	$2.79 \times 10^{-4} \pm 3.09 \times 10^{-5}$	µCi/gram of dry ash
16-G	Grass	$4.37 \times 10^{-4} \pm 3.45 \times 10^{-5}$	µCi/gram of dry ash
17-G	Grass	$4.05 \times 10^{-4} \pm 3.10 \times 10^{-5}$	µCi/gram of dry ash
18-G	Grass	$3.89 \times 10^{-4} \pm 3.61 \times 10^{-5}$	µCi/gram of dry ash
22-G	Grass	$3.46 \times 10^{-4} \pm 3.40 \times 10^{-5}$	µCi/gram of dry ash

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

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

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

Table V.E.4

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

Sample Type	Average LLD Value	Range of LLD Values	Reporting Units
Soil	2.19×10^{-5}	1.42×10^{-5} to 3.26×10^{-5}	μCi/gram of dry soil
Water	2.68×10^{-8}	2.59×10^{-8} to 2.79×10^{-8}	μCi/cc
Vegetation	3.81×10^{-5}	8.28×10^{-6} to 9.67×10^{-5}	μCi/gram of dry ash

F. Radioactive Material Shipments

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

Table V.F.1

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

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Oceanography Corvallis, OR	1.4×10^{-3}	2	--	5	--	7
OSU Fisheries & Wildlife Corvallis, OR	7.5×10^{-3}	1	--	8	--	9
Institute of Human Origins Berkeley, CA	1.2×10^{-5}	2	--	--	--	2
University of California Berkeley, CA	1.0×10^{-3}	--	--	6	--	6
Idaho State University Pocatello, ID	1.1×10^{-2}	--	--	7	--	7
University of Washington Seattle, WA	3.0×10^{-7}	1	--	--	--	1
Stanford University Stanford, CA	9.2×10^{-5}	1	--	1	--	2
Stanford University Palo Alto, CA	3.6×10^{-7}	1	--	--	--	1
Brigham Young University Provo, UT	8.5×10^{-6}	2	--	--	--	2
U.S. Bureau of Mines Salt Lake City, UT	1.3×10^{-4}	--	--	1	--	1
Rensselaer Polytechnic Institute Troy, NY	7.2×10^{-5}	6	--	--	--	6
TOTALS	2.1×10^{-2}	16	0	28	0	44

Table V.F.2

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

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Oceanography Corvallis, OR	3.4×10^{-7}	1	--	--	--	1
OSU Fisheries & Wildlife Corvallis, OR	7.2×10^{-4}	--	--	1	--	1
Oregon Health Sciences University Portland, OR	1.7×10^{-5}	17	--	--	--	17
Lawrence Berkeley Laboratory Berkeley, CA	1.8×10^{-5}	--	--	1	--	1
U.S. Bureau of Mines Salt Lake City, UT	1.9×10^{-3}	--	--	1	--	1
NASA Johnson Space Center Houston, TX	3.7×10^{-6}	3	--	--	--	3
University of Missouri--Columbia Columbia, MO	5.0×10^{-8}	1	--	1	--	1
TOTALS	2.7×10^{-3}	22	0	3	0	25

Table V.F.3

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

Shipped To	Total Activity (Curies)	Number of Shipments				
		Excepted Package	Type A Quantity: White I	Type A Quantity: Yellow II	Type A Quantity: Yellow III	Total
Free University Amsterdam, The Netherlands	1.1×10^{-4}	--	--	1	--	1
FAPIG Radiation Research Yokosuka, Japan	6.7×10^{-7}	2	--	--	--	2
TOTALS	1.1×10^{-4}	2	0	1	0	3

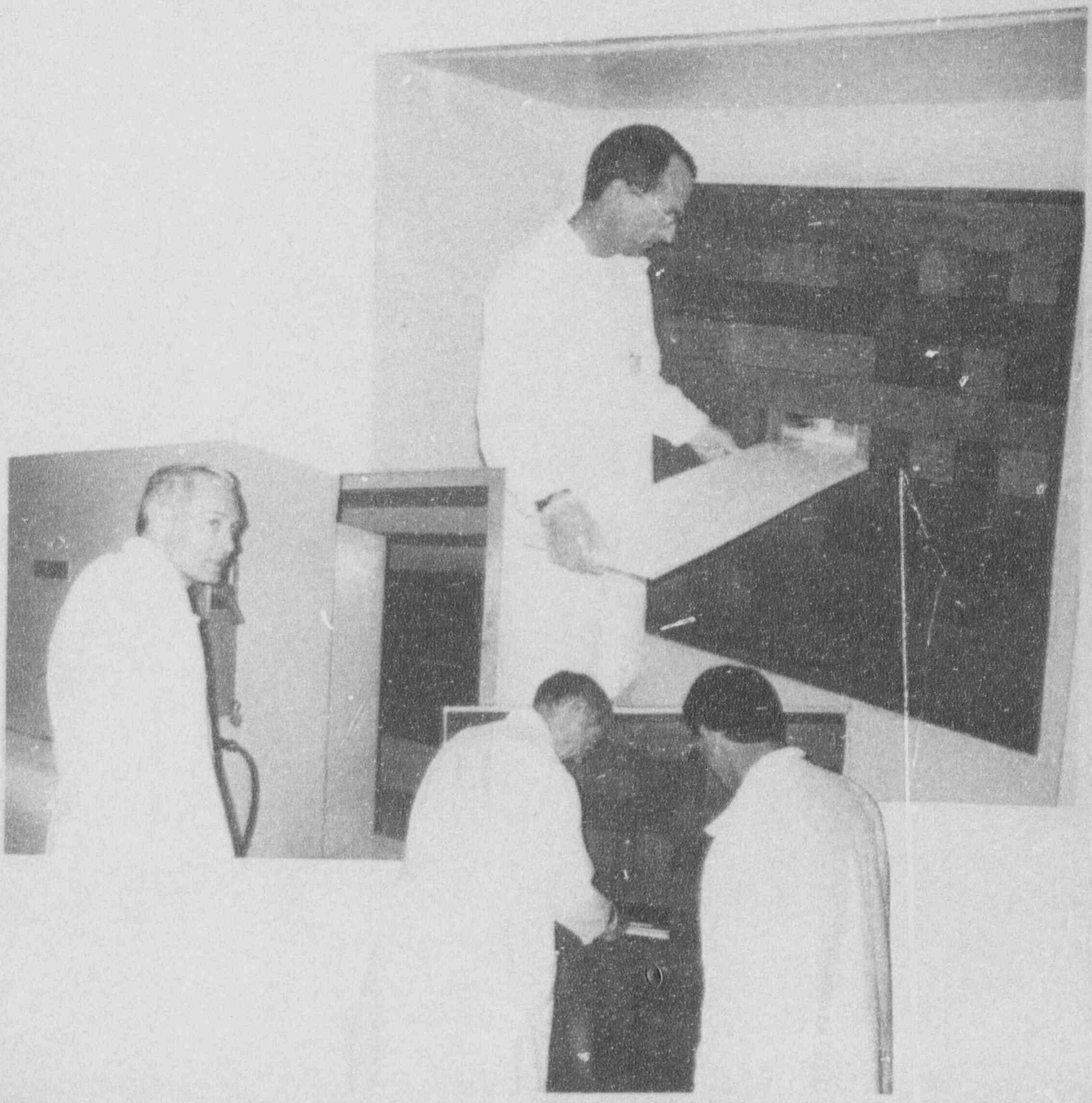
G. References

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).

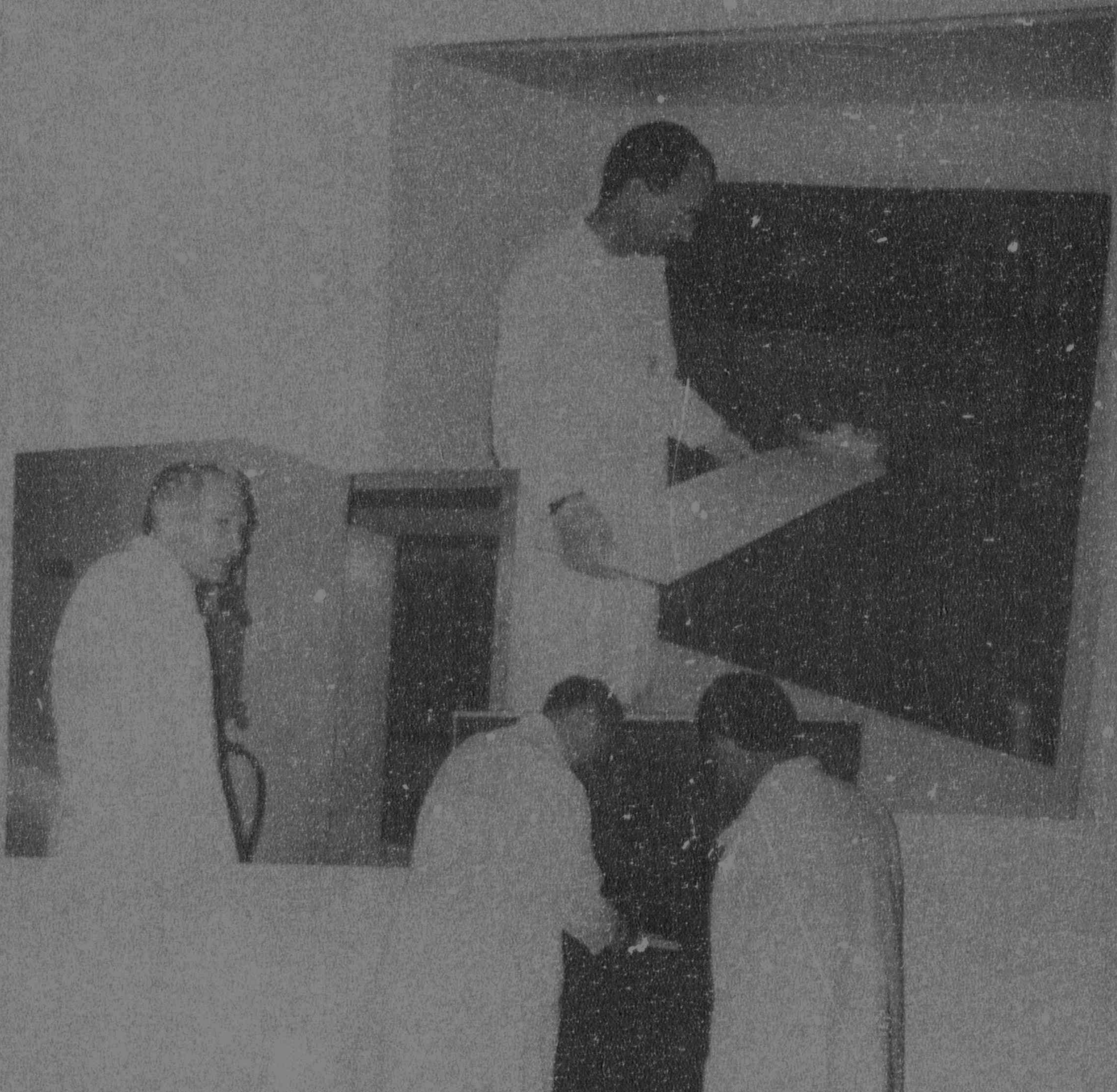
PART VI

WORK



PART VI

WORK



PART VI
WORK

A. Summary

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

B. Teaching

The most important responsibility of the Radiation Center and reactor is to support OSU's academic programs. Implementation of this support occurs through direct involvement of the Center's staff and facilities in the teaching programs of various departments and through our participation in University research programs. For example, during the current reporting period, the Radiation Center accommodated 77 OSU academic classes involving a number of different academic departments. In addition, portions of classes from other Oregon universities were also supported by the Radiation Center. The OSU teaching programs (not including research) utilized 816 hours of reactor time. Tables III.A.1 and III.E.1 plus section VI.C.5 provide more detailed information on the use of the Radiation Center and reactor for instruction and training.

