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

July 1, 1989 - June 30, 1990

To satisfy the requirements of:

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

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

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

Written by:

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October 1990

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

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PART I

OVERVIEW

A. Acknowledgements

During the 1989-90 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 offer 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 our facilities and services; to the OSU Physical Plant, who patiently provided invaluable assistance through their engineering, maintenance, and other supporting programs; to the OSU Security and University Police who are always there when we need them; and to the OSU Department of Printing, who consistently produce a quality product; we most earnestly say thank you.

As a final note of gratitude, the staff would like to highlight the talents and the tolerance of our secretarial staff, who performed admirably during the preparation of this report.

B. Executive Summary

The OSU Radiation Center is pleased to report the completion of another successful year - a year in which there was a continuation of the growth identified in previous years, as well as significant advances in several new areas. However, before we summarize our achievements, we would like to express our appreciation to everyone who contributed to our success. In particular, we wish to thank the university's administration for their financial and administrative support and for their encouragement. We are also most grateful to the U.S. Department of Energy for their valuable support through the university reactor sharing program and for the benefits we received from the DOE's important new program designed to help modernize research reactor equipment. We would also like to extend our gratitude to the many other organizations who funded research and technical services conducted at the Center. The resources obtained through these channels continued to create valuable opportunities for numerous students and new researchers to use the unique facilities present at the Radiation Center.

With respect to one of the Center's most visible programs, the reactor remained busy and continued to be used about 90% of the available 45-hour work week. This use frequency is the maximum possible for a one-shift operation. In order to increase the availability of the reactor within the limits of our present operating schedule, we encouraged simultaneous use of the reactor's numerous irradiation facilities. As a result, for the second consecutive year we experienced a 13% overall increase in the time the reactor was used to support more than one project, which is a further indication of the growth in demand for reactor irradiation time at OSU. However, as in previous years, we occasionally were required to operate beyond our normal schedule to accommodate all of our requests for irradiations.

In the area of teaching, the Radiation Center's use also remained high as illustrated by the approximately 50 OSU classes which were accommodated using Center facilities. About one-half of these classes used the reactor and about 25% of the reactor's total operating hours were in direct support of such classes.

This year we are especially pleased to note that the overall number of students involved in academic projects using the Radiation Center and reactor showed a 101% increase.

More significant, however, is the fact that this increase included a 108% increase in students from OSU. In addition, there was a 68% increase in the number of graduate student theses based on work accommodated by the Radiation Center.

Growth in the volume of research performed at the Radiation Center was also prominent again this year. Several key indications of this expanded research effort are the number of individual Radiation Center projects accommodated, which increased 26%; the number of funded research projects, which increased by 29%; and the number of shipments of radioactive material for use in research, which increased by 46%.

A particularly notable addition to the Radiation Center's facilities this year was the purchase and installation of a 7000 curie cobalt-60 gamma irradiator. This new device will enable the Radiation Center to perform considerably higher dose gamma irradiations in much shorter time intervals and will thus greatly improve our capability in this area. We are very pleased to have this new irradiator and feel confident that it will see much use. For example, even though the new gamma irradiator was not installed until the end of the current reporting period, the number of cobalt-60 gamma irradiations last year still increased by 36%.

The Radiation Center also continued to be a popular place to visit, particularly for high schools, community colleges, and interested citizens. We again hosted nearly 900 visitors during the course of the year.

Scholarly publications involving a contribution by the Radiation Center increased in number by about 5%, and there were 34 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 have been approximately 118 total articles generated during the 1989-90 reporting period which involved a contribution by the Radiation Center.

As a result of this past year's performance, we believe that the OSU Radiation Center has continued to enhance its image as a regional and as a nationally recognized instructional and research facility, and we are gratified by the fact that the number of institutions using the Center continues to increase each year. This year the increase in user institutions was 15%; however, it is very important to note that this increased use did not reduce the availability of any Radiation Center facilities, particularly the reactor, to OSU students or researchers. In fact, the amount of reactor time used for OSU research showed a healthy 19% increase.

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 new expanded 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 reactor operating data in this report relate only to the FLIP-fueled core. 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. An executive summary is also included for those already familiar with the Radiation Center's operation.

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.

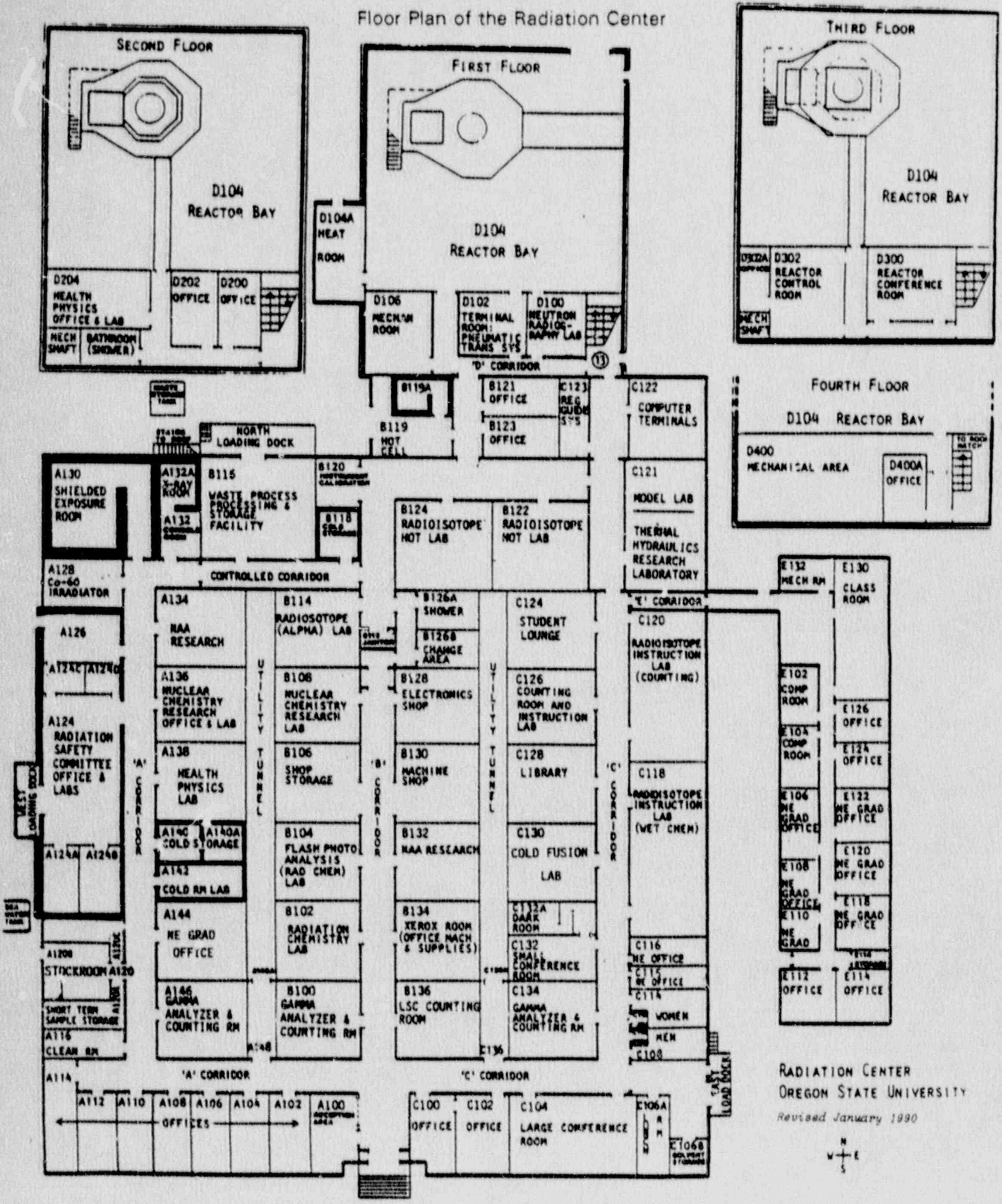
Located in the Radiation Center are major items of specialized equipment and unique teaching and research facilities. These include a TRIGA Mark II research nuclear reactor; two cobalt-60 gamma irradiators; a 300 kVp X-ray generator; a number of state-of-the-art computer-based gamma radiation spectrometers 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. Figure I.D.1 shows the layout of these facilities at the Radiation Center.

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



RADIATION CENTER
OREGON STATE UNIVERSITY

Revised January 1990

E. Summary of OSTR Environmental and Radiation Protection Data

1. Liquid Effluents Released (See Table V.B.1)	Year July 1, 1989 Through June 30, 1990
a. Total estimated quantity of radioactivity released (to the sanitary sewer)[1]	3.34×10^{-4} Curies
b. Detectable radionuclides in the liquid waste	^{3}H, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{75}Se
c. Estimated average concentration of released radioactive material at the point of release	2.59×10^{-5} μCi/cc
d. Percent of applicable MPC for released liquid radioactive material at the point of release	1.0%[2] 0.03%[3]
e. Total volume of liqu'd effluent relcased, including diluent, which contained an OSTR contribution[4]	3415 gallons

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

(2) Based on values listed in 10 CFR 20, Appendix B, Table 2, Column 2.

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

(4) 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.

		Year July 1, 1989 Through June 30, 1990
2.	Airborne Effluents Released (See Table V.B.2)	
a.	Total estimated quantity of radioactivity released	6.5 Curies
b.	Detectable radionuclides in the gaseous waste[1]	^{41}Ar ($T^{1/2}$ = 1.83 hr)
c.	Estimated average atmospheric diluted concentration of argon-41 at the point of release	4.1×10^{-8} μCi/cc
d.	Percent of applicable MPC for diluted concer., ation of argon-41 at the point of release	1.0%
e.	Total estimated release of radioactivity in particulate form with half-lives greater than 8 days[2]	None

		Year July 1, 1989 Through June 30, 1°
3.	Solid Waste Released (See Table V.B.3)	
a.	Total amount of solid waste packaged and disposed of	15.0 ft^3
b.	Detectable radionuciides in the solid waste	^{24}Na, ^{46}Sc, ^{51}Cr, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{75}Se, ^{99}Tc, ^{124}Sb, ^{125}Sb, ^{131}I, ^{132}Te, ^{137}Cs, ^{140}Ba, ^{140}La, ^{141}Ce, ^{152}Eu, ^{154}Eu, ^{182}Ta
c.	Total radioactivity in the solid waste	1.3×10^{-3} Curies

(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] — Year July 1, 1989 Through June 30, 1990

		(mrem)
a.	Facility Operating Personnel	
	(1) Average whole body	17
	(2) Average extremities	47
	(3) Maximum whole body	135
	(4) Maximum extremities	480
b.	Key Facility Research Personnel	
	(1) Average whole body	2
	(2) Average extremities	10
	(3) Maximum whole body	20
	(4) Maximum extremities	210
c.	Physical Plant Maintenance Personnel	
	(1) Average whole body	<1
	(2) Maximum whole body	20
d.	Laboratory Class Students	
	(1) Average whole body	0
	(2) Average extremities	5
	(3) Maximum whole body	0
	(4) Maximum extremities	120
e.	Campus Police and Security Personnel	
	(1) Average whole body	3
	(2) Maximum whole body	0
f.	Visitors	
	(1) Average whole body	<1
	(2) Maximum whole body	8

(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. <u>Number of Routine Onsite and Offsite Monitoring Measurements and Samples</u> — <u>Year July 1, 1989 Through June 30, 1990</u>

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	16
(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.
June 1990	Installation of a 7000 Ci ^{60}Co Gammacell irradiator.

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 these people is given in Table VI.C.1, and 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

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

*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

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*Reactor users for research and/or teaching.

Hart, Lucas P.
Research Associate, Chemistry

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

Klein, Andrew C.
Assistant Professor of Nuclear Engineering

*Loveland, Walter D.
Professor of Chemistry

MacVicar, Robert
President Emeritus, OSU

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

*Pastorek, Christine
Instructor of Chemistry

Popovich, Milosh
Vice President Emeritus, OSU

*Pratt, David S.
Research Assistant
Health Physicist

Reyes, Jose N.
Assistant Professor of Nuclear Engineering

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

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

*Schmitt, Roman A.
Professor of Chemistry

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*Reactor users for research and/or teaching.

*Walker, Robert J.
Research Assistant
Neutron Activation Analysis Specialist

Wang, Chih H.
Professor Emeritus, OSU

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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
*Abdur, Rahman	Nuclear Engineering (Bangladesh)	A. H. Robinson
Behm, Marten	Nuclear Chemistry (Sweden)	W. D. Loveland
*Collins, Derek	Oregon Episcopal School (Portland, Oregon)	J. F. Higginbotham
*Yokoyama, Akihiko	Nuclsar Chemistry (Japan)	W. D. Loveland

*Reactor users for research and/or teaching.

C. OSU Graduate Students

Name	Degree Program	Field	Advisor
Al-Baroudi, Homan	PhD	Nuclear Engr.	A. C. Klein
Ala, Abbas	PhD	Nuclear Engr.	J. N. Reyes
Almarshad, Abdullah	PhD	Nuclear Engr.	A. C. Klein
Almasoumi, Abdullah	PhD	Nuclear Engr.	S. E. Binney
Anand, Ajay	PhD	Nuclear Engr.	S. E. Binney
Baik, Seung-Hyuk	MS	Radiation Health	J. F. Higginbotham
Bukar, Kyari A.	MS	Nuclear Engr.	A. H. Robinson
Cho, Byung-Oh	MS	Nuclear Engr.	A. H. Robinson
Eichenberg, Thomas W.	MS	Nuclear Engr.	J. N. Reyes
Fu, Yingxian	MS	Chemistry	M. Daniels
*Greek, Kevin	PhD	Nuclear Engr.	A. H. Robinson
Greene, Kenneth	PhD	Nuclear Engr.	A. H. Robinson
Gulshan-Ara, Zubaida	MS	Nuclear Engr.	A. C. Klein
Heaberlin, Joan	PhD	Nuclear Engr.	A. H. Robinson
Hicks, Thomas	MS	Radiation Health	B. Dodd
*Hill, Brittain E.	PhD	Geosciences	E. M. Taylor
Jordheim, Danial P.	MS	Nuclear Engr.	S. E. Binney
King, John	MS	Nuclear Engr.	J. N. Reyes
Lafi, Abd Y.	PhD	Nuclear Engr.	J. N. Reyes
Lee, Hsing H.	MS	Nuclear Engr.	A. C. Klein
Lewis, Bryan R.	MS	Nuclear Engr.	A. C. Klein
*Liu, Yung-Gang	PhD	Chemistry	R. A. Schmitt
Marks, Tim	MS	Nuclear Engr.	A. C. Klein
Miles, Todd L.	MS	Nuclear Engr.	S. E. Binney
Pauley, Keith	MS	Nuclear Engr.	A. C. Klein
Pawlowski, Ronald	MS	Nuclear Engr.	A. C. Klein
Piepmier, Edward H.	PhD	Pharmacy	J. W. Ayres
*Pratt, David	MS	Radiation Health	A. G. Johnson
Reardon, Michael F.	MS	Nuclear Engr.	S. E. Binney
Saleh, Hassan	PhD	Nuclear Engr.	S. E. Binney
*Schilk, Alan J.	PhD	Chemistry	R. A. Schmitt
Van Winkle, James A.	MS	Nuclear Engr.	A. C. Klein
*Walker, Robert J.	PhD	Geosciences	C. W. Field
*Yousef, Samir	MS	Radiation Health	J. F. Higginbotham
Zahm, Lance	MS	Nuclear Engr.	A. C. Klein

*Reactor users for research and/or teaching.