C. Research and Service

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

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

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

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

Table VI.C.1

Institutions and Agencies Which Utilized the Radiation Center

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*Oregon State University[1] Corvallis, Oregon	44	72	26	433[2]
*U.S. Environmental Protection Agency Corvallis, Oregon	2	NA	NA	6
Good Samaritan Hospital Corvallis, Oregon	1	NA	NA	5
Corvallis Fire Department Corvallis, Oregon	1	NA	NA	5
*U.S. Bureau of Mines Albany, Oregon	4	NA	NA	6
Teledyne Wah Chang Albany, Oregon	2	NA	NA	3
Aromatics Albany, Oregon	1	NA	NA	3
McBee and Associates Lebanon, Oregon	2	NA	NA	15
Oregon Department of Energy Salem, Oregon	1	NA	NA	15
*Willamette University Salem, Oregon	3	1	0	3
Boy Scouts District Executive Salem, Oregon	1	NA	NA	1
McNary High School Keizer, Oregon	1	1	1	1
Sun Seeds Brooks, Oregon	2	NA	NA	3
U.S. Environmental Protection Agency Newport, Oregon	1	NA	NA	1
*University of Oregon Eugene, Oregon	9	7	8	10
Molecular Probes Eugene, Oregon	1	NA	NA	18

(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 the AP600 project which involves daily use of Radiation Center facilities.

* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
Saturday Academy Beaverton, Oregon	1	1	1	1
*NEA, Inc. Beaverton, Oregon	1	NA	NA	1
*Oregon Health Sciences University Portland, Oregon	3	2	1	76
Vollum Institute, OHSU Portland, Oregon	1	1	NA	1
Oregon State Health Division, Radiation Control Portland, Oregon	3	NA	NA	12
Oregon State Police Portland, Oregon	1	NA	NA	1
Kaiser-Permanente Portland, Oregon	1	1	1	7
Warren Chism Vancouver, Washington	1	NA	NA	1
Umpqua Research Myrtle Creek, Oregon	1	NA	NA	3
Chiloquin School Chiloquin, Oregon	1	1	0	1
*University of Washington Seattle, Washington	4	3	2	4
Nyssa Elementary School Nyssa, Oregon	1	1	20	1
U.S. Department of Agriculture Arcata, California	1	1	0	3
*Institute of Human Origins Berkeley, California	1	1	0	4
*Lawrence Berkeley Laboratory Berkeley, California	1	1	0	1
*University of California--Berkeley Berkeley, California	1	1	1	8
*Stanford University Stanford, California	2	3	0	4
*San Jose State University San Jose, California	1	1	0	1
*University of California--Santa Cruz Santa Cruz, California	2	4	1	2

* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*Idaho State University Pocatello, Idaho	2	5	4	5
*Dr. Don Livingston Las Vegas, Nevada	1	1	0	1
*Brigham Young University Salt Lake City, Utah	1	1	0	2
*U.S. Bureau of Mines Salt Lake City, Utah	2	NA	NA	4
*California State University--Northridge Northridge, California	1	1	1	1
*University of California--Los Angeles Los Angeles, California	3	3	2	3
D. Parsons Fallbrook, California	1	NA	NA	1
*University of Wyoming Laramie, Wyoming	1	1	1	1
*University of Colorado Boulder, Colorado	3	3	2	3
*University of New Mexico Albuquerque, New Mexico	1	1	0	1
*Texas Tech University Lubbock, Texas	5	2	2	5
*University of Texas--Arlington Arlington, Texas	2	2	0	2
*Trinity University San Antonio, Texas	1	1	1	1
*Rice University Houston, Texas	3	2	2	3
*University of Notre Dame South Bend, Indiana	1	1	0	2
*Indiana State University Terre Haute, Indiana	1	1	0	1
*Tulane University New Orleans, Louisiana	1	1	1	1
*Louisiana State University Baton Rouge, Louisiana	1	1	2	1
*University of Rochester Rochester, New York	1	1	1	1

* Project which involves the OSTR.

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
*Clemson University Clemson, South Carolina	1	1	1	1
*University of South Carolina Columbia, South Carolina	1	1	0	1
*University of North Carolina Chapel Hill, North Carolina	1	2	1	1
*North Carolina State University Raleigh, North Carolina	2	1	1	2
*Lehigh University Bethlehem, Pennsylvania	1	1	1	1
*State University of New York Albany, New York	3	1	1	3
*Rensselaer Polytechnic Institute Troy, New York	3	3	2	8
*City College of the City University of New York New York, New York	3	1	0	3
*Johns Hopkins University Baltimore, Maryland	1	1	0	1
*University of Florida Gainesville, Florida	1	1	1	1
*University of Maine Orono, Maine	2	2	1	5
*University of Hawaii Honolulu, Hawaii	1	1	0	1
*Kyoto Fission-Track Kyoto, Japan	1	NA	NA	1
*First Atomic Power Industrial Group--Japan Nagasaka, Yokosuka, Japan	1	NA	NA	1
*Geologisch Institute of Kiel Keil, Germany	1	1	0	1
TOTALS	159	148	90	730(3)

(3) This total does not include the AP600 project which involves daily use of Radiation Center facilities.

* Project which involves the OSTR.

Table VI.C.2

Graduate Student Research Which Utilized the Radiation Center

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
OREGON STATE UNIVERSITY				
Abdul-Hamid, S.	MS	Nuclear Engineering	Klein	Lifetime Performance of Thermionic Fuel Elements
Ahn, H.	MS	Nuclear Engineering	Higginbotham	Individual Plant Examination Project for the Trojan Nuclear Power Station
Al-Baroudi, H.	PhD	Nuclear Engineering	Klein	Heat Rejection Systems in Space Reactors
Al-Kheliewi, A.	PhD	Nuclear Engineering	Klein	Transient Thermalhydraulic and Thermionic Performance Analysis
Ala, A.	PhD	Nuclear Engineering	Binney	Actinide Burning Reactor
Astrahantseff, K.	PhD	Zoology	Morris	Interactions Between Stromal and Epithelial (Mouse) Cells During Estrogen Stimulation
*Bae, J.	MS	Radiation Health	Higginbotham	Development of a Methodology to Accurately Inventory Activation Products
Betts, C.	MS	Nuclear Engineering	Kulas	Coupled Neutronic and Thermal Hydraulic Calculations
Cantaloub, M.	MS	Nuclear Engineering	Reyes	Not yet determined.
*Day, T.	PhD	Chemistry	Loveland	Speciation of Plutonium in Aquatic Environmental Systems
Dekoning, J.	PhD	Microbiology	Kaattari	Irradiation of Anterior Kidney Suppressor Cells (Fish)
Demessie, S.	PhD	Chemical Engineering	Levine	Impregnation of Fibrous Materials Using Supercritical Fluids
*Desonie, D.	PhD	Oceanography	Duncan	^{40}Ar-^{39}Ar Dating
Dickinson, J.	MS	Nuclear Engineering	Klein	Multi-Cell Thermionic Fuel Element Performance Analysis
Donnely, P.	PhD	Forest Science	Entry	Herbicide Degradation
Drongesen, J.	MS	Microbiology	Rohovec	Immunosuppression and EIBS of Fish Blood
Ferguson, B.	MS	Botany	Hanson	Root Rot of Abies and Pinus Species
Franz, S.	MS	Nuclear Engineering	Reyes	Flow Instrumentation Development for the AP600 Reactor
*Fitz, C.	MS	Radiation Health	Dodd	Emergency Action Levels for Accidental Releases from Research Reactors
Fu, Y.	PhD	Chemistry	Daniels	Time-Resolved Laser Spectroscopy of Nucleic Acids

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
Fundak, R.	MS	Nuclear Engineering	Klein	Not yet determined.
Gulshan-Ara, Z.	MS	Nuclear Engineering	Klein	Radiation Heat Transfer for Fabric Composites for Space Radiators
Hamoudi, A.	MS	Radiation Health	Higginbotham	Geographic Information System for Nuclear Power Plant Emergency Preparedness
*Johnson, J.	MS	Radiation Health	Binney	Pituitary Tumor Therapy Using Boron Neutron Capture Therapy
Kains, J.	PhD	Pharmacy	Ayres	Changes in Uremic Gut Using Coated L. Acidophilus Beads
Kellar, M.	MS	Radiation Health	Dodd	Re-Evaluation of Dosimetry for Radiopharmaceuticals
Kiestler, W.	MS	Nuclear Engineering	Klein	Fabric Composite Heat Pipe Testing and Construction
Lee, H.	PhD	Nuclear Engineering	Klein	Systems Analysis for an Advanced Thermionic Reactor
Lewis, B.	MS	Nuclear Engineering	Klein	Development of System Analysis Program for Space Reactor Studies
Ma, C.	MS	Nuclear Engineering	Reyes	RELAP 5 Thermal Hydraulic Analysis for the AP600 Reactor
*MacLean, J.	MS	Geosciences	Grunder	Practical Application of INAA to Geologic Materials.
Mankowski, M.	MS	Entomology	Morrell	Host Preference of Dampwood Termites on Western Wood Species
*Martsolf, S.	MS	Radiation Health	Binney	Pituitary Tumor Therapy Using Boron Neutron Capture Therapy
*McElwee, C.	PhD	Oceanography	Duncan	^{40}Ar-^{39}Ar Dating
*Merritt, P.	MS	Nuclear Engineering	Klein	Three Dimensional TRIGA Core Analysis
Ortega, H.	PhD	Microbiology	Kaattari	Limiting Dilution Assay of Fish Peripheral Blood Cells
Potter, N.	MS	Radiation Health	Dodd	Not yet determined.
*Pratt, D.	MS	Radiation Health	Higginbotham	New Developments and Uses of Beta Spectroscopy
Rogers, J.	PhD	Biological Oceanography	Sherr	Production Release Assays
*Shepherd, S.	PhD	Nuclear Engineering	Ringle	Chemonuclear Dissociation of Waste Materials
Snuggerud, R.	MS	Nuclear Engineering	Klein	Theory of Fabric Composite Heat Pipe Operation
*Streck, M.	PhD	Geosciences	Grunder	Petrochemical Interpretation of the Rattlesnake Ash-Flow Tuff, Southeastern Oregon