D. **Business, Administrative and Clerical Staff**

Director	A. G. Johnson
Business Manager	S. C. Campbell
Administrative Assistant	E. C. Flickinger
	D. K. Dalton
Office Specialists	J. F. Hopkins
	J. R. Smith
Custodian	M. L. Benad
Office Coordinator (Nuclear Engineering)	D. L. Cramer
Word Processing Specialist (Nuclear Engineering)	R. A. Keen

E. **Reactor Operations Staff**

Principle 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
	J. F. Higginbotham
Reactor Operator	A. D. Hall

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. Cook
	A. Evans
	C. Grier
	V. Meacham
	N. Moreno
	C. Rak
	S. Reese
	E. Rockett
	J. Starr
	C. Vostmeyer

G. Scientific Support Staff

Senior Neutron Activation Analyst	R. A. Schmitt
Neutron Activation Analysis Specialists	M. R. Conrady
	R. J. Walker
Neutron Activation Analysis Technicians (Students)	T. Berkman
	A. Mathis
	E. Schuefort
	M. Streck
Scientific Instrument Technicians	H. L. Busby
	S. P. Smith

H. OSU Radiation Safety Office Staff

Title	Name
Radiation Safety Officer	G. A. Little
Acting Radiation Safety Officer (May 15, 1990 - June 30, 1990)	R. H. Farmer
Radiation Specialists	D. L. Harlan
Secretary	K. L. Miller

I. Committees

1. Reactor Operations Committee

Name	Affiliation
S. E. Binney, Chairman	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
G. Merrill, Chairman	Biochemistry/Biophysics
R. Collier	Oceanography
J. Higginbotham	Radiation Center and Nuclear Engineering
D. Keszler	Chemistry
S. Radosevich	Forest Science
C. Rivin	Botany and Plant Pathology
G. Rohrmann	Agricultural Chemistry
C. Schreck	Fisheries and Wildlife
G. Little, Secretary & RSO	Radiation Safety Office

3. Radiation Center Safety Committee

Name	Affiliation
W. D. Loveland, Chairman	Chemistry
T. V. Anderson	Radiation Center
H. L. Busby	Radiation Center
S. C. Campbell	Radiation Center
M. R. Conrady	Radiation Center
J. G. Higginbotham	Radiation Center and Nuclear Engineering
A. G. Johnson	Radiation Center and Nuclear Engineering

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, two 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.

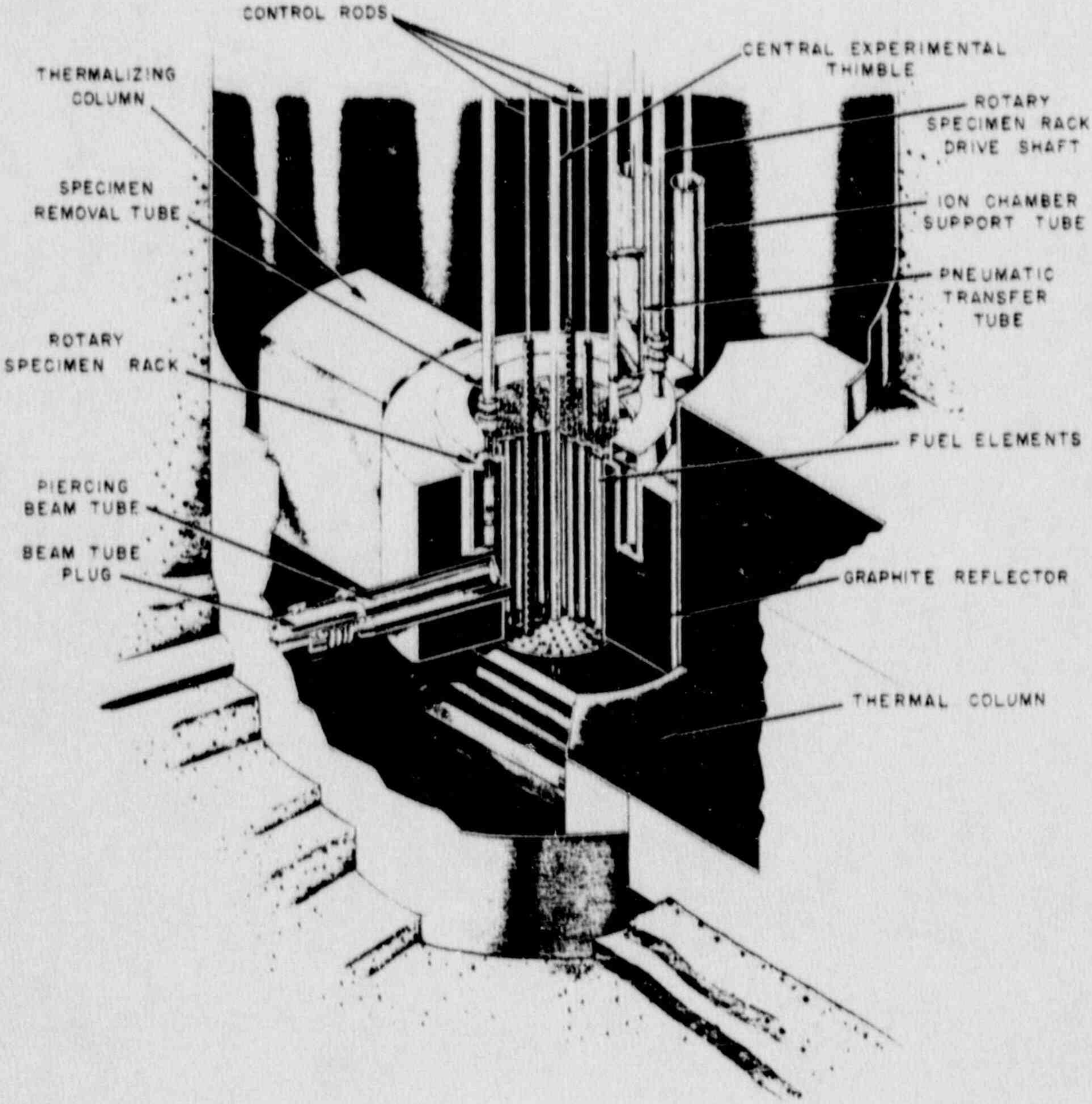

Fig. III.A.1 Cutaway View of Standard TRIGA Mark II Core Arrangement

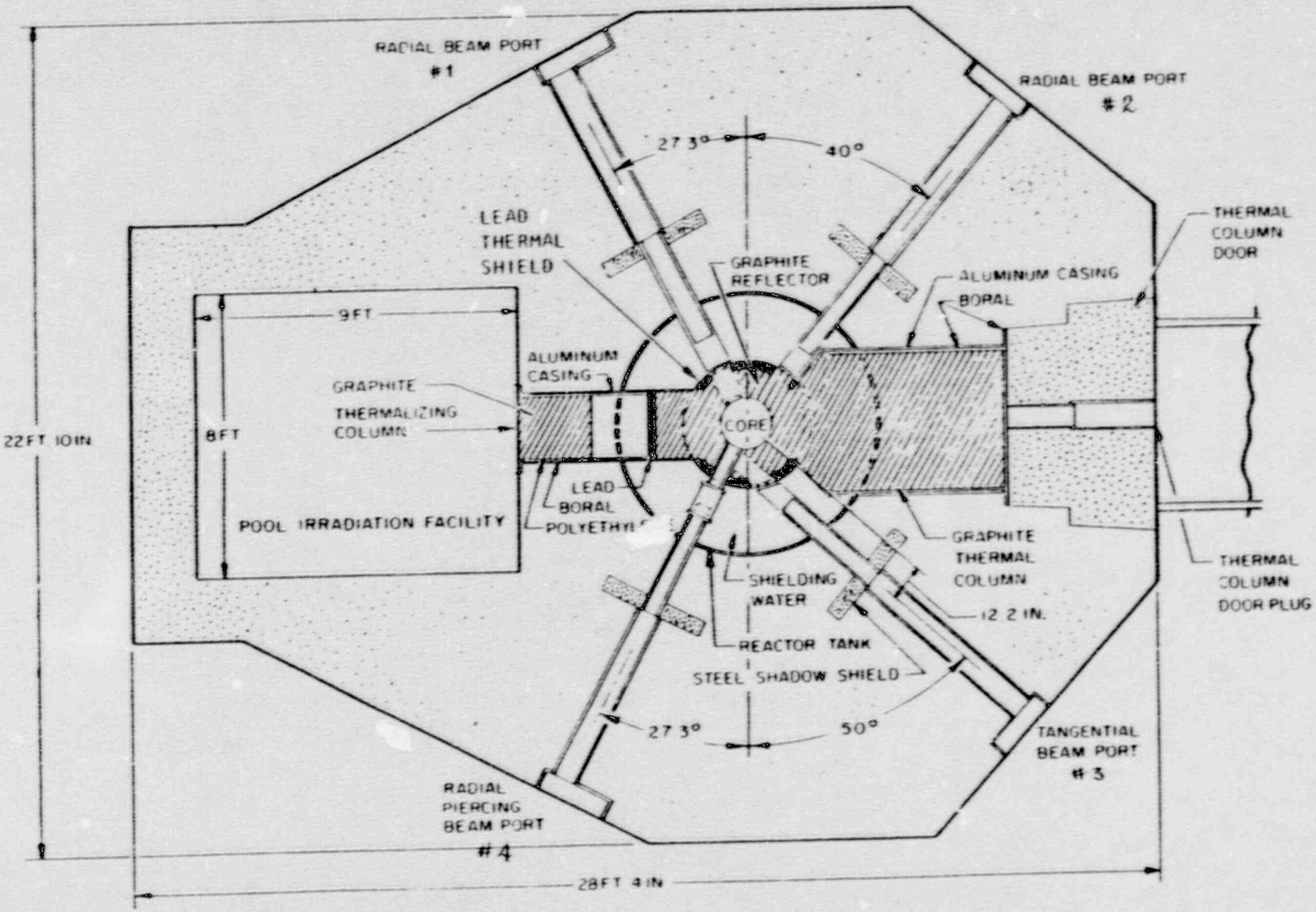

Fig. III.A.2 Horizontal Section of TRIGA Mark II Reactor

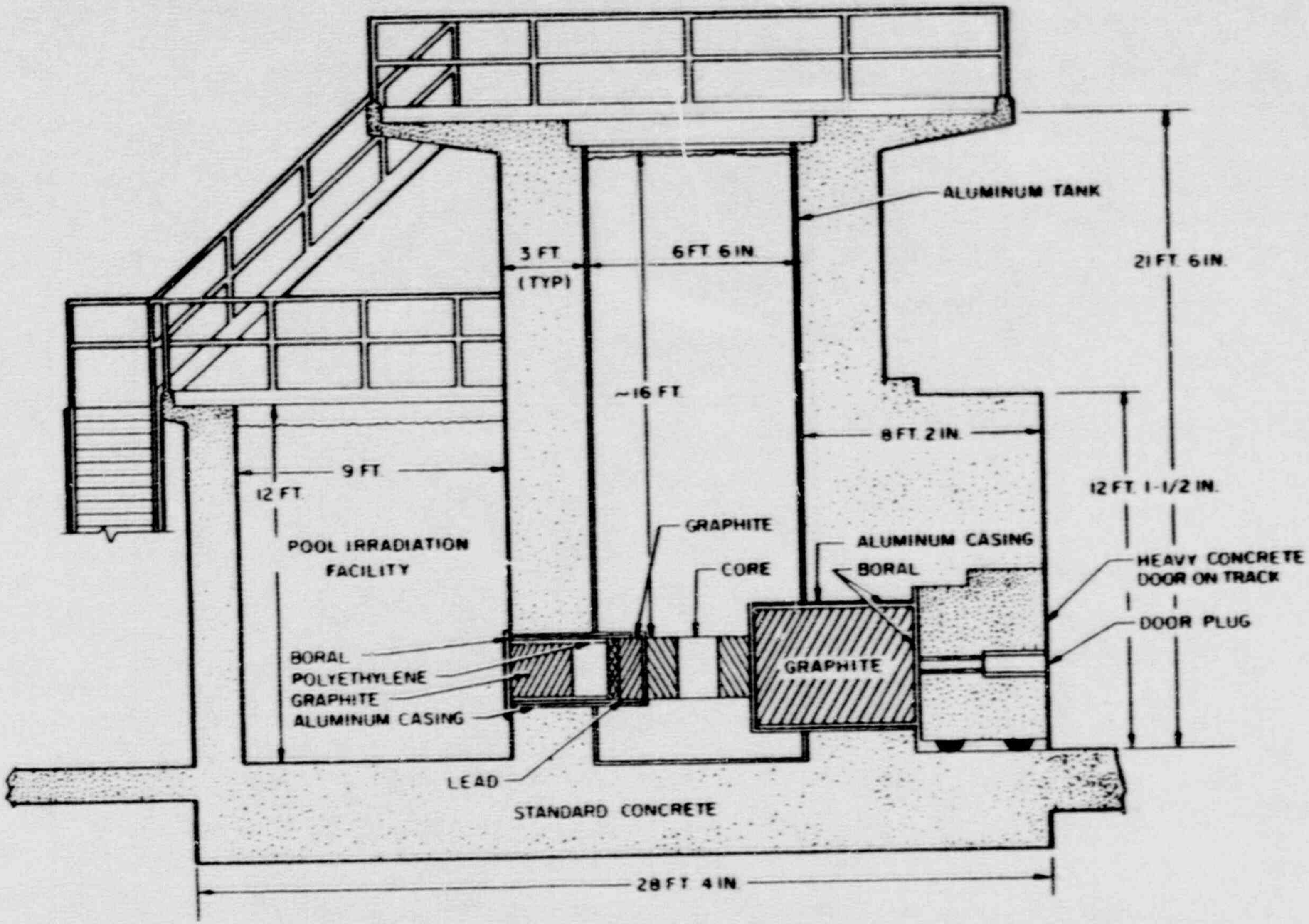

Fig. III.A.3 Vertical Section of TRIGA Mark II Reactor

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 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 40 hours during a typical 45-hour work week. Hence, the reactor was used approximately 90% 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 23 different OSU academic classes. In addition, portions of classes from other Oregon universities were also supported by the OSTR. The OSU teaching programs utilized 245 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 111X	Nuclear Engineering Orientation
NE 112X	Nuclear Engineering Orientation
NE 203	Nuclear Radiation Detection and Measurement
NE 405A	Field Practices in Radiation Protection (Undergraduate)
NE 406D	Design Projects (Nuclear Engineering)
NE 441	Nuclear Reactor Experiments
NE 461	Radiation Protection Engineering
NE 503	Thesis (Nuclear Engineering)
NE 505A	Field Practices in Radiation Protection (Graduate)
CH 106	General Chemistry Laboratory
CH 107	General Chemistry Laboratory
CH 202	General Chemistry
CH 207	General Chemistry Laboratory
CH 419	Radioactive Tracer Methods
CH 461	Experimental Chemistry II
CH 503	Thesis (Chemistry)
CH 528	Activation Analysis
H 170	Personal Health
H 344	Man, Health, and Environment
G 503	Thesis (Geology)
ME 503	Thesis (Mechanical Engineering)
OC 503	Thesis (Oceanography)
PH 503	Thesis (Physics)