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
Stevens, O.	MS	Nuclear Engineering	Reyes	AP600 Analysis Methods
*Vostmyer, C.	MS	Radiation Health	Binney	Neutron Beam Design Optimization for Boron Neutron Capture Therapy
Wang, Y.	MS	Nuclear Engineering	Reyes	Mid-Loop Operations Analysis for a Standard PWR
Wu, R.	MS	Radiation Health	Dodd	Determination of Collective Effective Doses from the Use of Columbia River Sediments
Zhou, L.	MS	Nuclear Engineering	Robinson	Expert System for the Classification of Accidents at Nuclear Power Plants
UNIVERSITY OF OREGON				
*Getahun, A.	PhD	Geological Sciences	Reed	Chemical Gains and Losses in Altered Wall Rocks Around a High Temperature Volcanic Fumarole and in an Acid Sulfate Gold-Copper Deposit
*Rice, A.	MS	Geological Sciences	Retallack	Geochemical Evaluation of Acid Rain in Paleosols at the Cretaceous-Tertiary Boundary
UNIVERSITY OF WASHINGTON				
*Anders, N.	PhD	Geological Sciences	Nelson	Transition of Tholeiitic to Alkalic Volcanism on Ocean Islands
*Russell, A.	PhD	Oceanography	Emerson	Use of Uranium in Foraminifera as a Tracer of Deep Water Anoxia in the Pleistocene
IDAHO STATE UNIVERSITY				
*Thompson, R.	MS	Anthropology	Lohse	Stratigraphic Analysis of a Presumed Prehistoric Midden from Hells Canyon, Oregon
UNIVERSITY OF CALIFORNIA--BERKELEY				
*Mansouri, A.	PhD	Nuclear Engineering	Olander	Fission Product Migration in UO_2 Disks
UNIVERSITY OF CALIFORNIA--NORTHRIDGE				
*Savage, K.	MS	Geological Sciences	Weigand	Origin of Miocene Volcanic Rocks from the Los Angeles Area

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
UNIVERSITY OF CALIFORNIA--LOS ANGELES				
*Feeley, T.	PhD	Earth & Space Sciences	Davidson	Geology and Petrology of Quaternary Volcanic Rocks from the Salon De Vyvni Region, Southwest Bolivia
*Hassanzedeh, J.	PhD	Earth & Space Sciences	Davidson	Cenozoic Magmatism and Associated Mineralization in Shahr Babak Area, SE Central Iran
UNIVERSITY OF COLORADO				
*Verplanck, P.	PhD	CIRES	Farmer	Geochemistry of the Organ Needle Pluton, New Mexico
TEXAS TECH. UNIVERSITY				
*Husband, T.	MS	Geosciences	Barrick	Geochemical Characterization of Black Shales in a Pennsylvanian Cyclothemic Sequence, Kansas
*Johnson, K.	PhD	Geosciences	Barnes	Petrogenesis of the Tonalite-Trondhjemite Association, Cornucopia Stock, Eastern Oregon
RICE UNIVERSITY				
*Woodford, T.	MA	Geology	Leeman	Geochemical Variations in Cascade Magmas
*Xu, P.	PhD	Geology	Leeman	Fluid-Rock Interaction in Geothermal Systems
TULANE UNIVERSITY				
*Sanchez, E.	PhD	Geology	Nelson	Geology and Petrology of Socorro Island, Revillagigedo Archipelago, Mexico
LOUISIANA STATE UNIVERSITY				
*Lei, Q.	MS	Nuclear Science	Knaus	Measurement of Accretion Rates in Wetland Habitats Over a Six to Eight Year Time Span

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis/Project Topic
LEHIGH UNIVERSITY				
*Tenore-Nortrup, J.	MS	Geology	Bebout	Metasomatism at Blueschist-Grade Conditions: Alteration of Dioritic and Gabbroic Conglomerate Cobbles in the Blueschist Unit of the Catalina Schist, Southern California
UNIVERSITY OF ROCHESTER				
*Kohli, R.	PhD	Geological Sciences	DeCelles	Chemostratigraphic Analysis of Jurassic-Cretaceous Nonmarine Foreland Basin Fill in Wyoming and Idal[illegible]
STATE UNIVERSITY OF NEW YORK				
*Stuart, C.	MS	Geology	Harper	Te[illegible]magmatic Discrimination of a Silicic Alkaline Metavolcanic Unit in the Fra[illegible] Complex
RENSSELAER POLYTECHNIC INSTITUTE				
*Zhang, Y.	PhD	Geology	Miller	Thermal Hist[illegible]y of Sedimentary Basins
UNIVERSITY OF NORTH CAROLINA				
*Miller, J.	PhD	Geology	Glazner	Cenozoic Magmatism of the SW United States
NORTH CAROLINA STATE UNIVERSITY				
*Galar, P.	PhD	Marine, Earth and Atmospheric Science	Fodor	Petrogenesis of Gabbro and Ultramafic Xenoliths from Mauna Kea Volcano, Hawaii
UNIVERSITY OF MAINE				
*Connolly, J.	PhD	Biology	Jellison	Cation Transport by Degradative Fungi

* Thesis research which utilized the OSTR.

Table VI.C.3

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

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
118	G. Larson M. Herley	National Park Service, OSU Cooperative Studies Unit	Crater Lake	Study of the primary production of phytoplankton in Crater Lake using ^{14}C labelled substances.	Forestry, OSU
*165	J. Cooper	NEA, Inc.	Pollution Studies	NAA of sediments and filter papers.	NEA, Inc.
*231	H. Wollenberg	Lawrence Berkeley Laboratories	GRP Project	Fission track determination of uranium distribution and abundance in fractured heated rock.	Lawrence Berkeley Laboratories
*321	J. Steidtmann	Geology, University of Wyoming	Foreland Investigation	Fission track determination of the location of ^{235}U, ^{238}U and ^{232}Th in natural rocks and minerals.	University of Wyoming
*322	D. Miller	Geology, Rensselaer Polytechnic Institute	Fission Track Research	Fission track determination of the location of uranium and thorium in natural rocks and minerals.	Geology, Rensselaer Polytechnic Institute
*335	B. Kowallis	Geology, Brigham Young University	BYU Fission Track Study	Fission track dating of natural rocks and minerals.	Geology, Brigham Young University
*427	J. White	U.S. Bureau of Mines--Albany	Nitride Inclusions in Titanium Alloys	Development of INAA and neutron radiographic techniques to detect nitride inclusions in titanium alloys.	U.S. Bureau of Mines--Albany
*428	R. Schmitt Y.-G. Liu	Chemistry, OSU	Meteorites	INAA of meteorite samples.	NASA
*444	R. Duncan C. McElwee D. Desonie	Oceanography, OSU	^{40}Ar-^{39}Ar Dating	Production of ^{39}Ar from ^{39}K to measure radiometric ages on basaltic rocks from ocean basins.	Oceanography, OSU
*452	R. Schmitt Y.-G. Liu	Chemistry, OSU	NAA of Sediment Samples	Determination of Al content in selected sediment samples from the Pacific Ocean.	NASA
480	A. Johnson B. Dodd J. Higginbotham	Radiation Center, OSU	RC Technical Support to Oregon DOE and Department of Human Resources	Technical support to the state of Oregon to assist in emergency preparedness for the PGE-TROJAN facility.	Radiation Center, OSU
481	L. Winans	Oregon Health Sciences University	Calibration of Radiation Survey Instruments	Survey instrument calibration for the Oregon Health Sciences University.	Oregon Health Sciences University

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
482	D. Fox	Vollum Institute, Oregon Health Sciences University	Calibration of Radiation Survey Instruments	Survey instrument calibration for the Vollum Institute for Advanced Biomedical Research.	Vollum Institute
488	R. Farmer	Radiation Safety Office, OSU	Calibration of Portable Survey Instruments	Calibration of portable radiation survey instruments for radiation users on OSU campus.	Radiation Center, OSU
489	N. Goevelinger	Oregon State Health Division, Radiation Control Section	Calibration of Radiation Control Section Portable Survey Instruments	Calibration of portable radiation survey instruments for Oregon Radiation Control Section.	Radiation Control Section, OSHD
519	B. Livingstone J. Gile F. Monaco	USEPA--Corvallis	Instrument Calibration	Calibration of EPA portable radiation survey meters.	USEPA--Corvallis
*521	J. Vance	Geological Science, University of Washington	Fission Track Studies	Thermal column irradiation of zircon and other samples to induce fission tracks in catcher foils for dating.	Dept. of Geological Science, University of Washington
535	B. Nash	U.S. Bureau of Mines--Albany	Instrument Calibration	Calibration of Bureau of Mines' portable radiation survey meters.	U.S. Bureau of Mines--Albany Research Center
547	B. Boese	USEPA, Newport	Survey Instrument Calibration	Calibration of GM and other portable survey meters.	USEPA
*548	R. Schmitt Y.-G. Liu	Chemistry, Radiation Center, OSU	Major and Trace Element Study of Lunar Volcanic Glasses	INAA of very small lunar glass samples.	NASA
554	K. Niles D. Stewart-Smith	Oregon Department of Energy	Instrument Calibration for Oregon Department of Energy	Instrument calibration of survey meters for PUC truck inspectors.	Oregon Department of Energy
622	W. Chism	Private citizen	^{60}Co Irradiation of Wood Samples	Irradiate wood samples to be used in violin bridges in ^{60}Co irradiator.	Radiation Center, OSU
632	R. Thompson	Oregon State Police	Radiation Survey Instrument Calibration for Oregon State Police Crime Laboratory	Calibration of portable radiation survey instruments.	Oregon State Police, Crime Laboratory