Table III.A.2

OSTR Teaching Hours

Description	Annual Values for July 1, 1989 Through June 30, 1990 (hours)		Cumulative Values for August 1, 1976 Through June 30, 1990 (hours)
Departmental		168	2804
Nuclear Engineering	113		
Chemistry	49		
Health & Human Performance	6		
Geology[1]			
Mechanical Engineering[1]			
Oceanography[1]			
Physics[1]			
Special Classes and Projects[2]		77	435
Total Teaching Hours[3,4,5]		245	3239

(1) 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 102 funded research projects which utilized 1096 hours of reactor time, and 16 unfunded research projects which utilized 76 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 for July 1, 1989 Through [illegible] 30, 1990 (hours)	Cumulative Values for August 1, 1976 Through June 30, 1990 (hours)
OSU Research	461	6243
Off-Campus Research	711	3620
Total Research Hours[1][2]	1172	9863

(1) Total research hours statistics:

(a) 94% (1096 hours) of the total research hours were user-funded by federal, state, or other organizations.

(b) 6% (76 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 operating hours in support of OSU teaching and research programs approximately equal the hours the OSTR operated for off-campus research projects. Of the off-campus research hours OSTR recorded, nearly 7% (approximately 50 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 fourteen 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.3 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, PGT Ge(Li)	13.0
B100	Adcam 3, 8k Ortec, Canberra Ge(Li)	19.4
B100	Adcam 4, 8k Ortec, PGT Ge(Li)	13.2
Float	Adcam 5, 8k Ortec, Backup Analyzer	N/A
C126	Ace 1, 4k Ortec, NaI(Tl) 3x3	N/A
C123	Ace 2, 4k Ortec, PGT Ge(Li)	18.7
C126	2 K, ND60, NaI(Tl) 3x3	N/A
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	4x4 k ND Micro MCA, PGT Ge(Li)	16.2
C134	4x4 k ND Micro MCA, PGT Ge(Li)	19.3
C134	4x4 k ND Micro MCA, PGT LEP	N/A
C134	4x4 k ND Micro MCA, Canberra LEP	N/A
C126	Ace 3, 4k Ortec, 576A Alpha Spectrometer	N/A

Table III.B.2

Radiation Center Liquid Scintillation Counting Systems

Room	System
C126	Beckman, Betamate
C126	Beckman, Betamate
C126	Beckman, Betamate
C126	Beckman, Betamate
B136	Beckman, LS 7500
B136	Searle

Table III.B.3

Radiation Center Proportional Counting Systems

Room	System
C126	NMC 1, PC5
C126	NMC 2, PC5
C126	NMC 3, PC5
A138	NMC, PCC-11T and DS 2
A138	NMC Auto Counting System w/IBM XT

C. Radioisotope Irradiation Sources

1. Description

The Radiation Center is now equipped with two cobalt-60 gamma irradiation facilities which are capable of delivering high doses of gamma radiation to a wide variety of materials. During June 1990 a new Gammacell 7000 Ci cobalt-60 gamma irradiator was installed at the Radiation Center. This is a significant new facility which considerably expands the useful range of gamma doses available to researchers. The new irradiator will provide dose rates of the order to 900 krad/h compared to about 18 krad/h delivered by the old Budd irradiator. These two irradiators complement each other, so that the one which delivers the most appropriate dose rate for a particular experiment will be used.

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 cobalt-60 irradiator, the Center is also equipped with a variety of smaller cobalt-60, cesium-137, radium-226, 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 cobalt-60 irradiator. These projects included the irradiation of a variety of biological cells as well as the irradiation of flowers, seeds and leaves. In addition, the irradiator was used for radiation dosimeter analysis, soil sterilization, and materials evaluation. Data showing uses of the irradiator for this reporting period are given in Table III.C.1.

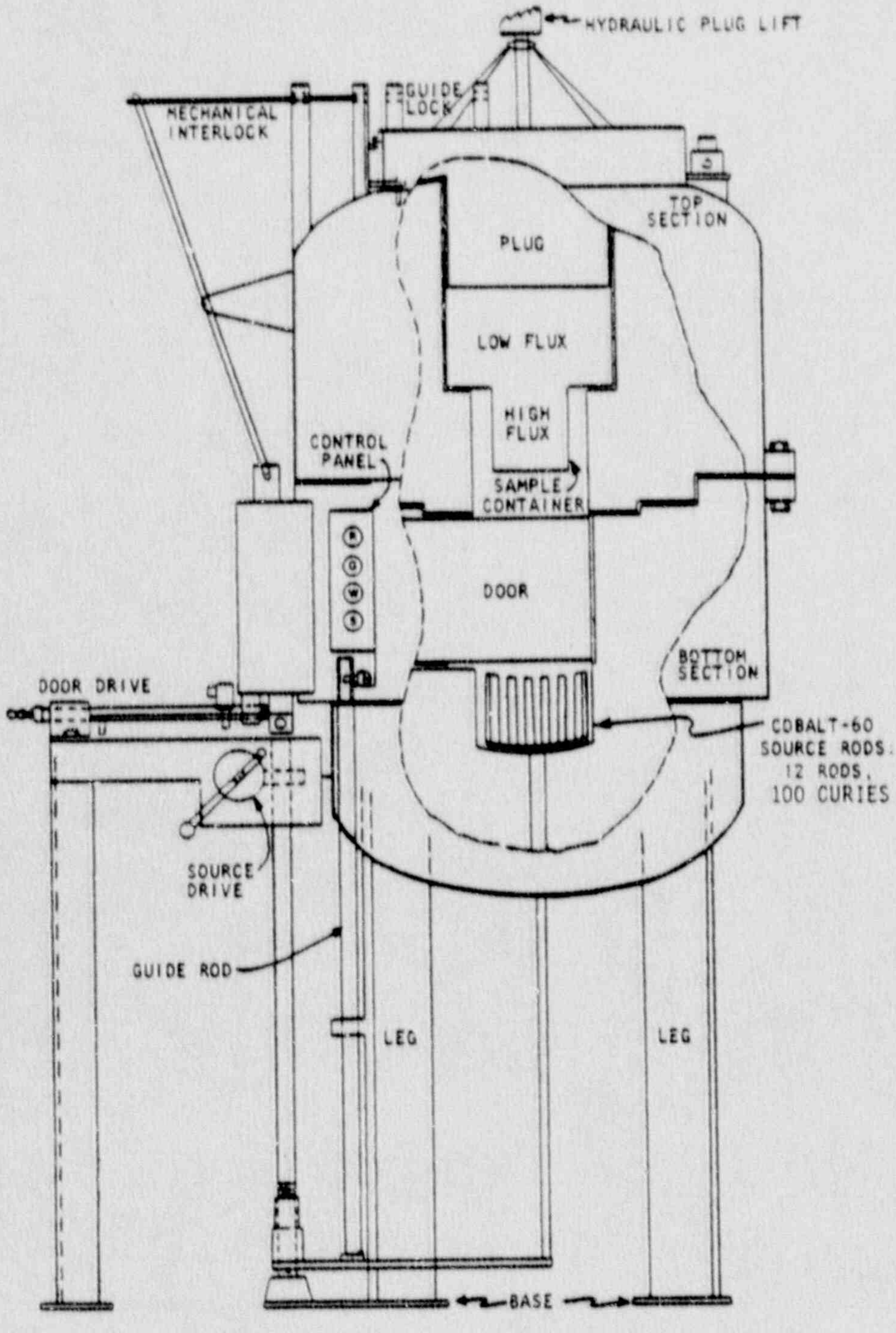

Fig. III.C.1 Budd Cobalt-60 Irradiator (Vertical Section)

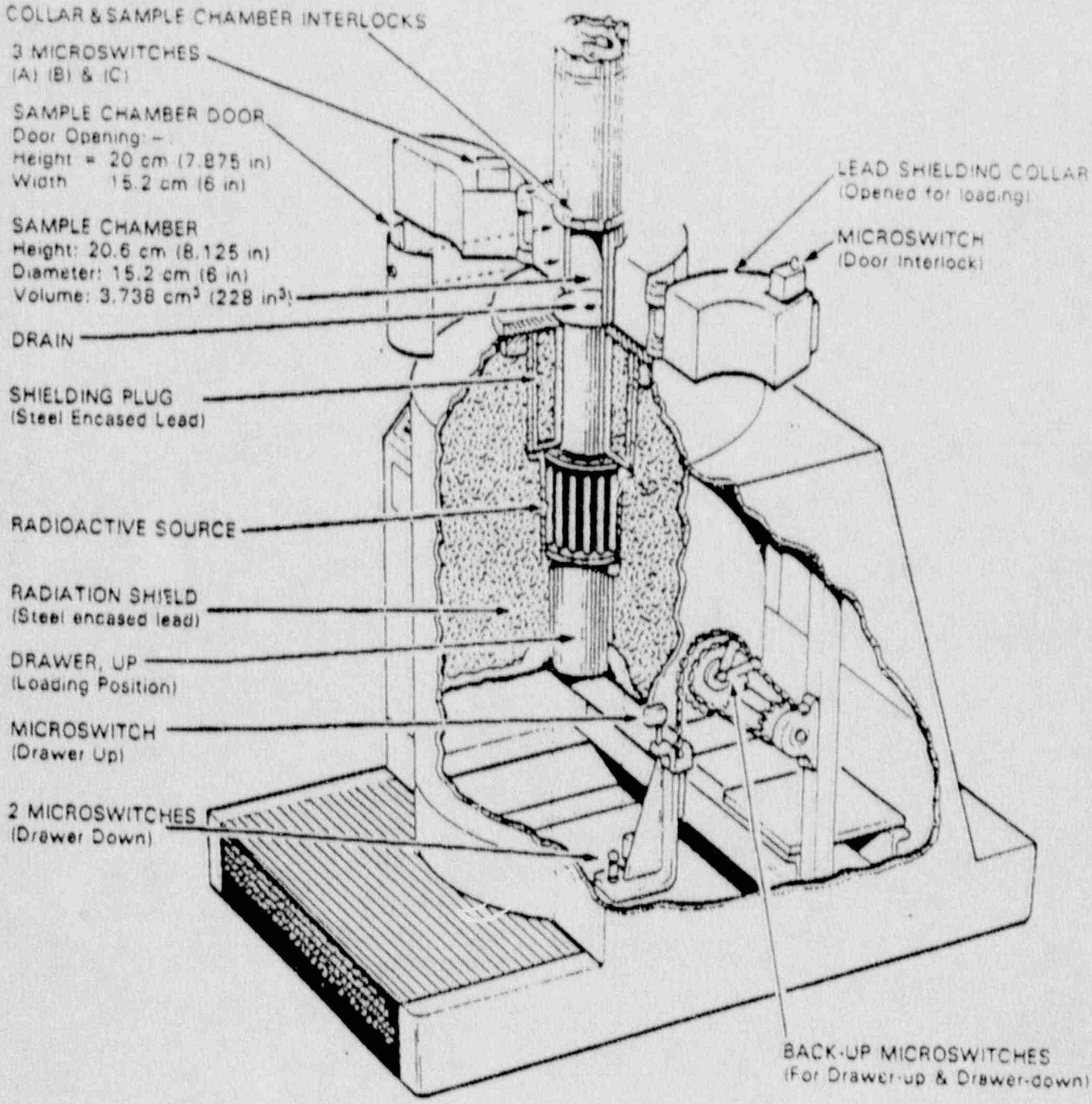

Fig. III.C.2 Gammacell 220 Cobalt-60 Irradiator

Table III.C.1

Cobalt-60 Irradiator Use

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Sterilization	Soil	9×10^5 - 5×10^6	10	5626
Botanical Studies	Onion flowers, bean seeds, quince leaves	2×10^3 - 1.1×10^5	6	15
Biological Studies	Collagens, spleen cells, dried protein, bacteria, culture	1×10^3 - 4.5×10^6	58	795
Dosimeter Analysis	TLDs, other dosimeters	35 - 3×10^3	36	44
Materials Evaluation	Wood, golf balls	3×10^5 - 1.6×10^6	10	1080
TOTALS			120	7560

D. X-Ray Machine

1. Description

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

2. Utilization

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

E. Laboratories and Classrooms

1. Description

The Radiation Center is equipped with a number of different radioactive materials 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 two nuclear instrumentation teaching laboratories 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 two student computer rooms equipped with microcomputers and terminals which are linked to other computers, both on and off campus.

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 35 students each. 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 a student study room/lounge as well as an office area for the student chapter of the American Nuclear Society.

This reporting period saw the beginning of a new thermal hydraulics laboratory in the space previously used by the AGN reactor. This laboratory is being developed by a member of the nuclear engineering faculty and involves the construction of several scale loops to meet the research needs of the nuclear industry.

2. Utilization

All of the laboratories and classrooms are used extensively during the academic year. For example, a listing of 50 courses accommodated at the Radiation Center during this reporting period along with their enrollments are given in Table III.E.1. Table III.A.1 gives a separate listing of the 23 classes specifically accommodated by the reactor during the reporting period. In addition, several laboratories are used for research projects throughout the year.