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*634	S. Binney	Nuclear Engineering, OSU	Production of Medical Radioisotopes	Determination of production rates and unknown or poorly known cross sections for radioisotopes of medical interest.	Nuclear Engineering, OSU
*639	R. Collier R. Conard	Oceanography, OSU	Trace Elements in Sediment Cores and Sediment Traps from Southern Oregon Coast	INAA of oceanographic sediment samples to determine trace element composition.	Marine Geology, OSU
640	J. Higginbotham	Radiation Center, OSU	Investigation of the Response of Glass Calibration Capsules to High Energy Gamma Ray Irradiation	Determination of the dose response of glass personnel radiation dosimeters.	Radiation Center, OSU
661	M. Dibblee J. Higginbotham	Oregon Health Division, Radiation Control Section; Radiation Center, OSU	In situ Measurement of Radionuclide Content of Canned Pacific Northwest Foodstuffs, 1930-1960	Gamma ray spectroscopy of foodstuffs canned between 1930 and 1960.	Radiation Center, OSU
664	M. Huntington	Good Samaritan Hospital, Special Imaging	Instrument Calibration, Radiation Survey Instruments	Calibration of radiation survey instruments.	Radiation Center, OSU
665	R. Shaw	Corvallis Fire Department	Instrument Calibration, Radiation Survey Instruments	Calibration of radiation survey instruments.	Radiation Center, OSU
*704	A. Russell S. Emerson	School of Oceanography, University of Washington	Use of Uranium in Foraminifera as a Tracer of Deep Water Anoxia in the Pleistocene	Thermal column irradiation of $CaCO_3$ samples containing trace quantities of uranium to induce fission tracks in backing foils.	School of Oceanography, University of Washington
708	J. Reyes H. Ahn A. Ala	Nuclear Engineering, OSU	AP600 Long Term Cooling Test	Fabrication and testing of a scale model of a section of the Westinghouse AP600 reactor cooling system.	Westinghouse
*709	B. Dodd R. Snuggerud	Nuclear Engineering, OSU	OSTR Rod Calibration Program	Development and testing of a computer program to enable computer-assisted control rod worth calibrations to be performed.	Radiation Center, OSU
711	D. Mattson	Veterinary Medicine, OSU	Diagnostic Biology	Sterilization of serum in ^{60}Co irradiator.	Veterinary Medicine, OSU

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
712	J. Entry P. Donnely	Forest Science, OSU	Herbicide Degradation by Fungi	Radiotracer research utilizing ^{14}C.	Forest Science, OSU
713	D. Parsons	Private citizen	Cobalt-60 Irradiation of Gemstones	Irradiation of various gemstones to prescribed levels in ^{60}Co irradiator to induce color changes.	D. Parsons
*715	J. Steiner R. Walker	City College of New York; Radiation Center, OSU	Continuing Geochemical Characterization of the Palisades Sill, New York and New Jersey	Investigation of petrochemical charges through magmatic differentiation and crystal fractionation in various parts of the Palisades Sill.	Radiation Center, OSU (Unfunded Research)
*722	R. Beard	U.S. Bureau of Mines--Salt Lake City, Utah	^{95}Zr Tracer Production	Production of ^{95}Zr by irradiation of ultra-pure Zr in the OSTR.	U.S. Bureau of Mines
724	J. Higginbotham J. Liedtke	Nuclear Engineering, OSU	Laboratory Preparedness for Radiological Emergency Response	Development of analysis procedures to ensure quick response to large-scale radiological emergencies.	Oregon Department of Energy
741	W. Loveland	Chemistry, OSU	Target Fragmentation in Low Energy, Intermediate Energy, Relativistic and Ultra Relativistic Nuclear Collisions	Gamma spectroscopy analysis of various targets irradiated at accelerator facilities throughout the world.	Chemistry, OSU
745	T. Clarke	University Hospital, Oregon Health Sciences University	Gamma Sterilization	Irradiation of various medicinals to OHSU-specified doses in ^{60}Co irradiator for the purpose of sterilization.	Radiation Center, OSU
747	B. McBee	McBee and Associates	Estimate of Gamma Shielding Properties of Sulfur Polymer Concrete	Measurement of the reduction in gamma intensity as a function of the thickness of sulfur polymer concrete.	McBee and Associates
*748	D. Rosenberg	U.S.D.A., Fisheries and Wildlife, OSU	Migration and Predator Loss of Salamanders	Production of ^{182}Ta in the OSTR in small wire segments for implantation into salamanders.	Fisheries and Wildlife, OSU
*751	B. Albertson S. Binney S. Martsolf J. Johnson	Medicine/Endocrinology, Oregon Health Sciences University; Radiation Center, OSU	Pituitary Tumor Therapy Using Boron Neutron Capture Therapy	Irradiation of tissue samples containing ^{10}B compounds to enhance cell killing in B-loaded cells.	Oregon Health Sciences University
752	D. Barnes C. Rawson	Biochemistry, OSU	Schistosoma Cell Culture	Irradiation of feeder layer with ^{60}Co irradiator.	Biochemistry, OSU

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
756	M. Craig S. Smith D. Wachenheim D. Bilich	Veterinary Medicine, OSU	Bacterial Incubation with ^{14}C-Trinitrotoluene	Incubation of bacteria in ^{14}C-labelled TNT with (analysis and separation) of metabolic products by liquid scintillation counting and other methods.	Veterinary Medicine, OSU
768	S. Kaattari J. Dekoning	Microbiology, OSU	Irradiation of Anterior Kidney Suppressor Cells (Fish)	Irradiation of kidney cells using the ^{60}Co irradiator.	Microbiology, OSU
771	S. Kaattari H. Ortega	Microbiology, OSU	Limiting Dilution Assay of Fish Peripheral Blood Cells	Irradiation of fish peripheral blood cells in ^{60}Co irradiator.	Microbiology, OSU
*773	D. Miller M. Roden C. Ravenhurst J. Jackson	Rensselaer Polytechnic Institute	Thermal History of Sedimentary Basins	Use of fission track dating of apatites and zircons to determine the thermal history of a basin as it subsides and is uplifted.	USDOE (Reactor Use Sharing)
*775	J. Davidson T. Feeley	Earth and Space Sciences, University of California--Los Angeles	Petrology and Geochemistry of Volcano Ollaque, Andean Central Volcanic Zone	Use of INAA to understand the petrogenesis of volcanic rocks erupted from volcano Ollaque and for comparison with other volcanic rocks from the Central Volcanic Zone.	USDOE (Reactor Use Sharing)
*777	P. Verplanck G. Farmer	CIRES, University of Colorado	Geochemistry of the Organ Needle Pluton, New Mexico	Use of INAA to characterize the compositional variations within the Organ Needle Pluton for evaluation of the differentiation processes leading to element zonations in silicic magma chambers.	USDOE (Reactor Use Sharing)
*779	W. Leeman P. Xu	Geology and Geophysics, Rice University	Fluid-Rock Interaction in Geothermal Systems	Use of INAA to evaluate trace element mobility in aqueous fluids from two geothermal systems: Valles Caldera and Broadlands (New Zealand).	USDOE (Reactor Use Sharing)
*782	J. Schieber	Geology, University of Texas--Arlington	Trace Element Investigation of the Jurassic "Opalinuston" in SW Germany	Investigation of rare earth element patterns in sedimentary basins and post-emplacement weathering effects.	USDOE (Reactor Use Sharing)
783	J. Entry N. Vance	Forest Science, OSU	Cesium and Strontium Uptake in Forest Trees	Determination of the rate of uptake of cesium and strontium radiotracers by trees.	Forest Science, OSU

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*787	C. Shearer	Institute of Meteoritics and Department of Geology, University of New Mexico	Construction of Devonian Tectonic Models for Central Massachusetts Using Trace Element Chemistry of Plutonic Rocks	Determination of the processes of magmatism during the early Paleozoic of eastern North America.	USDOE (Reactor Use Sharing)
*788	D. Smith	Geology, Trinity University	Petrology and Geochemistry of the Enchanted Rock Batholith, Llano Uplift, Texas	Determination of the petrogenesis of the Enchanted Rock batholith through the relationships of the trace element content of the various plutons.	USDOE (Reactor Use Sharing)
*789	P. Weigand K. Savage	Geological Sciences, California State University--Northridge	Origin of Miocene Volcanic Rocks from the Los Angeles Area	Trace element comparison of volcanic rocks to determine their geologic origin, whether tectonic or magmatic.	USDOE (Reactor Use Sharing)
*790-I	A. McBirney E. Sonnenthal G. Goles R. Lambert R. Naslund	Geological Sciences, University of Oregon	Geochemical Studies of the Skaergaard Intrusion	Refinement of the petrochemical data available on the Skaergaard to further constrain petrologic modelling of a differentiated magma.	USDOE (Reactor Use Sharing)
*790-II	A. McBirney E. Sonnenthal G. Goles R. Lambert R. Naslund	Geological Sciences, University of Oregon	Geochemical Studies of the Skaergaard Intrusion	INAA of geological samples from the Skaergaard Intrusion.	Geological Sciences, University of Oregon
*792	S. de Silva	Geography and Geology, Indiana State University	Source Characteristics of Young Volcanic Rocks in the Central Andes	Use of trace element analysis to determine the sources of magmas for volcanic rocks erupted in the Central Andes, South America.	USDOE (Reactor Use Sharing)
*793	S. DeBari	Geology and Geophysics, University of Hawaii	Intracrustal Magma Evolution in a Jurassic Island Arc: A Case Study of the Wrangellian Crustal Section from Vancouver Island, Canada	Vertical trace element characterization through a volcanic island arc.	USDOE (Reactor Use Sharing)

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*794	R. Fodor P. Galar	Marine, Earth and Atmospheric Sciences, North Carolina State University	Geochemistry of Gabbroic Xenoliths and Their Clinopyroxenes, Mauna Kea Volcano, Hawaii	Determination of parent magma compositions for the gabbros through their clinopyroxene and whole-rock chemistry.	USDOE (Reactor Use Sharing)
*797	P. DeCelles R. Kohli	Geological Sciences, University of Rochester	Chemostratigraphic Analysis of Jurassic-Cretaceous Nonmarine Foreland Basin Fill in Wyoming and Idaho	Use of INAA to determine trace element compositions of mudstones to establish chemostratigraphic correlations and sequence stratigraphy.	USDOE (Reactor Use Sharing)
*798	J. Steiner	Earth and Atmospheric Sciences, City College of New York	Rare Earth Element Systematics of the Northern Palisades Sheet, New York	Use trace element concentrations to delineate a recently discovered diabase layer within the Palisades Sill.	USDOE (Reactor Use Sharing)
*799	G. Retallack A. Rice	Geological Sciences, University of Oregon	Geochemical Evaluation of Acid Rain in Paleosols at the Cretaceous-Tertiary Boundary	Determination of trace element concentrations of paleosols to investigate the action of acid rain at the Cretaceous-Tertiary boundary.	USDOE (Reactor Use Sharing)
*800	B. Nelson N.-L. Anders	Geological Sciences, University of Washington	Transition of Tholeiitic to Alkalic Volcanism on Ocean Islands	Determination of trace element concentrations of basalts in a cliff on Molokai, Hawaii.	USDOE (Reactor Use Sharing)
*801	K. Hoernle J. Gill H. Schmincke	Earth Sciences, University of California--Santa Cruz	Petrogenesis of Volcanics from Madeira and Porto Santo Islands, Atlantic Ocean	Determination of trace element concentrations of dated basalts from these islands to determine their origin.	USDOE (Reactor Use Sharing)
*802	J. Hassanzadeh J. Davidson M. Barton	Earth Sciences, University of California--Los Angeles	Cenozoic Magmatism and Associated Mineralization in Shahr Babak Area, SE Central Iran	Investigation of mineralized volcanics for Iran using trace element contents determined using INAA.	USDOE (Reactor Use Sharing)
*804	D. McCreery	Religion, Willamette University	The Tell Nimrin Project	Trace element investigation of ancient flax seeds and sediments to establish salinization of the soil due to irrigation.	USDOE (Reactor Use Sharing)
810	R. Murer	Sun Seeds-II	Egg Transformation in Onion Flowers Via ^{60}Co Irradiation	Irradiation of onion flowers using ^{60}Co to induce changes in cell nuclei.	Sun Seeds

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*814	D. McCreery	Religion, Willamette University	The Tell Nimrin Project	Trace element investigation of ancient flax seeds and sediments to establish salinization of the soil due to irrigation.	Religion, Willamette University
815	J. Morrell M. Mankowski C. Sexton	Forest Products, Entomology, OSU	Sterilization of Wood Samples for Fungal Evaluations	Sterilization of wood samples in ^{60}Co irradiator (Gammacell 220).	Forest Products, OSU
819	R. Smith B. Webb S. Todd F. Garmon	Umpqua Research Company	Sterilization of Water Purification Components	Sterilization of water purification system components for space travel using the ^{60}Co irradiator.	Umpqua Research Co.
*820	W. Ayres R. Bryson R. Mauricio O. Kataoka R. Olmo	Anthropology, University of Oregon	Determination of Prehistoric Basalt "Logs" Sources	Trace element characterization of columnar basalts from Nan Madol to determine the source of the basalts.	USDOE (Reactor Use Sharing)
*821	T. Connolly	Museum of Natural History, University of Oregon	Geochemical Characterization of Rhyolitic Obsidians from Newberry Volcano, Central Oregon	Trace element characterization to determine if these obsidians are the source/sources for prehistoric Native Americans.	USDOE (Reactor Use Sharing)
*822	Radiation Center Staff	Radiation Center, OSU	Radiation Center Tours	Tours of the Radiation Center and TRIGA reactor for various non-OSU academic groups on an as-requested basis.	USDOE (Reactor Use Sharing)
*823	C. Barnes K. Johnson	Geosciences, Texas Tech University	Petrogenesis of the Tonalite-Trondhjemite Association, Cornucopia Stock, Eastern Oregon	Determination of the source of cordierite-bearing trondhjemite from the Wallowa batholith using trace element characteristics.	USDOE (Reactor Use Sharing)
*824	A. Glazner D. Coleman J. Miller	Geology, University of North Carolina	Geochemical Transect of Mafic Rocks in the Sierra-Mojave Batholith	Quantification of chemical differences of the lithosphere that gave rise to Sierra and Mojave batholiths.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR.

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*828	S. Nelson E. Carballido-Sanchez	Geology, Tulane University	Geology and Petrology of Socorro Island, Revillagigedo Archipelago, Mexico	Geochemical characterization of lavas associated with Volcan Evermann, Mexico.	USDOE (Reactor Use Sharing)
*829	G. Harper	Geological Sciences, State University of New York	Re-examination for Thorium, Josephine Ophiolite	Analysis of previous project on the Josephine ophiolite in an attempt to provide better thorium values.	USDOE (Reactor Use Sharing)
*830	R. Thompson S. Lohse D. Fortsch	Anthropology, Geology, Idaho State University	Stratigraphic Analysis of a Presumed Prehistoric Midden from Hells Canyon, Oregon	Trace element content matching of archeological material to determine if they have the same source.	USDOE (Reactor Use Sharing)
*831	J. Shervais	Geological Sciences, University of South Carolina	Metamorphic Rocks of the Coast Range, California	Trace element characterization of metamorphic basalts from the Franciscan formation, California.	Geological Sciences, University of South Carolina
*832	C. Neal	Geological Sciences, University of Notre Dame	INAA of Clinopyroxene Mineral Separates	Analysis of mineral separates using INAA.	Geological Sciences, University of Notre Dame
*834	S. Binney	Nuclear Engineering, OSU	Production of ^{13}N	Production of ^{13}N by $^{10}B(n,\alpha)^{7}Li$ + $^{10}B(\alpha,n)^{13}N$.	Radiation Center, OSU
*838	M. Kasuya	Kyoto Fission-Track Co., Ltd., Japan	Fission Track Dating of Geologic Materials	Thermal column irradiation of geologic materials for fission track age dating.	Kyoto Fission-Track Co., Ltd.
841	D. Ulaeto	Microbiology, OSU	Cell Mediated Immune Responses to Vaccinia Virus	^{60}Co irradiation of murine cells.	Microbiology, OSU
842	P. Millard	Molecular Probes	Viability of Bacillus Subtillus Spores	^{60}Co irradiation of spore samples.	Molecular Probes
*844	M. Reed A. Getahun	Geological Sciences, University of Oregon	Chemical Gains and Losses in Altered Wall Rocks Around a High Temperature Volcanic Fumarole and in an Acid Sulfate Gold-Copper Deposit	Comparison of actual geochemical data to analytical values predicted by computer models for the two deposit types.	USDOE (Reactor Use Sharing)
*846	H. Shioda	First Atomic Power Industrial Group (FAPIG), Japan	Irradiation and Analytical Support	Irradiation and analytical support for studies being carried out by FAPIG.	FAPIG, Japan

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
850	W. Vanmuiswinkel	Microbiology, OSU	Memory Formation in Fish	Irradiation of fish cells in Budd irradiator.	Microbiology, OSU
854	E. Hansen B. Ferguson	Botany, OSU	Root Rot of Abies and Pinus Species	^{60}Co sterilization of wood samples.	Botany, OSU
*855	G. Klinkhammer R. Conard	Marine Geology, Oceanography, OSU	Trace Element Analysis in Ocean Drilling Project Core Site 846	INAA of 40 samples for trace element analysis.	Oceanography, OSU
*858	J. Higginbotham D. Pratt	Nuclear Engineering, Radiation Health, OSU	Beta Spectroscopy	Preparation and analysis of five standard and four mixed source cloth smears.	Radiation Center, OSU (Unfunded Research)
859	R. Muren	Sun Seeds-III	^{60}Co Irradiation of Onion Flowers	Gamma irradiation of onion flowers to 25K and 50K R.	Roger Muren
*860	C. Neal	Civil Engineering, Geological Sciences, University of Notre Dame	INAA of Mineral Separates	INAA of 13 mineral separates.	Civil Engineering, Geological Sciences, University of Notre Dame
863	J. Morris K. Astrahantseff	Zoology, OSU	Interactions Between Stromal and Epithelial (Mouse) Cells During Estrogen Stimulation	Creation of a non-dividing feeder layer.	Zoology, OSU
*864	B. Gallagher R. Walker	Radiation Center, OSU	INA Analysis for Study of Gesteins Formations	Trace element determination of various rock samples from significant geologic sites around the United States to determine composition and origin.	Radiation Center, OSU (Unfunded Research)
865	J. Ayres J. Kalns	Pharmacy, OSU	Changes in Uremic Gut Using Coated L. Acidophilus Beads	Gamma irradiation of L. Acidophilus bacteria.	Pharmacy, OSU
*866	D. Olander A. Mansouri	Nuclear Engineering, University of California--Berkeley	Fission Product Migration in UO_2 Disks	Irradiation of depleted UO_2 disks for evaluation of fission product migration.	Nuclear Engineering, University of California--Berkeley
*867	S. Shepherd J. Ringle	Nuclear Engineering, OSU	Chemonuclear Dissociation	Irradiation of chemicals in X-ray, ^{60}Co and reactor to induce breakdown of molecules.	Nuclear Engineering, OSU

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*868	J. Jellison	Plant Biology & Pathology, University of Maine	Cation Analysis of Wood Degraded by White & Brown Rot Fungi	INAA of wood samples to measure selected elements.	University of Maine
869	T. Nelson	Teledyne Wah Chang--Albany	Attenuation of Gamma Rays from ^{226}Ra (with Daughters) by Asphalt	Measurement of the gamma ray attenuation provided by asphalt to find the half- and tenth-value layers for radiations from ^{226}Ra and daughter products.	Teledyne Wah Chang
*870	W. McBee	McBee and Associates	Resistance of Sulfur Polymer Concrete to Gamma Radiation	Irradiation of samples of sulfur polymer concrete to 10^9 rads in the ^{60}Co irradiator.	W. McBee
*871	J. Higginbotham	Radiation Center, OSU	^{60}Co Investigations into Color Center Activation in Topaz Stones	Irradiation of one, one-gram raw topaz stone to 250 MRad.	Radiation Center, OSU (Unfunded Research)
*872	V. Sisson	Geology & Geophysics, Rice University	Kodiak Island, Alaska Sediments	INAA of graywocke & argillite sediments from Kodiak Island, Alaska.	Rice University
873	G. Wilson	Chiloquin School	Irradiated Bean Seeds	Irradiation of bean seeds in ^{60}Co irradiator.	Chiloquin School
*874	A. Grunder M. Streck	Geosciences, OSU	Petrology of the Rattlesnake Ash Flow Tuff	INAA to determine the petrogenesis of high silica rhyolites, dacites, and andesites in the Rattlesnake Tuff magma chamber.	Radiation Center, OSU
*875	K. Levine S. Demessie	Chemical Engineering, OSU	Impregnation of Fiberous Materials Using Supercritical Fluids	INAA of impregnated wood samples to assess uptake of a biocide compound.	Chemical Engineering, OSU
876	D. Holbo	Forest Research Lab, OSU	Density Measurements of Wood Using X-Rays	Consultation on the design of a facility to assess density of wood using X-rays and/or radioisotopes.	Forest Research Lab, OSU
*878	A. Grunder J. MacLean	Geosciences, OSU	Petrology and Geochronology of Silicic Dome Complexes in Southeastern Oregon	Age and geochemistry study of late Miocene silicic rocks in the Harney Basin, SE Oregon, to constrain mechanism of vent migration and relation to large volume ignimbrites, i.e. Rattlesnake Tuff.	Radiation Center, OSU
*879	J. Steiner	Earth & Planetary Sciences, City College of New York	Petrologic Study of Ore Deposits	Petrologic study of Sterling Hill and Franklin Furnace ore bodies as well as newly discovered facies of the Palisades sheet of New York and New Jersey.	USDOE (Reactor Use Sharing)