Table III.E.1

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

Course	Credit	Course Title	Number of Students		
			Fall 1989	Winter 1989	Spring 1990
Nuclear Engineering Courses					
*NE 111X	3	Introduction to Nuclear Engineering	18	--	--
*NE 112X	3	Introduction to Nuclear Engineering	--	14	--
NE 103	3	Intro. Nuclear Engineering & Comp.	--	--	11
NE 201	3	Nuclear Energy Fundamentals	21	--	--
NE 202	3	Nuclear Radiation and Matter	--	18	--
*NE 203	3	Nuclear Radiation Detection & Measurement	--	--	17
NE 361X	3	Nuclear Reactor Systems	--	12	--
*NE 405A +	1-3	R&C/Field Practice Radiation Health	1	--	--
NE 406	1-6	Projects	1	--	2
**NE 406D	1-6	Individual Design Project	5	10	3
NE 407	1	Seminar	10	11	9
NE 415	4	Principles of Radiation Safety	18	--	--
NE 421	3	Nuclear Reactor Analysis & Computation	10	--	--
NE 422	3	Nuclear Reactor Analysis & Computation	--	11	--
NE 423	3	Nuclear Reactor Analysis & Computation	--	--	12
NE 430	3	Nuclear Fuel Cycle	--	--	26
NE 431	3	Reactor Thermal Hydraulics	12	--	--
NE 432	3	Nuclear Reactor Design	13	--	--
NE 433	3	Nuclear Reactor Design	--	13	--
NE 434	3	Nuclear Reactor Design	--	--	12
**NE 441	3	Nuclear Engineering Experiments	--	--	11
**NE 461	3	Radiation Protection Engineering	--	16	--
NE 465	3	Nuclear Rules & Regulations	--	--	14
NE 501	1-15	Research	--	--	3
**NE 503	1-15	Thesis	16	17	14
NE 505	1-15	Reading & Conference	--	1	1
*NE 505A	1-3	R&C/Field Practice Radiation Health	--	1	--
NE 506	1-15	Projects	1	1	3
NE 507	1	Seminar	3	1	--
NE 511	3	Neutron Transport Theory	8	--	--
NE 512	3	Advanced Nuclear Reactor Theory	--	--	8
NE 532	3	Advanced Nuclear Reactor Design	3	--	--
NE 533	3	Advanced Nuclear Reactor Design	--	3	--
NE 534	3	Advanced Nuclear Reactor Design	--	--	3
NE 542	3	Advanced Thermal Hydraulics	--	--	10
NE 581N	3	ST/Advanced Numerical Techniques	1	--	--
NE 583W	3	ST/Radioactive Waste Management	--	16	--
NE 589X	3	ST/Radioactive Material Transport	--	--	9

Table III.E.1 (Continued)

Course	Credit	Course Title	Number of Students		
			Fall 1989	Winter 1989	Spring 1990
Chemistry Courses					
*CH 106+	5	General Chemistry	33	--	--
*CH 107	2	General Chemistry Lab	8	--	--
*CH 202	3	General Chemistry	--	52	--
*CH 207	2	General Chemistry Lab	6	--	--
**CH 419	4	Radioactive Tracer Methods	--	-	--
*CH 461	3	Experimental Chemistry	24	--	--
*CH 503	1-16	Thesis (Chemistry)	--	--	--
**CH 528	4	Activation Analysis	--	--	--
Other Courses					
*G 503	1-16	Thesis (Geosciences)	3	3	3
*ME 503	1-16	Thesis (Mechanical Engineering)	1	1	1
*OC 503	1-16	Thesis (Oceanography)	1	1	1
*PH 503	1-16	Thesis (Physics)	4	4	4

*OSTR used occasionally for demonstration and/or experiments.

**OSTR used heavily.

+Class held Summer Term 1989.

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 U.S. Environmental Protection Agency, the U.S. Bureau of Mines, and the U.S. Forest Service. Additional information regarding instrument repair and calibration efforts, is given in Tables VI.C.4 and VI.C.5.

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

A. Operating Statistics

For the current reporting period, the operating statistics for the OSTR remained stable at a high reactor use rate. 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 42.2 megawatt days (MWD). The cumulative thermal energy generated by the FLIP core now totals 486.4 MWD from August 1, 1976 through June 30, 1990. Reactor use time averaged approximately 90% of the normal nine-hour, five-day per week schedule. Tables IV.A.3 through IV.A.6 detail the operating statistics applicable to this reporting period.

The reactor core excess reactivity remained about the same during the current reporting period even though a number of significant changes occurred in the core. These changes and their contributions to reactivity change are listed below.

1. Consumption of the erbium burnable poison in the fuel increased reactivity.
2. Removing a fuel element because of cladding deformation decreased reactivity, and installation of a new replacement fuel element increased reactivity.
3. Fuel burnup decreased reactivity.
4. Installation of a new transient rod to replace the original one increased the rod worth but decreased excess reactivity.

Table IV.A.1

OSTR Operating Statistics (Using the FLIP Fuel Core)
for the Period August 1976 - June 1984

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)
for the Period July 1984 - June 1990

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		
Megawatt Hours	946	1042	993	1001	1025	1013		
Megawatt Days	39.4	43.4	41.4	41.7	42.7	42.2		
Grams ^{235}U Used	49.5	54.4	51.9	52.3	53.6	53.0		
Hours at Full Power (1 MW)	904	1024	980	987	1021	1009		
Numbers of Fuel Elements Added or Removed (-)	0	0	0(1)	-2(2)	0	-1, +1(3)		
Number of Irradiation Requests	407	403	387	373	290	301		

(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.

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 for July 1, 1989 Through June 30, 1990	Cumulative Values for August 1, 1976 Through June 30, 1990
MWH of energy produced	1,013	11,671
MWD of energy produced	42.2	486.4
Grams ^{235}U used	53.0	610.7
Number of fuel elements added to (+) or removed from (-) the core	-1, +1	85 + 3 FFCR[1]
Number of pulses	7	1,155
Hours reactor critical	1,136	15,282
Hours at full power (1 MW)	1,009	11,367
Number of startup and shutdown checks	253	3,518
Number of irradiation requests processed[2]	301	5,301
Number of samples irradiated	2,886	62,001

(1) Fuel Follower Control Rod.

(2) Each irradiation request could authorize from 1 to 120 samples. The number of samples per irradiation request averaged 9.6 during the current reporting period.

Table IV.A.4

OSTR Use Time in Terms of Operational Functions

OSTR Operational Function	Annual Values for July 1, 1989 Through June 30, 1990 (hours)	Cumulative Values for August 1, 1976 Through June 30, 1990 (hours)
Checkout, core excess and shutdown	427	5,229
Reactor in use(1)	2,183	22,233
Total reactor use time	2,610	27,462

(1) This function includes preclude time, multiple reactor experiment time, and the time the reactor is in use for teaching but not necessarily operating. (Preclude time is the time the reactor is not available for regular use due to performance of surveillance and maintenance items, such as fuel element inspections, transient rod lubrication, control rod calibration, power calibration, as well as sample loading and unloading time.)

Table IV.A.5

OSTR Use Time in Terms of Specific Use Categories

OSTR Use Category	Annual Values for July 1, 1989 Through June 30, 1990 (hours)	Cumulative Values for August 1, 1976 Through June 30, 1990 (hours)
Teaching (departmental and others)(1)	245	3,239
OSU research(2)	461	6,243
Off-campus research(2)	711	3,620
Forensic services	1	155(3)
Reactor preclude time	923	9,269
Facility time(4)	242	4,714
Visitor demonstration(5)	27	222
Total reactor use time	2,610	27,462

(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.6

OSTR Multiple Use Time[1]

Number of Users	Annual Values for July 1, 1989 Through June 30, 1990 (hours)	Cumulative Values for August 1, 1976 Through June 30, 1990 (hours)
Two	216	1,371
Three	90	368
Four	14	116
Five	0	10
Six	0	23
Seven	0	4
Total multiple use time	320[2]	1,892[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 28% of the total hours the reactor was critical during this reporting period.

(3) This represents 12% of the total hours the reactor was critical since startup with FLIP fuel in August of 1976.

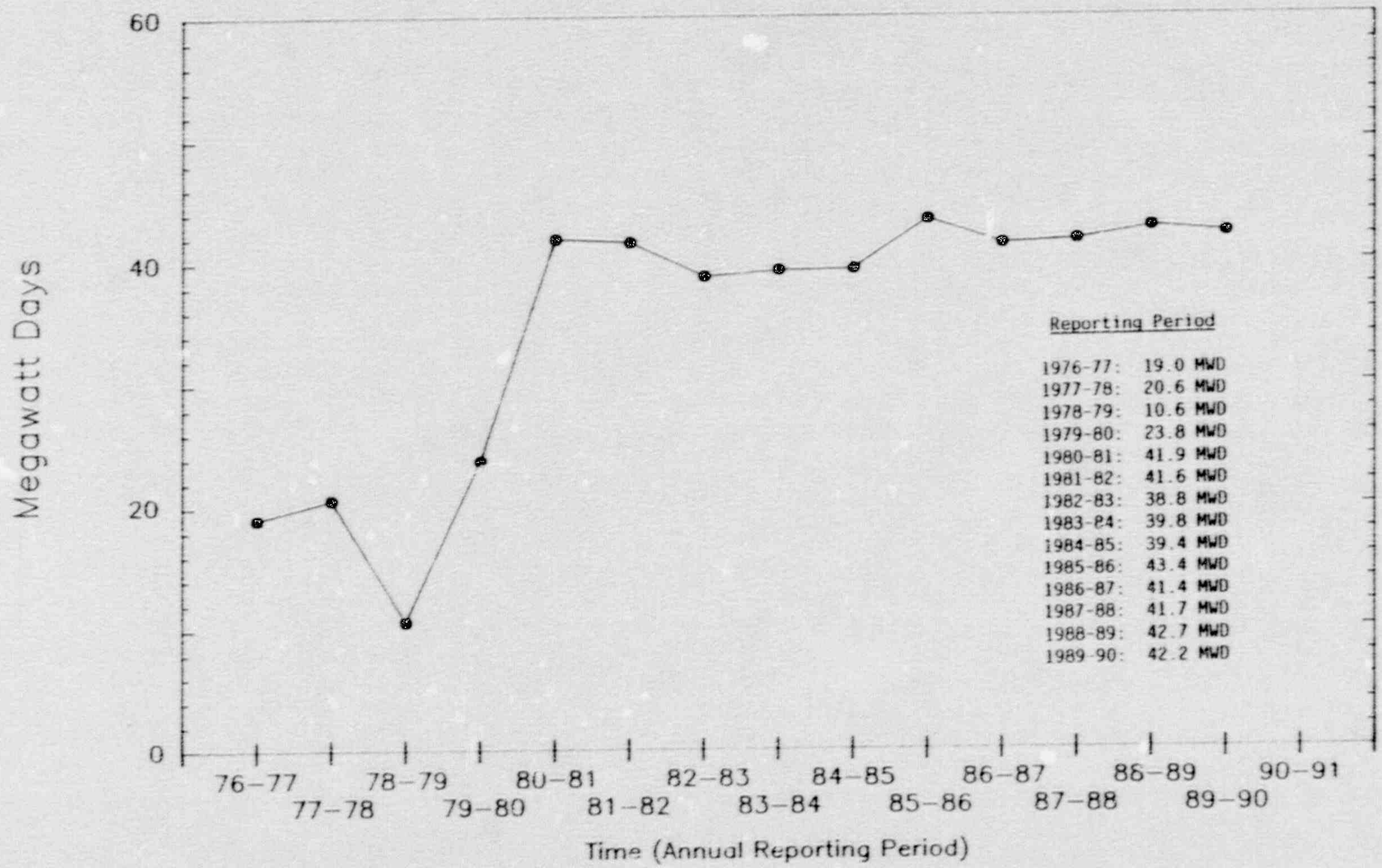

Figure IV.A.1 OSTR Annual Energy Production Vs. Time (Annual Reporting Period)

B. <u>Experiments Performed</u>

During the current reporting period there were 11 approved reactor experiments available for use in reactor related programs. The following list of reactor experiments identifies the 11 approved experiments. Missing numbers signify reactor experiments which are in the inactive file and are not currently being used.

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-21	Beam Port No. 3 Neutron Radiography Facility; Amendment No. 1 to B-21; Neutron Holography.
B-23	Studies Using TRIGA Thermal Column.
B-24	General Neutron Radiography.
B-25	Neutron Flux Monitors.
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. Presently, 25 experiments are in the inactive file and could be reapproved for use if needed.

Table IV.B.1

Use of OSTR Reactor Experiments[1]

Reactor Experiment Number[2]	Research	Teaching	Forensic	Facility Time[3]	TOTAL
A-1	0	33	N/A	65	98
B-3	127	25	1	N/A	153
B-11	13	0	0	N/A	13
B-12	1	0	0	N/A	1
B-23	0	1	0	N/A	1
TOTAL	141	59	1	65	266

(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 TRIGA Thermal Column

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

C. <u>Unplanned Shutdowns</u>

There were five unplanned reactor shutdowns (scrams) during the current reporting period. Table IV.C.1 contains a summary of the unplanned shutdowns including a brief description of the cause of each.

Table IV.C.1

Unplanned Reactor Shutdowns (Scrams)

Type of Scram	Number of Occurrences	Cause of Shutdown
Manual	2	Stack monitor filter failure. Replacing the expired filter tape remedied the problem. Reactor operation was resumed.
Manual	1	Transient rod low air pressure. Replacing the failed air hose between the solenoid valve and the transient rod corrected the problem.
Manual	1	Bulk water high temperature. The reactor was scrammed and cooling expedited. The cooling system was found to be functioning at less than full capacity due to a closed make-up valve. The valve was opened and reactor operation was resumed.
Safety Channel	1	The scram set point on the safety channel was reached as the reactor was approaching full power with an experiment located in-core. The flux perturbation caused by the in-core experiment resulted in lower readings on the linear and % power channels relative to the reading on the safety channel.

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

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

1. 10 CFR 50.59 Changes to the Reactor Facility

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

a. AIR FLOW ANNUNCIATORS FOR THE REACTOR BAY VENTILATION SYSTEM

(1) Description

Until recently, the method of detecting operating abnormalities or failure of the reactor bay ventilation system was through annunciators linked to the electrical power for the air supply and exhaust fan motors, and through damper annunciators associated with the air-operated ventilation system dampers. The reactor operations staff has supplemented these annunciators by installing air pressure sensors in the air supply and exhaust ducts for the reactor bay ventilation system. The pressure sensors were installed in the ducts in locations where they will detect a significant decrease or total loss of air flow due to any cause. Installation involved drilling a small hole in the supply duct sheet metal and using an existing tap in the exhaust duct. The air

pressure sensors and associated switches were connected to the control room annunciator panel so that a lack of flow for any reason will sound and illuminate a "ventilation low flow" annunciator.