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*880	S. Olsen	Earth & Planetary Sciences, Johns Hopkins University	A Geochemical Study of Migmatites in the Lauterbrunnen Crystalline Complex, Swiss Alps	Comprehensive geochemical/isotopic/field study of the migmatites in the Lauterbrunnen Valley in the Aar Massif in the Swiss Alps.	USDOE (Reactor Use Sharing)
*881	G. Harper	Geological Sciences, State University of New York	Thorium Analysis of Late Jurassic Syntectonic Dikes	Epithermal INAA of 14 geologic samples to assess Th content.	USDOE (Reactor Use Sharing)
*882	J. Hansen B. O'Conner	U.S. Bureau of Mines, Albany	Precious Metals in Municipal Incinerator Slag	INAA of municipal incinerator slag to assess Au & Ag content.	S. Binney, BNCT Contract
*883	C. Barnes	Geosciences, Texas Tech. University	Analysis of Gabbro Samples	INAA of 6 gabbro samples.	Texas Tech. University
884	F. Heinith D. Pratt	Kaiser-Permanente	^{45}Ca Verification Project	Confirmation of the presence of ^{45}Ca in solutions provided by Kaiser and measurement of their radioactivity content.	Kaiser-Permanente
885	S. Ramos	Science Class, Nyssa Elementary School	Gamma Irradiation of Seeds	Irradiation of bean seeds to different doses in the ^{60}Co irradiator for a class experiment.	Radiation Center, OSU (Unfunded Research)
*886	C. Barnes	Geosciences, Texas Tech. University	Geochemical Comparison of Jurassic Greenshists, Klamath Mountains, Oregon and California	INAA to measure rare earth elements, Th, Hf and U in Greenshists.	USDOE (Reactor Use Sharing)
*887	J. Davidson S. Nelson	Earth & Space Sciences, University of California--Los Angeles	Geochemical Characteristics of the Basement Subjacent to the Tatara-San Pedro Volcanic Complex, S. Chile	INAA to measure rare earth elements, Hf, Ta, Th, U and Sc to evaluate the evolution of an active arc volcano.	USDOE (Reactor Use Sharing)
*888	D. Miller M. Roden C. Ravenhurst Y. Zhang	Earth & Environmental Sciences, Rensselaer Polytechnic Institute	Thermal History of Sedimentary Basins	Thermal history study of rocks using fission track analysis of apatites and zircons.	USDOE (Reactor Use Sharing)
*889	B. Epperson J. Curtis	McNary High School	NAA of Columbia River Area Rock Samples to Determine Age, Source and Origin	Neutron activation analysis of rock samples from sources near the Columbia River in Portland, Oregon, to trace age, source and likely origin.	USDOE (Reactor Use Sharing)

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Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*890-I	M. Reed A. Getahun	Geological Sciences, University of Oregon	Chemical Gains and Losses in Altered Wall Rocks Around a High Temperature Volcanic Fumarole	Measurement of the chlorine content in selected samples from an acid-sulfate gold-copper deposit.	USDOE (Reactor Use Sharing)
*890-II	M. Reed A. Getahun	Geological Sciences, University of Oregon	Fluid-Rock Reactions and Mineralization in Two High-Level Volcanic Settings: Augustine Fumaroles and the Summitville Acid-Sulfate Copper-Gold Deposit	Documentation of the alteration of mineral assemblages of the Summitville shallow level acid-sulfate environment and the deep level "porphyry type" mineralization and study of the genetic relationship of the two systems.	USDOE (Reactor Use Sharing)
*891	C. Barnes K. Johnson	Geosciences, Texas Tech. University	Mesozoic and Cenozoic Plutonism in the Blue Mountains, NE Oregon.	Characterization of the compositional nature of Blue Mountains plutons with respect to their spatial and temporal distributions.	USDOE (Reactor Use Sharing)
*892	R. Fodor P. Galar	Marine, Earth & Atmospheric Sciences, North Carolina State University	Geochemistry and Mineral Chemistry of Gabbro Xenoliths, Mauna Kea Volcano, Hawaii	Determination of parent magma compositions for the gabbros.	USDOE (Reactor Use Sharing)
*893	K. Hoernle J. Gill H. Schmincke	Earth Sciences Board, University of California--Santa Cruz	Spatial Variation in Trace Element Geochemistry of Holocene Canary Volcanics	INAA of nephelimites through tholeiites, and basanites through phonolites.	USDOE (Reactor Use Sharing)
*894	R. Knaus Q. Lei D. VanGent	Nuclear Science Center, Louisiana State University	Measurement Via INAA of Recent Accretion Rates in Four Wetland Habitats Over a Time Span of Six to Eight Years	Measurement of ^{152}Sm, ^{169}Dy and ^{24}Na levels in dried mud samples using INAA.	USDOE (Reactor Use Sharing)
*895	A. McBirney E. Sonnenthal	Geology, University of Oregon	Two-Dimensional Map of a Large Differentiated Intrusion	INAA to test models of trace element behavior in igneous rocks.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*896	D. McCreery	Willamette University	The Tell Nimrin Project	Archaeological investigation of Tell Nimrin, Jordan, for synchronic and diachronic analysis of ancient agricultural practices and climatic conditions in the Jordan Valley to determine which cultigens were grown at the site and which species were imported from the highlands.	USDOE (Reactor Use Sharing)
*897	P. Mueller S. Tamman	Geology, University of Florida	Evolution of the Archean Mantle in the Wyoming Province	Chemical analyses of mafic rocks emplaced in the Wyoming craton.	USDOE (Reactor Use Sharing)
*898	B. Nelson	Geological Sciences, University of Washington	Mesozoic Accretion of Continental Crust in Far-Eastern Russia	Determination of age and composition of underlying crust for granite intrusions in the Sikhote-Alin belt of far-eastern Russia.	USDOE (Reactor Use Sharing)
*899	J. Schieber R. Schmerold	Geology, University of Texas--Arlington	A Geochemical Survey of Proterozoic Metasediments and Metavolcanics From Central Ethiopia (Part II)	Irradiation and counting of geological sediments and volcanics.	USDOE (Reactor Use Sharing)
*900	M. Skewes	Geological Sciences, University of Colorado	Miocene Volcanic Rocks of the Central Valley of Chile, South America	Use of INAA to understand the origin of Miocene volcanism which occurred during the initial stages of the development of the central valley in south-central Chile.	USDOE (Reactor Use Sharing)
*902	G. Harper C. Stuart	Geological Sciences, State University of New York	Tectonomagnetic Discrimination of a Silicic Alkaline Metavolcanic Unit in the Franciscan Complex	INAA of silicic alkaline metavolcanic rocks for rare earth elements.	USDOE (Reactor Use Sharing)
*903	P. Verplanck G. Farmer	CIRES, University of Colorado	Geochemistry of the Organ Needle Pluton, New Mexico	INAA of rock samples to assess trace element content.	USDOE (Reactor Use Sharing)
*905	S. Hughes M. McCurry H. Ore J. Rochocki M. Hall T. Reid	Geology, Idaho State University	Instrumental Neutron Activation Analysis of Geologic Materials and Other Dry Solids	INAA supporting geochemical studies conducted by graduate students and faculty at Idaho State University.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
906	B. Sherr E. Sherr J. Rogers	Biological Oceanography, OSU	Production Release Assays	Liquid scintillation counting of cultural samples containing tritium.	Oceanography, OSU
*907	R. Warner N. Kidd	Earth Sciences, Clemson University	Crystallization of Pyroxene and Spinel Group Minerals in Diabase Dikes	INAA of pyroxene and spinel group minerals in diabase dikes.	USDOE (Reactor Use Sharing)
*908	M. Sparrow B. Conard F. Prahl B. Evenmeyer	Oceanography, OSU	Columbia River Estuary	INAA of Columbia River Estuary samples.	Oceanography, OSU
910	E. Riggs	Teledyne Wah Chang, Albany	Direct Radiation Levels from Zircon Sand	Measurement of direct gamma radiation levels from different containers of zircon sand.	Teledyne Wah Chang
*911	J. Barrick T. Husband	Geosciences, Texas Tech University	Geochemical Characterization of Black Shales in Pennsylvanian Cyclothemic Sequences	Characterization of major, trace, and rare earth elements within a well-studied Pennsylvanian black shale-dominated cyclothemic sequence.	USDOE (Reactor Use Sharing)
*912	S. DeBari	Geology, San Jose State University	Petrology of an Island Arc Crustal Section, Western Vancouver Island	Analysis of pre-existing crust onto that which the Jurassic Bonanza Arc was built.	USDOE (Reactor Use Sharing)
*913	G. Bebout J. Tenore-Nortrup	Earth & Environmental Sciences, Lehigh University	Trace Element Investigation of Devolatilization History in Metamorphosed Sedimentary and Mafic Rocks of the Catalina Schist (California)	INAA investigation of volatile loss and trace element behavior during progressive metamorphism of mafic and sedimentary rocks in the Catalina Schist, California.	USDOE (Reactor Use Sharing)
*914	J. Jellison J. Connolly	Plant Biology and Pathology, University of Maine	Comparison of Estimated Cation Concentrations in Wood	Comparing estimated cation concentrations in wood as determined by INAA vs ICP analysis.	USDOE (Reactor Use Sharing)
*916	W. Leeman T. Woodford	Geology & Geophysics, Rice University	Analysis of Basaltic Rocks from Western Cascades	Comparison of geochemical variations in Cascade magmas as a function of time with emphasis on early development of the volcanic arc.	USDOE (Reactor Use Sharing)

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*917	K. Falkner	Oceanography, OSU	Determination of Osmium in Seawater	Production of Os-191 and subsequent counting of seawater samples containing the osmium tracer.	Oceanography & Radiation Center, OSU
918	S. Sherrod Boy Scout Troup	Calapooia District Exec, Salem	Boy Scouts of America Atomic Energy Merit Badge	Tour and experiments conducted to allow completion of Atomic Energy Merit Badge.	Radiation Center, OSU (Unfunded Research)
*919	J. White	U.S. Bureau of Mines, Albany	Natural Levels of U and Th in Soil	Assessment of levels of U and Th in representative "clean" soil samples from Oregon and Idaho by epithermal INAA.	U.S Bureau of Mines--Albany
*920	T. Becker	Institute of Human Origins	Ar-Ar Dating	Production of ^{39}Ar from ^{39}K to determine ages in geologic materials.	Institute of Human Origins
921	J. White	U.S. Bureau of Mines--Albany	Gamma Counting of Soils and Effluents	Gamma spectroscopy on samples of soil, furnace effluents and filter residues to assess isotopic content and quantity (especially U, Th, Ra and daughters).	U.S. Bureau of Mines--Albany
922	D. Barnes D. Hobbs	Biochemistry, OSU	Schistosoma Juvenile Worm Mutagenesis	Irradiation of mice to 850 rads in Budd ^{60}Co irradiator.	Biochemistry, OSU
923	C. Bayne	Zoology, OSU	Schistosoma Sporocyst Mutagenesis	Irradiation of hamsters to 850 rads in Budd ^{60}Co irradiator.	Zoology, OSU
*924	G. Sturtz	Aromatics	^{60}Co Gamma Irradiation of Dill Seeds	Irradiation of packages of dill seeds to 2 kilorads, 10 kilorads, and 20 kilorads in the Budd irradiator.	George Sturtz
*925	R. Schmitt A. Hamoudi	Chemistry, OSU	Chemistry 505	Forensic INAA of bullets.	Radiation Center, OSU (Unfunded Research)
*926	D. Livingston	Technology & Resource Assessment Corp.	Yucca Mountain Rare Earth Element Study	INAA of calcite samples from Yucca Mountain to assess rare earth element abundances.	Technology & Resource Assessment Corp
*927	J. Steiner	Earth & Atmospheric Sciences, City College of New York	Meteorite/Bomb	INAA of meteorite samples.	City College of New York

* Project which involves the OSTR. INAA = Instrumental Neutron Activation Analysis

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
928	C. Palm	USEPA, Corvallis	Fate & Persistence of Transgenic Plant Protein in Soil	^{60}Co irradiation to sterilize soil samples (5 megarads dose).	Mantech Environmental
*929	R. Beard	U.S. Bureau of Mines--Salt Lake City	Production of ^{186}Re	Production of ^{186}Re by the irradiation ultra pure rhenium powder in the OSTR.	U.S. Bureau of Mines--Salt Lake City
*930	M. McWilliams B. Hacker	Geophysics, Stanford University	$^{40}Ar/^{39}Ar$ Dating of Geologic Samples	Irradiation of mineral grain samples for specified tiles to allow $^{40}Ar/^{39}Ar$ dating.	Stanford University
931	N. Kerkvliet P. Lawrence	Agricultural Chemistry, OSU	Study Effects of TCDD on T-Cell Activation, Using T-h Cell Clones	^{60}Co irradiation of spleen cells from mice.	Agricultural Chemistry, OSU
*932	T. Dumitru	Geology, Stanford University	Fission Track Dating	Thermal column irradiation of geological samples for fission track age dating.	Geology, Stanford University
*933	J. O'Connor	Geologisch Institute of Kiel, Germany	$^{40}Ar/^{39}Ar$ Dating	Epithermal irradiation of geological samples for $^{40}Ar/^{39}Ar$ dating.	Geologisch Institute

* Project which involves the OSTR.

INAA = Instrumental Neutron Activation Analysis

1. Neutron Activation Analysis

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

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

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

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

2. <u>Forensic Studies</u>

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. <u>Irradiations</u>

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

4. <u>Radiological Emergency Response Services</u>

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

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

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

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

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

5. Training and Instruction

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

Special training programs generally fall into one of several categories: visiting faculty and research scientists; International Atomic Energy Agency (IAEA) fellows; special short-term courses; or individual reactor operator or health physics training programs. During this reporting period there were six visiting scientists

and special trainees. Two visiting scientists, one from Sweden and one from Iran, worked in the field of nuclear chemistry under the direction of Dr. Loveland. A visiting associate professor from Portland Community College worked extensively on neutron activation analysis with the Radiation Center's geochemist this past year. One visiting student from Vassar College worked under the Space Grant Program with Dr. Klein. Finally, two high school students were mentored by Radiation Center staff and faculty during this reporting period.

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

6. Radiation Protection Services

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

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

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

In the current reporting period, the Radiation Center health physics program supported the OSU Radiation Safety Office by performing gamma spectroscopy on a number of charcoal filters and paper smears to identify possible airborne or surface contamination, by assisting the office with equipment and instrumentation needs, and by performing instrument calibrations for a number of organizations.

7. Radiological Instrument Repair and Calibration

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

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

In addition to the instrument repair capability, the Radiation Center has a facility for calibrating essentially all types of radiation monitoring instruments. This includes typical portable monitoring instrumentation for the detection and measurement of alpha, beta, gamma and neutron radiation, as well as instruments designed for low-level environmental monitoring. Higher range instruments for use in radiation accident situations can also be calibrated in most cases. Instrument

calibrations are performed using radiation sources certified by the National Institute of Standards and Technology (NIST) or traceable to NIST.

Table VI.C.4 is a summary of the instruments which were calibrated in support of the Radiation Center's instructional and research programs during this reporting period, 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.

8. Consultation

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

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

Table VI.C.4

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

Type of Instrument	Number of Calibrations
Radiation Center Instruments	
GM Detectors	73
Ion Chambers	35
Alpha Detectors	5
Neutron Detectors	5
Micro-R Meters	8
Mini Detectors	10
Civil Defense Detectors	20
Personnel Ion Chambers	92
Support Agency Instruments	
Corvallis Fire Department	31
Good Samaritan Hospital (Corvallis, OR)	16
TOTAL	295

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	7
Animal Sciences	4
Biochemistry/Biophysics	7
Bioresource Engineering	1
Botany and Plant Pathology	6
Chemistry	6
Crop Science	2
Entomology	1
Fisheries and Wildlife	2
Food Science and Technology	4
Forest Science	3
Horticulture	2
Microbiology	7
Nutrition and Food Management	1
Oceanic and Atmospheric Sciences	4
Pharmacy	1
Physics	5
Radiation Safety Office	15
Veterinary Medicine	2
Zoology	1
Non-OSU Agencies	
U.S. Bureau of Mines	1
U.S. Department of Agriculture, Agriculture Research Service	5
U.S. Environmental Protection Agency	6
Oregon Department of Energy	3
Oregon Department of Transportation, Highway Division	6
Oregon Health Sciences University	16
Oregon Public Utilities Commission	5
Oregon State Health Division	6
Good Samaritan Hospital	6
TOTAL	135

Table VI.C.6

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

Date	Organization	Instrument	Calibrated?	Nature of Repair
7/7/92	Oregon Health Sciences University	Victoreen 885	Yes	Replace GM tube
7/8/92	Biochem/Biophysics, OSU	Ludlum 14C	Yes	Replace battery case contacts
7/8/92	Botany, OSU	Eberline E120	Yes	Repair external speaker unit
7/20/92	Oregon Health Sciences University	Bicron Surveyor 2000	No	Correct misadjustment
7/21/92	Animal Science, OSU	Ludlum 2	Yes	Reassemble scintillation probe
8/7/92	South Eugene High School	Thornton Demonstrator	Yields	Design/construct HV power supply
8/20/92	Oregon State Health Division	Victoreen/Lionel CDV-700	No	Adapt for Ludlum end window GM probes
8/24/92	Radiation Safety Office, OSU	Technical Associates PUG-1	Yes	Replace battery carrier
9/23/92	Oregon Health Sciences University	Eberline RM14	No	Install Gel Cell battery backup
10/16/92	Radiation Safety Office, OSU	Technical Associates PUG-1	Yes	Replace transistor
10/30/92	Physics, OSU	Technical Associates PUG-1	Yes	Replace meter
10/30/92	Botany, OSU	Ludlum 2	No	Build new cable
11/4/92	Oregon Health Sciences University	Mini Monitor Series 900	No	Correct circuit noise problem
11/16/92	Pharmacy, OSU	Mini Monitor 5.10	Yes	Modify for pancake GM probe
12/11/92	Oregon Health Sciences University	Ludlum 12	No	Repair meter movement
12/22/92	Radiation Safety Office, OSU	Eberline E-120	Yes	Replace GM tube
1/12/93	Microbiology, OSU	Mini Monitor Series 900	Yes	Replace GM tube
2/10/93	Oregon State Health Division	Victoreen 471A	Yes	Replace Reed switch
2/10/93	Food Science and Technology, OSU	Technical Associates PUG-1	Yes	Replace transistor
2/12/93	Botany, OSU	Eberline E-120	Yes	Replace GM tube

Table VI.C.6 (continued)

Date	Organization	Instrument	Calibrated?	Nature of Repair
3/12/93	Radiation Safety Office, OSU	Ludlum 28	Yes	Repair power supply
3/18/93	Oregon Public Utilities Commission	Ludlum 6	Yes	Replace meter bezel
3/25/93	Oregon Health Sciences University	Mini Monitor Series 900	No	Replace probe with BNC connector, modify HV power supply
4/12/93	Oregon Health Sciences University	Nuclear Associates 3700	No	Replace probe with BNC connector, add speaker
4/21/93	Food Science and Technology, OSU	Bertold Flat Plate Scanner	No	Complete system checkout
4/28/93	Oregon Health Sciences University	Ludlum 3	No	Replace battery contacts, replace meter scale
6/28/93	Oregon Health Sciences University	Mini Monitor Series 900	No	Replace probe with BNC connector, modify HV power supply
6/29/93	U.S. Dept. of Agriculture	Ludlum 3	No	Cut off damaged end of cable, reinstall connector
Total Number of Repairs			**28**	