(2) Safety Evaluation

There are no negative safety implications associated with the installation of the air pressure sensors and switches. Indeed, they will enhance safety by reducing the already small probability that any ventilation system failures will go unnoticed. The basis for this conclusion stems from the fact that the new pressure switches will detect changes in or loss of ventilation air flow from any cause and not just from a loss of electrical power or a loss of instrument air pressure to the ventilation system dampers.

b. REPLACEMENT OF THE ANNUNCIATOR PANEL DAY/NIGHT SWITCH

(1) Description

In order to put the new "ventilation low flow" annunciator mentioned in D.1.a onto the day/night switch, it was necesary to replace the old switch with a new one which had more contacts. To do this, the switch location on the reactor console also needed to be changed. The old conductivity monitor (which was no longer used) was removed from the left console tower and a new panel was installed. The new day/night switch was installed in this panel. This has the additional advantage of placing the new switch in a more convenient location on the left console side cabinet.

(2) Safety Evaluation

This change of a switch and its location on the console has absolutely no safety implications whatsoever. Even though the original switch was located on the console, it did not interact in any way with any reactor safety circuitry or instrumentation.

c. ARGON VENT FAN REWIRING

(1) Description

The reactor staff had the electrical circuit to the argon vent fan rewired so that if the entire reactor bay ventilation system shuts down, or if only the reactor bay exhaust fan shuts down, the argon vent fan will also stop automatically. In addition, as part of the rewiring effort the electrical power for the argon vent fan was routed through a timer so that the argon fan will not restart until after a preset interval. During this delay interval, power will first be restored to the reactor building exhaust fan, and this system will be allowed to reach full operating capacity before the argon fan starts.

(2) Safety Evaluation

These facility changes were made to enhance safety, and are part of the Center's commitment to the ALARA program. Ensuring that the argon vent fan automatically stops whenever the entire reactor bay ventilation system shuts down or when the reactor bay exhaust fan shuts down will prevent the undiluted release of any small amounts of argon-41 which may be in the argon ventilation system piping. It will also relieve the reactor operator from having to shut off the argon fan manually in the event of a ventilation system shutdown. In both cases, the amount of argon-41 released during shutdown of the reactor bay ventilation system will be reduced.

Starting the argon vent fan after a preset time delay will ensure that any argon-41 in the argon ventilation system piping will not be drawn out until the reactor bay ventilation system is working at its full capacity. Thus, argon-41 concentrations will continue to be very low at the point of release. In addition, there is already a control room annunciator for the argon vent fan, so the operator is aware of the argon vent fan status at all times.

d. ROTATING RACK ANNUNCIATOR

(1) Description

The reactor operations staff installed an annunciator which will alert the reactor operator if the rotating rack should stop turning. The hardware to initiate the signal for the annunciator consists of:

(a) A permanent magnet attached to the large gear wheel on the rotating rack drive train.

(b) A magnetic-field sensor mounted on the rotating rack drive housing.

(c) An adjustable time-delay receiver that will receive a signal from the magnetic-field sensor.

The time-delay will trigger the annunciator panel if it does not receive a periodic signal from the magnetic-field sensor.

(2) Safety Evaluation

The installed electronic circuit is separate from all other reactor controls and circuits and, therefore, will in no way be detrimental to reactor safety. In fact, it may slightly enhance safety by alerting the reactor operator when (and if) the rack stops rotating. The circuit will only interact with a selected annunciator window. If, for some reason, the circuit should fail, then there will either be a continuous annunciator or no annunciator at all (which is the present arrangement). The correct functioning of the annunciator is automatically tested each time the rotating rack is turned off (approximately daily).

2. <u>10 CFR 50.59 Changes to Reactor Procedures</u>

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

a. REVISION OF OREGON STATE UNIVERSITY TRIGA REACTOR OPERATING PROCEDURE (OSTROP) 18--ENCAPSULATION REQUIREMENTS

(1) Description

The reactor operations staff expanded the encapsulation requirements as detailed in OSTROP 18. These requirements were originally written with the rotating rack and the pneumatic transfer system in mind and were, therefore, silent with respect to encapsulation requirements for other facilities. For these reasons, the encapsulation requirements were completely reevaluated. Instead of one table showing all encapsulation requirements, there are now five individual tables which detail the acceptable encapsulations for each of the OSTR irradiation facilities. In addition, the narrative description of encapsulation requirements, limitations, and other pertinent considerations contained in paragraphs 1) and 2) were slightly revised to accommodate the new tables, and a new paragraph 3) was added regarding specific ROC approval of encapsulations. A new paragraph 4) was also added to indicate that more rigorous encapsulations of a currently approved type may be used in lieu of less stringent polyethylene encapsulation.

(2) Safety Evaluation

It is difficult with such a large revision to specifically discuss every single encapsulation change. Therefore, the principles and philosophy of the changes will be addressed.

The general philosophy of the new encapsulation requirements is that they should be stated in a manner which will give experimenters as much flexibility as possible consistent with the known limitations of the various containers. This philosophy leads to the different categories in the tables.

The decision to split up the original encapsulation table into several different tables which are specific to certain irradiation facilities makes it possible to take into account factors such as neutron and gamma flux levels, neutron spectra, the temperature in the various irradiation facilities, and methods commonly used to handle irradiated samples. This added detail enhances safety in that it enables the encapsulation to be more specifically tailored to the type of facility rather than to some generic standard. For example, it was recognized that it was not always desirable in order to ensure containment using polyethylene vials, to allow irradiations longer than about 10 to 12 minutes in the rabbit facility when the reactor was at high power levels (e.g., 500 to 1000 kW) and cadmium covers were being used. Therefore, there is now a 100 kWh limit for polyethylene encapsulated, cadmium-covered samples in the rabbit.

The second general principle used in the reevaluation was that stable solid materials generally need only one level of containment, whereas liquids, powders and similar loose materials need two levels of containment. In this manner, containment appropriate to the material or substance being irradiated is achieved. However, with respect to this policy it should also be noted that in almost every case the containment specifications are in addition to the extra containment provided by the standard TRIGA tubes or by the rabbit tubes used to hold the encapsulated samples during irradiation.

For the rotating rack and pneumatic transfer facilities, the desired integrated neutron flux also affects the encapsulation requirements. Experience and testing has shown that there are limits to the capabilities of the various sizes of polyethylene vials used in these facilities. Therefore, these limitations are build into the new tables.

The final factor considered was whether or not cadmium covers will be used. The heating the extra gamma flux associated with the use of cadmium covers degrades polyethylene vials and, therefore, encapsulation is more restrictive when cadmium is used.

There are no known limitations to quartz and aluminum encapsulations; however, an administrative limit of 35 MWh has been chosen for routine approval. If needed, a greater irradiation time may be approved through the "Other Encapsulation Methods" option.

A new paragraph 3) has been added which allows for variances from these encapsulation requirements if the experiment has gone through the ROC approval procedure described in OSTROP 18.5. This does not reduce safety in any way because the experiment approval procedure requires specific ROC approval and is, therefore, even more rigorous.

A new paragraph 4) has also been added, and simply clarifies that more rigorous forms of currently approved encapsulations may be used in lieu of polyethylene. The only possible impact this can have is to enhance safety.

In conclusion, all of the encapsulation changes were made according to the philosophy and principles outlined above. In this manner, it is felt that each new table describes appropriate and safe levels of containment described in the tables are based on actual experience in use and/or testing, and have been found to prevent radioactive material release under the stated conditions of use.

b. REVISIONS TO THE OSTR AND RADIATION CENTER EMERGENCY RESPONSE PLAN--JULY 1989

(1) Description

In response to a previous amendment to the OSTR emergency plan, the USNRC required an amendment to revise the line of succession for the Senior Health Physicist (SHP) position. It was the Commission's opinion that the Radiation Center Director should not be included in the SHP line of succession. Hence, the position of Reactor Operator was substituted for the RC Director. Other changes included: adding the OSU Office of Environmental Health and Safety to the list of support agencies, updating the administrative title for the Public Information Officer to Assistant Vice President for University Relations, and including a typed version of Figure 3.2.

(2) Safety Evaluation

The aforementioned changes do not decrease the effectiveness of the emergency response plan. With respect to the SHP line of succession, the Reactor Operator is the most acceptable choice to replace the RC Director when considering the available staff members and their current commitments to the emergency response plan. The Reactor Operator position is regularly trained and examined in the topics of radiation protection and emergency response and consequently can fulfill the basic responsibilities of Senior Health Physicist.

The addition of the OSU Environmental Health and Safety office increases the effectiveness of the plan by including additional, skilled personnel who may be able to help in specific situations. The administrative title change and the typing of Figure 3.2 clearly do not decrease the effectiveness of the plan.

c. REVISIONS TO THE OSTR AND RADIATION CENTER EMERGENCY RESPONSE PLAN--OCTOBER 1989

(1) Description

As a result of the annual review of the emergency response plan on September 29, 1989, it was decided to make a number of small changes in the OSTR and Radiation Center Emergency Response Plan. These changes are detailed below.

Front Cover - The last revision date was updated.

Page 1-2 - The typographical error in the spelling of "service" was corrected.

Page 3-3 - Under the heading "City of Corvallis Police Department", the sentence from "The City of Corvallis Police Department will be involved in emergency..." was changed to "The City of Corvallis Police Department could be involved in an emergency..."

Page 3-14 - The diagram on the interface of the various on and off-site emergency organizations was updated to include the OSU Department of Environmental Safety, the name of OSU Campus Security was changed to OSU Campus Police and Security and the Federal Radiological Monitoring and Assessment Plan box was changed to Federal Emergency Management Agency (FRMAP).

Changes were also made to the Emergency Response Plan Implementing Procedures to update telephone numbers, and allow for personnel turnover.

(2) Safety Evaluation

There are clearly no safety implications of any of the changes to the emergency plan, as they do not affect any response actions. Most of the changes merely were made to keep the plan current. The City of Corvallis Police will not necessarily always respond to an emergency as the OSU Police now have increased capabilities and will normally be asked to respond to any significant emergencies.

d. REVISION TO THE OSTR AND RADIATION CENTER EMERGENCY RESPONSE PLAN--June 1990

(1) Description

It was determined that the decontamination equipment maintained at the OSU Student Health Center was no longer a necessary part of the existing emergency response plan for the OSU TRIGA reactor and Radiation Center. Therefore, the emergency response plan was revised in order to delete all references to the Student Health Center decontamination facility. Other minor changes to the plan were needed to correct a typing omission, to change the name of the OSU Department of Information and to update the plan to ensure that it was consistent with other reactor procedures. All of these changes are detailed below.

Page 3-4 — The sentence under Good Samaritan Hospital beginning: "Arrangements have also been made..." was deleted.

Page 3-5 — The section headed: "OSU Student Health Service" was deleted.

The words "Department of Information" was changed to "News and Communication Services" in two locations.

Page 3-10 The words "Director of the OSU Department of Information" were changed to "Assistant Vice-President for University Relations" in the first paragraph.

Page 3-14 That section of Figure 3.2 which shows the OSU Student Health Center was deleted.

"Department of Information" was changed to "News and Communication Services".

Page 7-3 All of the μ prefixes associated with airborne radioactivity concentrations were inadvertently omitted on this page. Therefore, this page was reissued with the μ prefixes inserted.

Page 7-10 Section 7.2.4.i).i) -- The last sentence: "This information is indicated on a personnel status board maintained in the control room." was deleted.

Page 8-6 Paragraph 8.3.2.c) was replaced with: "Injured personnel will normally be decontaminated and then dispatched to the Good Samaritan Hospital."

Page 8-7 Paragraph 8.3.3.c) was replaced with: "In the event that these showers are not accessible or available, there are further personnel decontamination facilities at the Good Samaritan Hospital."

Paragraph 8.3.4.b) was deleted and subsequent paragraphs renumbered.

Page 10-1 The wording "and OSU Student Health Center" was deleted from paragraph 10.1.b).iv).

Page 10-3 The wording "Student Health Service decontamination room and those in the" from paragraph 10.4.2.c) was deleted.

Page 10-4 Section 10.4.2.e) was changed to read: "The emergency evacuation horns are functionally tested each quarter."

Paragraph 10.4.3.b) was deleted and the following paragraph renumbered.

Section 10.4.3.c) was changed from "annually" to "semiannually".

Page B-1 Section B.2.b) was deleted and subsequent sections renumbered.

Pages B-2 through B-14

These pages were replaced with a revised example of the inventory checklist which did not reference the Student Health Center.

(2) Safety Evaluation

A recent reevaluation of the procedures to be used in the event of personnel injury involving contamination highlighted the fact that virtually no use would be made of the facility at the OSU Student Health Center. There are many decontamination facilities at the Radiation Center which would be used in preference to the Student Health Center. If these were unavailable due to the nature of the

accident or if injuries requiring immediate medical attention were involved, then the facilities which have been established at the Good Samaritan Hospital would normally be used. In addition, the decontamination kits which are maintained in the Corvallis Fire Department's Hazmat vehicle would also be available if needed. Therefore, it was concluded that the OSU Student Health Center's decontamination facility could be decommissioned with no reduction in the effectiveness of the existing emergency plan. Appropriate changes to the plan were made to implement this conclusion.

The revisions to the plan relating to the Department of Information's name change to News and Communication Services have no safety implications whatsoever. All of the expected responses remain the same.

The change to page 7-3 was merely correcting a typing omission which occurred when the page was revised. The plan itself, the alarm set points and the detection limits were not actually changed, so clearly there are no safety implications associated with this correction. Airborne concentration action levels in the plan and in the implementing procedures were, and are, still correct.

The personnel status board referred to on page 7-10 had not proven to be necessary and, therefore, it was felt that its use could be discontinued. Because there is normally only one or two people in the reactor bay at any one time, the reactor operator can easily keep track of where they are. During classes, the escorting instructor is responsible for the evacuation of his students if required. It is felt that this change does not reduce the effectiveness of the emergency plan or compromise safety in any way.

Initial difficulties with the condition of the evacuation horn batteries resulted in a switch to monthly routine maintenance of the batteries and monthly testing of the horns. After several years of experience, it was determined that the horn testing frequency could be reduced to quarterly, with no loss of confidence in the horns' ability to function when needed. This is largely due to the fact that the evacuation horn battery maintenance will remain on a monthly frequency. Again, it is felt that this change does not reduce the effectiveness of the emergency response plan.

The final change in the emergency plan on page 10-4 reflected the fact that the emergency equipment inventories at various locations are now checked on a semiannual rather than an annual basis. This is clearly an improvement in the plan.

e. REVISION OF THE REACTOR OPERATIONS COMMITTEE CHARTER AND OSTROP 6--ADMINISTRATIVE AND PERSONNEL PROCEDURES

(1) Description

As a result of the annual review of the Reactor Operations Committee (ROC) Charter, the reactor staff made one minor revision to section II.2 of the ROC Charter and to the corresponding wording from the charter which is contained in section 6.4.B.2 of OSTROP 6. Additional wording was inserted after the existing statement that "All members shall have equal voting rights and responsibilities." The new wording added the phrase, "In situations where a committee member has a conflict of interest, it shall be committee policy that the individual abstain from voting on the issue."