PART VII

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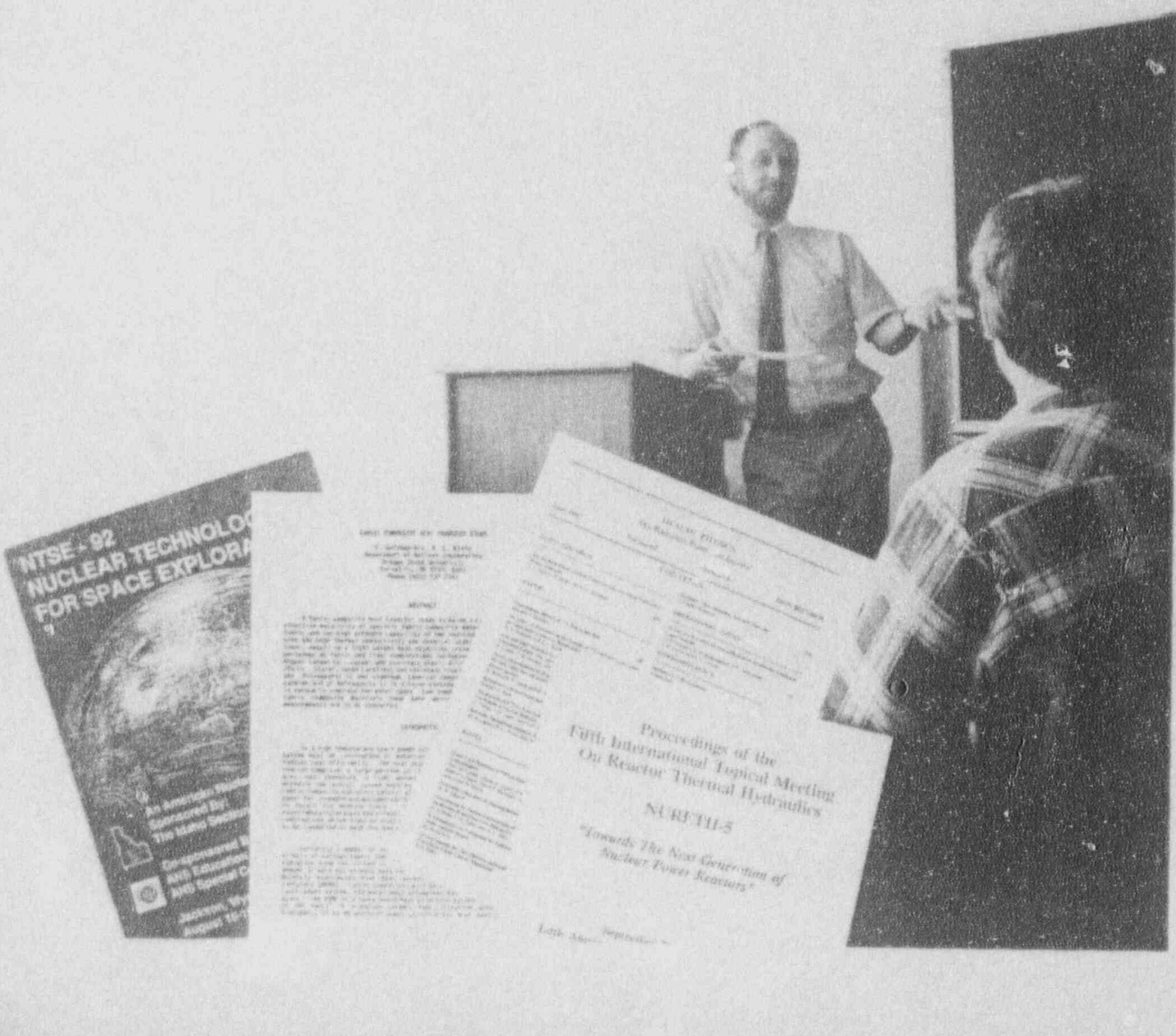

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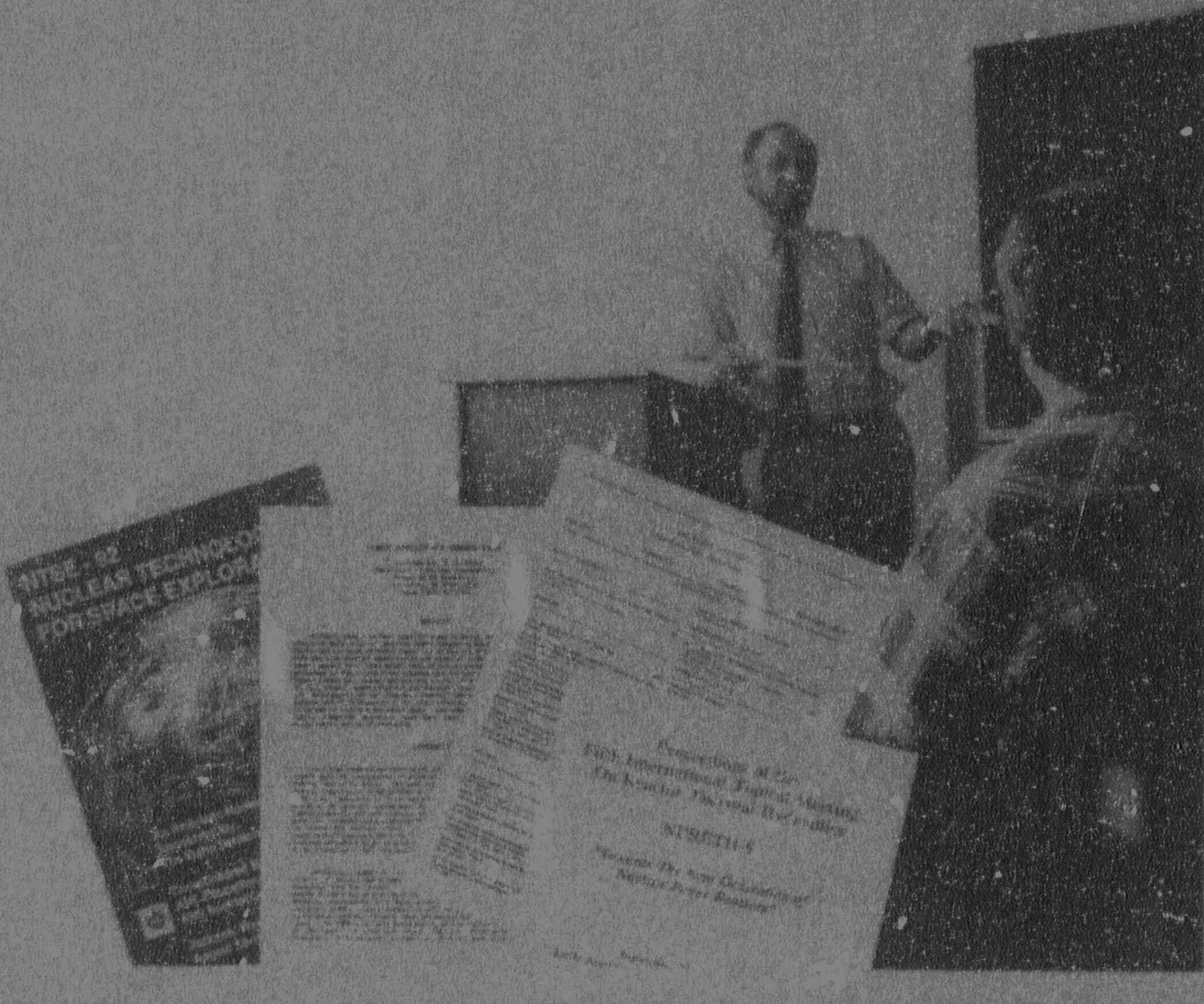

PART VII

WORDS

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* Indicates OSTR use.

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F. <u>Public Relations</u>

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 1,552 people were given pre-planned and scheduled tours during this reporting period. This is again an increase of those who visited last year. See Table VII.F.1 for statistics on scheduled visitors.

Table VII.F.1

Summary of Visitors to the Radiation Center

Date	No. of Visitors	Name
July 9, 1992	3	Charles and Patricia Cook
July 7, 8 & 10, 1992	57	Adventures in Learning (DCE)
July 10, 1992	1	William Washington
July 15, 1992	32	HAZMAT Response Team Members
July 16, 1992	42	SMILE Program
July 18, 1992	60	da Vinci Days
July 21, 1992	44	DAIDO Institute, Japan
July 22, 1992	78	Asia University Students
July 30, 1992	10	RC/NE Advisory Board
August 10, 1992	25	Research Experience for Undergraduates
August 11, 1992	2	Michelle Whipple and Craig Floid
September 29, 1992	21	International Brotherhood of Electric Workers, Local 280
October 13, 1992	3	Elaine Larison
October 20 & 22,1992	67	CH 219 Class
October 23 & 26, 1992	15	NE 111 Class
OCtober 29, 1992	1	Vice President for Research, George Keller
November 10, 1992	12	LBCC Class - Heating & Refrigeration Students
November 16, 1992	22	Adams School 2nd Grade Students
November 19, 1992	22	Adams School 2nd Grade Students
December 10, 1992	25	North Albany Elementary School 2nd & 3rd graders
December 13, 1992	8	College of Engineering Advisory Board
December 13, 1992	11	OSSHE Safety Officers
December 14, 1992	1	Japan Atomic Energy Research Institute
December 14, 1992	58	Alsea School (Phys Sci, Physics & Mar. Sci Classes)

Table VII.F.1 (Continued)

Date	No. of Visitors	Name
January 7, 14, 19, & February 2, 1993	14	Chemistry 462
February 6,1993	19	Boy Scout Group
February 6, 1993	208	Dad's Weekend Open House
February 12, 1993	27	Our Lady of the Lake Jr. High School
February 13, 1993	15	Beaver Open House
February 23, 1993	380	CH 222 Class
March 12, 1993	13	Society of American Military Engineers
March 13, 1993	23	SMILES
March 24, 1993	18	Homedale Science Class
March 26, 1993	4	Irene Hornyik, et. al.
April 9, 1993	2	Chris and Richard Rusher
April 16, 1993	28	Our Lady of the Lake Jr. High School
April 23, 1993	75	ANS Western Regional Conference
April 26, 1993	16	Coquille High School Students
May 1, 1993	41	Mom's Weekend Open House
May 18, 1993	2	Ron Guenther and guest from Germany
May 18, 1993	10	Dr. Paul Brown & Students, OHSU Nucl. Med.
June 3, 1993	10	TIC Employees
June 7, 1993	8	Corvallis Christian School
June 29, 1993	20	HAZMAT Response Team Members
June 29, 1993	1	Dr. D. Wang
TOTAL	1552	