(2) Safety Evaluation

Addition of the conflict of interest statement has no direct relationship to any specific safety issue and certainly does not introduce any new

or unreviewed safety questions. Any safety-related impact of the new statement is only positive and thus enhances safety by removing any non-objective voting which might potentially occur in the presence of a conflict of interest.

f. CHANGE TO OSTROP 10 RELATING TO CONTROL ROD CALIBRATION AND THE CADMIUM-LINED IN-CORE IRRADIATION TUBE (CLICIT)

(1) Description

OSTROP 10.7.B.6 stated that if the control rods have been recalibrated since the CLICIT was last used, and if, as a result of the calibration, the worth of any rod changed by more than 2 cents, then all of the rods must be recalibrated with the CLICIT in the core before the CLICIT could be used. It was recognized that this limitation was not needed and could be relaxed without compromising safety or without conflicting with the OSTR Technical Specifications. Therefore, this section of OSTROP 10 was eliminated and 10.7.B.7 was renumbered to 10.7.B.6.

(2) Safety Evaluation

Technical Specification 4.3.1 only requires that the reactivity worth of each control rod and the shutdown margin (SDM) be measured annually and following significant core or control rod worth changes. Therefore, calibrating the rods once each year, with and without the CLICIT in the core, will meet this requirement.

The only time the control rod worth curves are used for routine steady state operation is in the determination of the core excess and the SDM to ensure that the SDM remains greater that \$0.57. It is clear that if the reactor has sufficient SDM without the CLICIT installed, then because the CLICIT adds only negative reactivity, there will be more than sufficient SDM with it in the core. Hence, there are no safety,

license or operational needs to recalibrate the control rods with the CLICIT in the core more frequently than required by the Technical Specifications (i.e., once a year, or after other significant core or control rod changes).

g. REVISIONS TO THE FUEL ELEMENT HANDLING PROCEDURES (OSTROP 11)

(1) Description

It was recently recognized that OSTROP 11 addressed the insertion and removal of the sample-holding dummy fuel element, but did not address the insertion and removal of the cadmium-lined in-core irradiation tube (CLICIT). The purpose of this change was to incorporate necessary fuel handling procedures associated with the use of each of these devices in the same section of OSTROP 11, namely section D.2.

(2) Safety Evaluation

This change updated the OSTR fuel element handling procedures, and therefore, contributes to increased safety by generating additional written procedures which supplement those presently in place. The fuel handling procedure for insertion and removal of the CLICIT is the <u>same</u> as that approved for the sample-holding dummy fuel element, and this procedure has been used for many years with no difficulty. This procedural change does not in any way change the authorization process for fuel element movement. Therefore, use of the revised procedures still requires the normal review and authorization detailed in other sections of OSTROP 11.

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

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

E. Surveillance and Maintenance

1. Non-Routine Maintenance

July 12, 1989	Replaced the bearings in the reactor primary pump and repaired the primary pump shaft.
July 31, 1989	Removed a fuel element with cladding deformation from the reactor core and replaced it with a new spare fuel element.
July 31, 1989	Removed the old transient control rod from the reactor core and inserted a new transient control rod in the same core position.
Aug. 18, 1989	Replaced a failed printed circuit board in the emergency power invertor.
Aug. 29, 1989	Replaced a transistor in the panel-control circuit board of the control room annunciator panel.
Sept. 13, 1989	Installed two additional latches on the reactor bay main access double doors.
Nov. 1, 1989	Replaced the analog meter for the stack monitor gas channel.
Nov. 27, 1989	Replaced the stack monitor pump.
Jan. 4, 1989	Installed a new magnetic starter for the reactor bay ventilation system supply fan.
Jan. 4, 1990	Rerouted electric power to the argon ventilation fan through the reactor bay exhaust fan contactors.
Jan. 4, 1990	Installed a time-delay restart relay on the argon ventilation fan.
Jan. 4, 1990	Installed two pressure switches downstream of the reactor bay supply fan and the exhaust fan for monitoring ventilation system flow.
Jan. 7, 1990	Equipped the reactor building east side door with a new alarmed crash bar assembly.
Jan. 22, 1990	Installed an additional latching device on the roof hatch door of the reactor building.

Jan. 22, 1990	Installed a new control room day-night switch.
March 13, 1990	Installed a television monitor in the control room for viewing the east P.A. door.
March 26, 1990	Replaced three number-indicating tubes in the control rod position indicator panel.
April 26, 1990	Replaced the transient rod air hose between the solenoid valve and the transient rod.
May 21, 1990	Welded a cracked seam along a bottom plate of the thermal column door.
June 6, 1990	Replaced the photo-multiplier tube in the particulate channel of the continuous air monitor.
June 18, 1990	Installed a new drive motor for the rotating rack and cleaned and adjusted the rotating rack clutch assembly.

2. Routine Surveillance and Maintenance

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

F. Reportable Occurrences

There were no reportable occurrences during the reporting period.

Figure IV.E.1

Monthly Surveillance and Maintenance (Sample Form)

OSTROP 13 SURVEILLANCE & MAINTENANCE FOR THE MONTH OF ______________________

SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED	DATE COMPLETED	REMARKS & INITIALS
* 1 FUNCTIONAL CHECK OF REACTOR WATER LEVEL ALARMS	MAXIMUM MOVEMENT ±3 INCHES	UP: ____ inches DN: ____ inches ANN: ________				
2 MEASUREMENT OF THE REACTOR PRIMARY WATER pH	MIN: 5 MAX: 7.5					
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. DISCS UP					
4 EMERGENCY POWER SYSTEM BATTERY CHECKS — GENERATOR	S.G.: >1.250					
	VOLTS ≥ 12V DC					
	CORR: NONE					
5 EVACUATION HORN & P.A. EMERGENCY SYSTEM BATTERY CHECKS	LIQUID: FULL					
	S.G.: >1.250					
	VOLTS ≥ 12V 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 for license requirements 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 ____ / ____ / ____ 19

	SURVEILLANCE & MAINTENANCE TO BE PERFORMED	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED**	DATE COMPLETED	REMARKS & INITIALS
*1	REACTOR OPERATIONS 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	WESTRONIC RECORDER SLIDE WIRE CLEANING	SLIDE WIRE CLEANED					
9	STACK MONITOR CHECKS (OIL DRIVE MOTORS, H.V. READINGS)	MOTORS OILED					
		PART: 500 V ±50	VOLTS				
		GAS: 900 V ±50	VOLTS				
10	TRACERLAB AREA RADIATION MONITOR (ARM) VOLTAGE CHECKS	25 V SUPPLY ±10%	VOLTS				
		H.V. 560 V ±10%	VOLTS				
11	ARM SYSTEM ALARM CHECKS	FUNCTIONAL					
12	OPERATOR LOG	a) ≥4 hours: at console (RO) or as Rx.Sup.(SRO) b) Complete Operating Exercise	a) TIME	b) OPERATING EXERCISE			
13	CHECK FILTER TAPE SPEED ON STACK MONITOR	1"/HR ± 0.2					
14	INCORPORATE OIB & FCB INTO DOCUMENTATION	QUARTERLY					
15	*TRANSIENT ROD CALIBRATION	OSTROP 9.0					

Item 11 — ARM system alarm checks:

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

Item 12 — Operator log:

NAME

* License Requirement ‡ Physical Security Plan Requirement

** Date not to be exceeded for license requirements 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
16	FUNCTIONAL CHECK OF EVACUATION ALARMS	ALL FUNCTIONAL					
17	SUBMISSION OF SAFEGUARDS LOG BY P.S.O.	SUBMIT IF NEW ENTRIES					
18	STACK MONITOR ALARM CIRCUIT CHECKS	ALARM ON CONTACT					
19							

* License Requirement ‡ Physical Security Plan Requirement

** Date not to be exceeded for license requirements 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 & 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	c				
*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 SHUT DOWN 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					
*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							
13	WESTRONICS RECORDER ZERO & CALIBRATION CHECKS							
14	STANDARD CONTROL ROD MOTOR CHECKS			OILED ____				
15	FLUKE FUEL TEMPERATURE INSTRUMENT "D" CELL CHECK		TEST POSITION READ >800°C					

*License Requirements

**Date not to be exceeded for license requirements is equal to the date last time plus 7½ months.

Revised 8/88

Figure IV.E.3 (Continued)

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15 (continued)

SEMI-ANNUAL SURVEILLANCE & MAINTENANCE FOR ______________

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

Figure IV.E.4

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16.0

ANNUAL Surveillance and Maintenance for the Year ____________

	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)		SEPT 13					
*3	STANDARD CONTROL ROD CALIBRATION:	a) SAFE	OSTROP 9.0					
		b) SHIM						
		c) REG						
*4	REACTOR POWER CALIBRATION		OSTROP 8.0					
*5	CALIBRATION OF REACTOR TANK WATER TEMPERATURE METERS		OSTROP 16.5					
*6	CONTINUOUS AIR MONITOR CALIBRATION:	a) Particulate Monitor	RCHPP 18.0					
		b) Gas Monitor						
*7	STACK MONITOR CALIBRATION:	a) Particulate Monitor	RCHPP 18 & 26					
		b) Gas Monitor						
*8	AREA RADIATION MONITOR CALIBRATION		RCHPP 18.0					
*9	WATER MONITOR CALIBRATION		RCHPP 18.0					
10	REACTOR TANK AND CORE COMPONENT INSPECTION		NO POWDERY WHITE SPOTS					
11	SNM PHYSICAL INVENTORY		OSTROP 20.0					
12	EMERGENCY RESPONSE PLAN DRILL							
13	STANDARD CONTROL ROD DRIVE INSPECTION		OSTROP 16.13					
14	OSU POLICE AND SECURITY RETRAINING							
15	50.59 REPORT		SEPT					
16	INTRUSION ALARM RESPONSE DRILL (OSU POLICE AND SECURITY)		RESPONSE ≤5 MIN					
17	EMERGENCY POWER INVERTER TEST		OSTROP 22.0					
18	REPLACE P.A. & EVAC SYSTEM LEAD-ACID BATTERIES		EVERY 4 YEARS					

*License Requirements

**Date not to be exceeded for annual license requirements 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.

Revised 3/88

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

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

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 materials 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 one to five part-time Radiation Protection Technicians (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 Cente. 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 cobalt-60 irradiators and X-ray machine. Conduct personnel dosimeter training.

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 effec:ve 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

Whenever possible, liquid effluent is analyzed for radioactivity content at the time it is released to the collection point (a holdup tank). 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 only two liquid effluent releases, both to the sanitary sewer. All Radiation Center and reactor facility liquid effluent data pertaining to these two releases are contained in Table V.B.1.

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.

Table V.B.1

Monthly Summary of Liquid Effluent Releases to the Sanitary Sewer
for the year July 1, 1989 through June 30, 1990[1]
(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[2]
AUG 89 Radiation Center Plus OSTR	3.12×10^{-4}	^{3}H ^{51}Cr ^{60}Co ^{75}Se	5.75×10^{-5} ---- ---- ----	3.11×10^{-4} 1.04×10^{-7} 2.20×10^{-7} 8.22×10^{-7}	5.77×10^{-5}	2.1%[3] 0.06%[4]	1660
OSTR Contribution to Above	**(2.94×10^{-4})**	**(^{3}H)** **^{51}Cr)** **(^{60}Co)** **(^{75}Se)**	**(5.43×10^{-5})** **(----)** **(----)** **(----)**	**(2.94×10^{-4})** **(1.04×10^{-7})** **(1.76×10^{-8})** **(1.31×10^{-8})**	**(5.44×10^{-5})**	**(1.8%)[3]** **(0.05%)[4]**	
APR 90 Radiation Center Plus OSTR	7.74×10^{-6}	^{3}H ^{60}Co ^{65}Zn ^{75}Se	1.08×10^{-6} ---- ---- ----	7.17×10^{-6} 2.17×10^{-7} 5.14×10^{-7} 4.99×10^{-6}	1.17×10^{-6}	0.8%[3] 0.03%[4]	1755
OSTR Contribution to Above	**(4.03×10^{-6})**	**(^{3}H)** **(^{60}Co)** **(^{65}Zn)** **(^{75}Se)**	**(----)** **(----)** **(----)** **(----)**	**(3.66×10^{-6})** **(4.51×10^{-8})** **(5.14×10^{-7})** **(3.11×10^{-6})**	**(6.06×10^{-8})**	**(0.5%)[3]** **(0.02%)[4]**	
Annual Total for Radiation Center Plus OSTR	3.89×10^{-4}	^{3}H ^{51}Cr ^{60}Co ^{65}Zn ^{75}Se	Not Applicable	3.89×10^{-4}	3.01×10^{-5}	1.2%[3] 0.04%[4]	3415
OSTR Contribution to Above	**(3.34×10^{-4})**	**(^{3}H)** **(^{51}Cr)** **(^{60}Co)** **(^{65}Zn)** **(^{75}Se)**	**Not Applicable**	**(3.34×10^{-4})**	**(2.59×10^{-5})**	**(1.0%)[3]** **(0.03%)[4]**	

(1) The OSU operational policy is to subtract only detector background from our water analysis data and not background radioactivity in the Corvallis city water. There were no liquid effluent releases during months not listed.

(2) 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.

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

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

Table V.B.2

Monthly Summary of Gaseous Effluent Releases for the Year July 1, 1989 through June 30, 1990[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) (%)
JUL 89	0.47	0.47	3.5×10^{-8}	0.9%
AUG 89	0.51	0.51	3.9×10^{-8}	1.0%
SEP 89	0.85	0.85	6.5×10^{-8}	1.6%
OCT 89	0.57	0.57	4.2×10^{-8}	1.0%
NOV 89	0.53	0.53	4.1×10^{-8}	1.0%
DEC 89	0.67	0.67	4.9×10^{-8}	1.2%
JAN 90	0.50	0.50	3.7×10^{-8}	0.9%
FEB 90	0.35	0.35	3.0×10^{-8}	0.7%
MAR 90	0.50	0.50	3.8×10^{-8}	0.9%
APR 90	0.62	0.62	4.8×10^{-8}	1.2%
MAY 90	0.43	0.43	3.3×10^{-8}	0.8%
JUN 90	0.47	0.47	3.6×10^{-8}	0.9%
ANNUAL VALUE	6.5	6.5	4.1×10^{-8}	1.0%

(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.

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 lead-214 and bismuth-214, 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.

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.

Table V.B.3

Annual Summary of Solid Waste Generated and Transferred
for the Year July 1, 1989 through June 30, 1990

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	15	^{24}Sodium ^{46}Scandium ^{51}Manganese ^{58}Cobalt ^{59}Iron ^{60}Cobalt ^{65}Zinc ^{75}Selenium ^{99}Technicium ^{124}Antimony ^{125}Antimony ^{131}Iodine ^{132}Tellurium ^{137}Cesium ^{140}Barium ^{140}Lanthanum ^{141}Cerium ^{152}Europium ^{154}Europium ^{182}Tantalum	1.3×10^{-3}	Dec. 7, 1989 May 8, 1990
Radiation Center Laboratories	15	^{14}Carbon ^{46}Scandium ^{59}Iron ^{60}Cobalt ^{140}Lanthanum ^{154}Europium	9.0×10^{-6}	Dec. 7, 1990 May 8, 1990

(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.

C. **Personnel Doses**

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

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
For the Year July 1, 1989 through June 30, 1990

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	17	47	135	480	375	1030
Key Facility Research Personnel	2	10	20	210	80	330
Physical Plant Maintenance Personnel	<1	N/A	20	N/A	44	N/A
Laboratory Class Students	0	5	0	120	0	240
Campus Police and Security Personnel	3	N/A	20	N/A	80	N/A
Visitors	<1	N/A	8	N/A	68	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 Dosimet rs

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 sh w the room number or location. The highest recorded dose equivalent was measured in B119, the source storage room. Monitoring at this location commenced on August 4, 1989 when small sources from the shielded sealed source storage room (Hot Cell) were temporarily stored in the NAA permanent storage file cabinets while the Hot Cell was painted. Although the measured dose equivalent at the B119 location was 3500 mrem for the third quarter of 1989 (equivalent to 2.5 mrem/hr), the dose equivalent at MRCFE-7, at the unrestricted fence boundary, was essentially background (see Figure V.E.1 and Table V.E.1). The small sources were returned to the Hot Cell at the end of this period. The NAA permanent storage file cabinets were moved from B119 to B116 in March of 1990 to permit additional shielding to be placed between the cabinets and the outside wall.

Figure V.D.1

TRIGA Facility and Radiation Center Area Dosimeter Locations

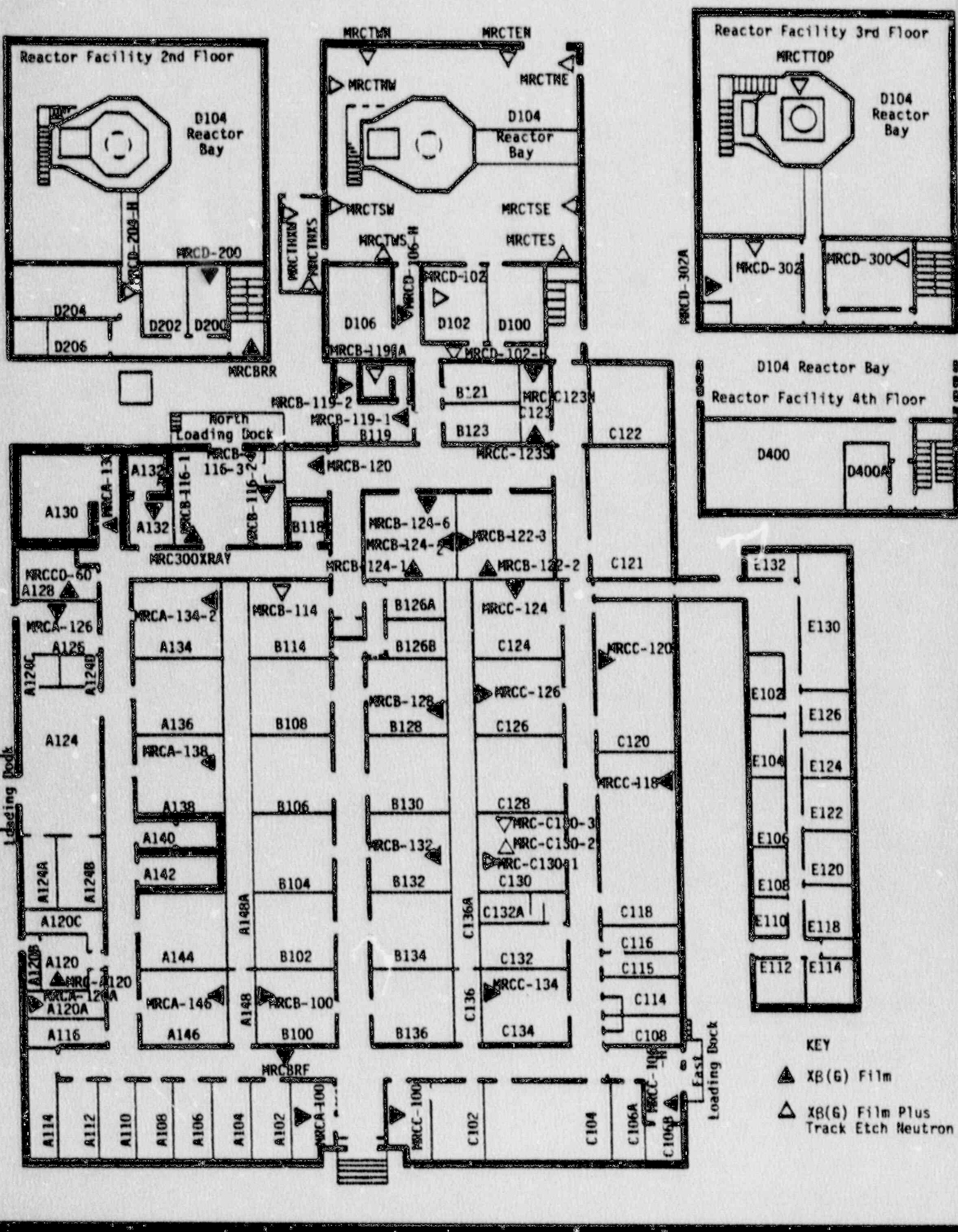


Table V.D.1

Total Dose Equivalent Recorded on Area Dosimeters Located
Within the TRIGA Reactor Facility for the Year
July 1, 1989 through June 30, 1990

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	35	0
MRCTSE	D104:	South Badge East Wall	0	0
MRCTSW	D104:	South Badge West Wall	65	0
MRCTNW	D104:	North Badge West Wall	90	0
MRCTWN	D104:	West Badge North Wall	15	0
MRCTEN	D104:	East Badge North Wall	115	0
MRCTES	D104:	East Badge South Wall	215	0
MRCTWS	D104:	West Badge South Wall	410	0
MRCTTOP	D104:	Reactor Top Badge	435	0
MRCTHXS	D104A:	South Badge HX Room	435	0
MRCTHXW	D104A:	West Badge HX Room	80	0
MRCD-302	D302:	Reactor Control Room	225	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 for the Year
July 1, 1989 through June 30, 1990

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	0 (2)	N/A
MRCA126	A126:	Campus RSO's Isotope Receiving Lab	105 (2)	N/A
MRCCO-60	A128:	Cobalt-60 Irradiator Room	180 (2)	N/A
MRCA130	A130:	Shielded Exposure Room	0 (2)	N/A
MRC300XRAY	A132:	X-Ray Console Room	25 (2)	N/A
MRCA134-2	A134:	NAA Research Office	230 (2)	N/A
MRCA138	A138:	Health Physics Laboratory	0 (2)	N/A
MRCA146	A146:	Gamma Analyzer Room (Storage Cave)	125 (2)	N/A
MRCB100	B100:	Gamma Analyzer Room (Storage Cave)	100 (2)	N/A
MRCB114	B114:	α Lab (Radium-226 Storage Facility)	1820	45
MRCB116-1	B116:	Storage Rm (NAA Permanent Storage)	35 (2)	N/A
MRCB116-2	B116:	Storage Rm (NAA Permanent Storage)	1130 (2)	N/A
MRCB116-3	B116:	Storage Rm (NAA Permanent Storage)	25 (2)	N/A
MRCB119-1	B119:	Source Storage Room	15 (2)	N/A
MRCB119-2	B119:	Source Storage Room	5610 (3)	N/A
MRCB119A	B119A:	Sealed Source Storage Room	4210	3050
MRCB120	B120:	Instrument Calibration Facility	55 (2)	N/A
MRCB122-2	B122:	Radioisotope Storage Hood	1250 (2)	N/A
MRCB122-3	B122:	Radioisotope Research Laboratory	0 (2)	N/A
MRCB124-1	B124:	Radioisotope Research Lab (Hood)	0 (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	15 (2)	N/A
MRCB132	B132:	Radioisotope Research Laboratory	980 (2)	N/A
MRCC100	C100:	Radiation Center Director's Office	0 (2)	N/A
MRCC106-H	C106H:	East Loading Dock	20 (2)	N/A
MRCC118	C118:	Radiochemistry Laboratory	0 (2)	N/A
MRCC120	C120:	Student Counting Laboratory	0 (2)	N/A
MRCC126N	C123:	Gamma Analyzer Room (Storage Cave)	590 (2)	N/A
MRCC123S	C123:	Gamma Analyzer Room	20 (2)	N/A

See footnotes next page.

Table V.D.2 (continued)

Total Dose Equivalent Recorded on Area Dosimeters
Located Within the Radiation Center for the Year
July 1, 1989 through June 30, 1990

Monitor I.D.	Radiation Center Facility Location (See Figure V.D.1)		Total Recorded Dose Equivalent (1)	
			$x\beta$(G) (mrem)	Neutron (mrem)
MRCC124	C124:	Student Office/Lounge	0 (2)	N/A
MRC126	C126:	Student Counting Laboratory	20 (2)	N/A
MRCC130-1	C130:	Radioisotope Laboratory (Hood)	15	0
MRCC130-2	C130:	Radioisotope Laboratory	0	0
MRCC130-3	C130:	Radioisotope Laboratory	0	0
MRCC134	C134:	Gamma Analyzer Room (Storage Cave)	95 (2)	N/A
MRCD102	D102:	Pneumatic Transfer Terminal Lab	135	0
MRCD102-H	D102H:	1st Floor Corridor at D102	0	0
MRCD106-H	D102H:	1st Floor Corridor at D106	145 (2)	N/A
MRCD200	D200:	Senior Health Physicist's Office	130 (2)	N/A
MRCBRR	D200H:	Rear Personnel Dosimetry Storage Rack	0 (2)	N/A
MRCD204-H	D204H:	2nd Floor Corridor at D204	15	0
MRCD300	D300:	3rd Floor Conference Room	15	0

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

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

(3) The total recorded dose equivalent reflects the summation of four quarterly beta-gamma dosimeters that commenced on August 4, 1989 (see text).

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 for the Year July 1, 1989 through June 30, 1990

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)	1	150	<500	<500
Reactor 2nd Deck Area (D104)	5	52	<500	<500
Reactor Bay SW (D104)	<1	12	<500	<500
Reactor Bay NW (D104)	<1	19	<500	<500
Reactor Bay NE (D104)	<1	15	<500	<500
Reactor Bay SW (D104)	<1	10	<500	<500
Class Experiments (D104,D302)	<1	4	<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	3	<500	<500
Health Physics Laboratory (A138)	<1	<1	<500	<500
^{60}Co Irradiator Room (A128)	<1	4	<500	<500
Radiation Research Labs (B114,B122,B124,B132,C130)	<1	9	<500	1000(2)
Radioactive Source Storage (B119A)	<1	12	<500	<500
Student Chemistry Laboratory (C118)	<1	<1	<500	<500
Student Counting Laboratories (C120,C126)	<1	<1	<500	<500
Operations Counting Room (C123)	<1	<1	<500	<500
Pneumatic Transfer Laboratory (D102)	<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 located on the fence surrounding the reactor facility (see Figure V.E.1). These stations consist of a standard metal mailbox attached to the fence at a height of four feet.

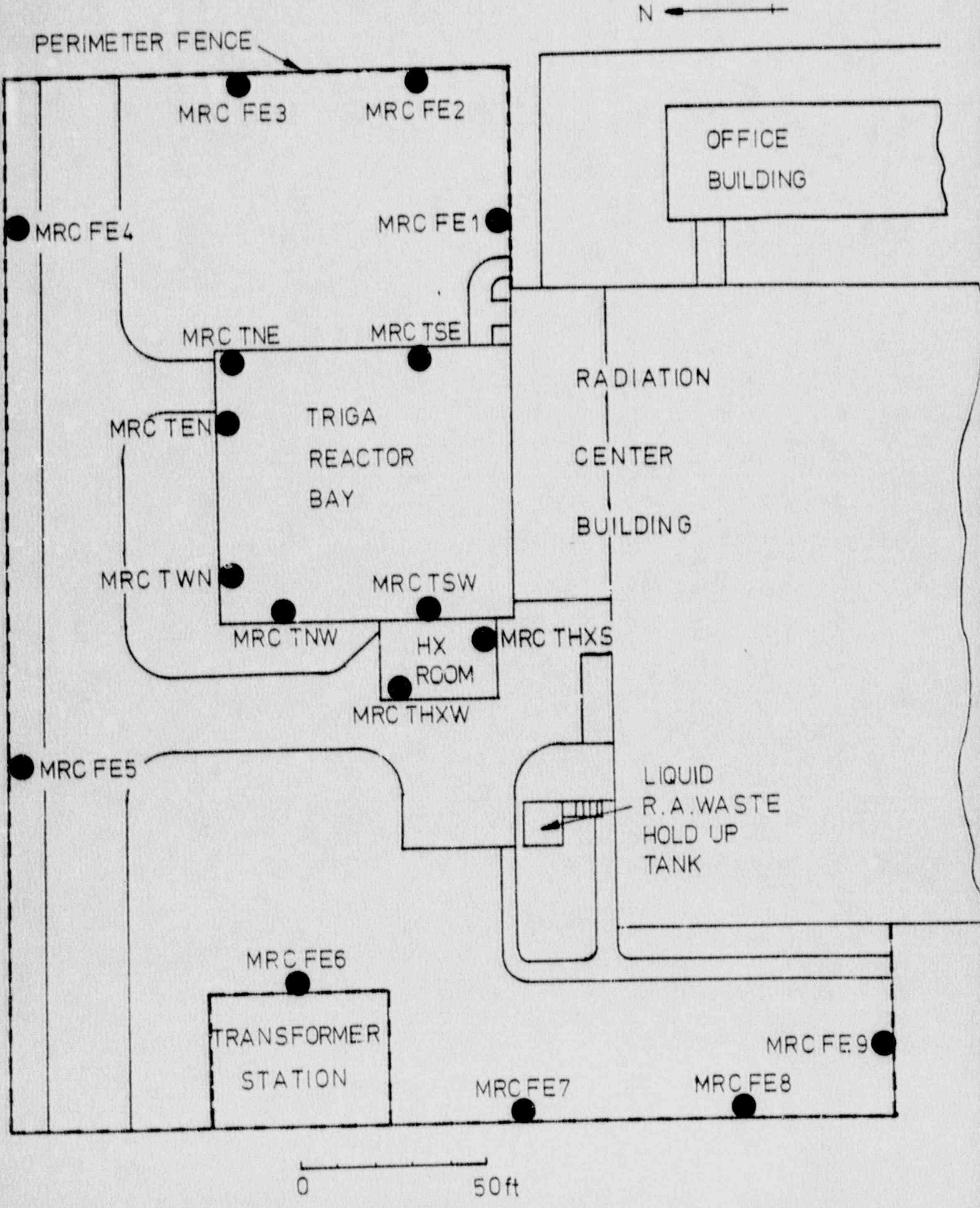
Each fence environmental station is equipped with an OSU supplied and processed TLD area monitor (normally three Harshaw ^{7}LiF TLD-700 chips per ^{7}Li monitor in a plastic "LEGO" mount). These monitors are exchanged and processed quarterly. The total number of TLD samples for the reporting period 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 micro-roentgens 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



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 at 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 sealed in a PVC tube which is taped 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 1 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. Thirteen of the off-site radiation monitoring stations also have a thin weather-tight aluminum box mounted to the post at approximately four feet above the ground (these stations do not have an "L" at the end of the station identification number). The aluminum box contains a packet with two $CaSO_4$ TLDs supplied and processed quarterly by the Radiation Detection Company. The total number of R. D. Co. TLD

Table V.E.1

Total Dose Equivalent at the
TRIGA Reactor Facility Fence
for the Year July 1, 1989 through June 30, 1990

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	86 ± 8	80 ± 23
MRCFE-2	100	87 ± 3	86 ± 21
MRCFE-3	101	91 ± 3	85 ± 23
MRCFE-4	106	91 ± 5	92 ± 28
MRCFE-5	88	82 ± 6	75 ± 26
MRCFE-6	93	83 ± 4	79 ± 38
MRCFE-7	95	86 ± 6	80 ± 23
MRCFE-8	92	85 ± 4	75 ± 20
MRCFE-9	88	78 ± 7	69 ± 17

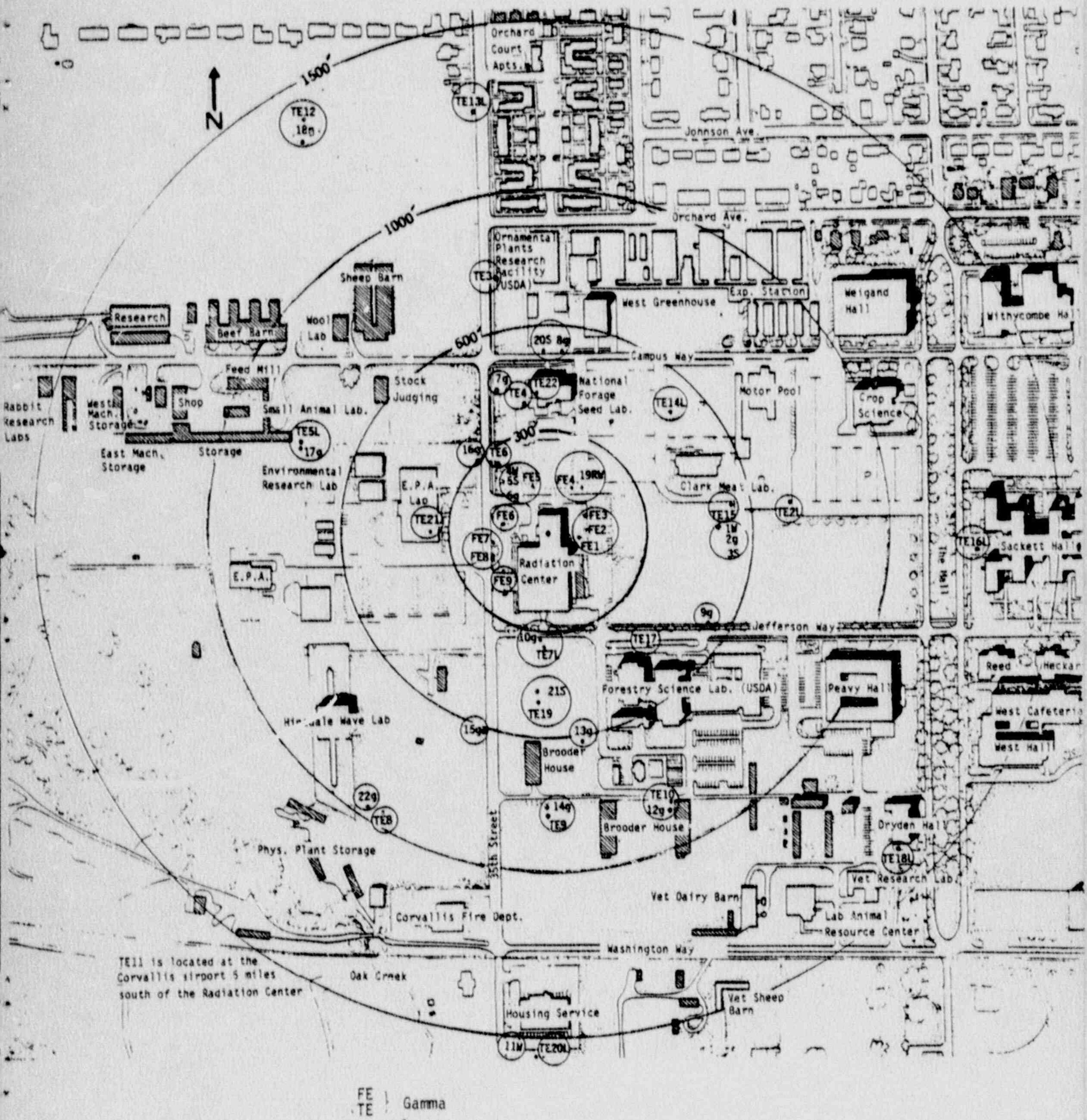
(1) Radiation Detection Company (R.D. Co.) TLD totals include their annual natural background contribution of 72 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 90 mrem for the same period.

(2) OSU fence totals include a measured natural background contribution of 70 ± 10 mrem.

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

Figure V.E.2

Monitoring Stations for the OSU TRIGA Reactor
For the Year July 1, 1989 through June 30, 1990



TE11 is located at the Corvallis airport 5 miles south of the Radiation Center

FE, TE — Gamma
g — Grass
S — Soil
W — Water
RW — Rainwater

SCALE: 0 100 200 300

Table V.E.2

Total Dose Equivalent at the
Off-Site Gamma Radiation Monitoring Stations
for the Year July 1, 1989 through June 30, 1990

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	---	85 ± 6	49 ± 12
MRCTE-3	97	69 ± 10[5]	86 ± 20
MRCTE-4	85	90 ± 3	73 ± 15
MRCTE-5L	---	108 ± 30	85 ± 15
MRCTE-6	95	97 ± 10	86 ± 20
MRCTE-7L	---	85 ± 6	88 ± 23
MRCTE-8	103	103 ± 7	96 ± 21
MRCTE-9	101	90 ± 12	94 ± 18
MRCTE-10	83	81 ± 9	65 ± 13
MRCTE-11	81	77 ± 4	63 ± 13
MRCTE-12	101	101 ± 11	95 ± 18
MRCTE-13L	---	116 ± 10	78 ± 17
MRCTE-14L	---	96 ± 11	66 ± 15
MRCTE-15	89	98 ± 9	78 ± 25
MRCTE-16L	---	103 ± 17	83 ± 10
MRCTE-17	89	92 ± 9	70 ± 12
MRCTE-18L	---	105 ± 5	75 ± 17
MRCTE-19	99	118 ± 12	94 ± 17
MRCTE-20L	---	112 ± 11	84 ± 13
MRCTE-21	71	80 ± 5	46 ± 12
MRCTE-22	79	84 ± 3	55 ± 12

(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 76 mrem for the reporting period. Average Corvallis area natural background using Radiation Detection Company TLDs totals 83 mrem for the same period.

(3) OSU off-site totals include a measured natural background contribution of 82 ± 34 mrem.

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

(5) The total dose equivalent for three quarterly monitoring periods only. The TLD packet was lost or stolen during one quarter.

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.

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. Soil, Water, and Vegetation Surveys

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

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

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

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

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

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

Table V.E.3

Annual Average Concentration of the Total Net Beta Radioactivity (Minus ^3H)
for Environmental Soil, Water, and Vegetation Samples
for the Year July 1, 1989 through June 30, 1990

Sample Location (See Figure V.E.2)	Sample Type	Annual Average Concentration of the Total New Beta (Minus ^3H) Radioactivity (1)	Reporting Units
1-W	Water	(2) $2.57 \times 10^{-8} \pm 6.20 \times 10^{-9}$	μCi/cc
4-W	Water	(2) $2.57 \times 10^{-8} \pm 6.20 \times 10^{-9}$	μCi/cc
11-W	Water	(2) $2.57 \times 10^{-8} \pm 6.20 \times 10^{-9}$	μCi/cc
19-RW	Rainwater	(2) $2.57 \times 10^{-8} \pm 6.20 \times 10^{-9}$	μCi/cc
3-S	Soil	$8.65 \times 10^{-5} \pm 1.45 \times 10^{-5}$	μCi/gram of dry soil
5-S	Soil	$7.76 \times 10^{-5} \pm 1.37 \times 10^{-5}$	μCi/gram of dry soil
20-S	Soil	$8.50 \times 10^{-5} \pm 1.39 \times 10^{-5}$	μCi/gram of dry soil
21-S	Soil	$8.80 \times 10^{-5} \pm 1.52 \times 10^{-5}$	μCi/gram of dry soil
2-G	Grass	$4.65 \times 10^{-4} \pm 4.98 \times 10^{-5}$	μCi/gram of dry ash
6-G	Grass	$2.63 \times 10^{-4} \pm 4.25 \times 10^{-5}$	μCi/gram of dry ash
7-G	Grass	$4.18 \times 10^{-4} \pm 4.96 \times 10^{-5}$	μCi/gram of dry ash
8-G	Grass	$3.53 \times 10^{-4} \pm 4.64 \times 10^{-5}$	μCi/gram of dry ash
9-G	Grass	$3.34 \times 10^{-4} \pm 4.93 \times 10^{-5}$	μCi/gram of dry ash
10-G	Grass	$3.81 \times 10^{-4} \pm 4.98 \times 10^{-5}$	μCi/gram of dry ash
12-G	Grass	$4.50 \times 10^{-4} \pm 3.79 \times 10^{-5}$	μCi/gram of dry ash
13-G	Grass	$4.54 \times 10^{-4} \pm 4.74 \times 10^{-5}$	μCi/gram of dry ash
14-G	Grass	$4.39 \times 10^{-4} \pm 4.56 \times 10^{-5}$	μCi/gram of dry ash
15-G	Grass	$2.76 \times 10^{-4} \pm 3.55 \times 10^{-5}$	μCi/gram of dry ash
16-G	Grass	$3.16 \times 10^{-4} \pm 4.53 \times 10^{-5}$	μCi/gram of dry ash
17-G	Grass	$4.59 \times 10^{-4} \pm 4.17 \times 10^{-5}$	μCi/gram of dry ash
18-G	Grass	$3.61 \times 10^{-4} \pm 3.54 \times 10^{-5}$	μCi/gram of dry ash
22-G	Grass	$4.02 \times 10^{-4} \pm 4.29 \times 10^{-5}$	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 of $2.57 \times 10^{-8} \pm 6.20 \times 10^{-9}$ μCi/cc.

Table V.E.4

Average LLD Concentration and Range of LLD Values for
Soil, Water and Vegetation Samples for the Year
July 1, 1989 through June 30, 1989

Sample Type	Average LLD Value	Range of LLD Values	Reporting Units
Soil	1.87×10^{-5}	1.19×10^{-5} to 2.45×10^{-5}	μCi/gram of dry soil
Water	2.57×10^{-8}	2.02×10^{-8} to 2.79×10^{-8}	μCi/cc
Vegetation	5.19×10^{-5}	2.90×10^{-5} to 1.24×10^{-4}	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.

Table V.F.1

Annual Summary of Radioactive Material Shipments Originating From the TRIGA Reactor Facility's NRC License R-106 for the Year July 1, 1989 through June 30, 1990

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Physics Dept. Corvallis, Oregon	1.0×10^{-3}	4	--	1	--	5
OSU Oceanography Corvallis, Oregon	2.6×10^{-2}	--	--	7	--	7
Univ. of Oregon Eugene, Oregon	4.2×10^{-2}	8	--	31	--	39
NEA, Inc. Beaverton, Oregon	9.2×10^{-4}	--	--	4	--	4
Univ. of Washington Seattle, Washington	1.0×10^{-6}	1	--	--	--	1
Battelle Pacific NW Laboratories Richland, WA	1.6×10^{-2}	--	--	4	--	4
Lawrence Berkeley Laboratory Berkeley, CA	2.0×10^{-5}	1	--	--	--	1
Brigham Young Univ. Provo, Utah	9.0×10^{-5}	2	--	--	--	2
Univ. of Wyoming Laramie, Wyoming	1.4×10^{-3}	8	--	1	--	9
Dartmouth Univ. Hanover, NH	3.0×10^{-5}	1	--	--	--	1
Rensselaer Poly. Institute Troy, New York	1.5×10^{-4}	5	--	--	--	5
TOTALS	8.8×10^{-2}	30	0	48	0	78

Table V.F.2

Annual Summary of Radioactive Material Shipments Originating
From the Radiation Center's State of Oregon License ORE 0005-3
For the Year July 1, 1989 through June 30, 1990

Shipped To	Total Activity (Curies)	Number of Shipments				
		Limited Quantity	Type A Quantity			Total
			White I	Yellow II	Yellow III	
OSU Physics Dept. Corvallis, Oregon	1.3×10^{-4}	1	--	--	--	1
OSU Oceanography Corvallis, Oregon	3.5×10^{-4}	4	--	--	--	4
OSU Chemistry Corvallis, Oregon	3.0×10^{-5}	1	--	--	--	1
OSU Pharmacy Corvallis, Oregon	1.1×10^{-4}	15	--	--	--	15
Oregon Health Div. Hermiston/Albany,OR	3.3×10^{-3}	--	--	2	--	2
Univ. of Oregon Eugene, Oregon	5.3×10^{-5}	2	--	--	--	2
Battelle Pacific NW Laboratories Richland, WA	4.0×10^{-6}	1	--	--	--	1
Lawrence Berkeley Laboratory Berkeley, CA	9.3×10^{-5}	2	1	1	--	4
UC San Diego San Diego, CA	1.6×10^{-6}	2	--	--	--	2
Univ. of Missouri Columbia, Missouri	2.2×10^{-5}	5	--	--	--	5
Univ. of Maryland Baltimore, MD	9.0×10^{-5}	1	--	--	--	1
TOTALS	4.2×10^{-3}	34	1	3	0	38

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

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 50 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 245 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 thesis 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	49	58	67	204
U.S. Environmental Protection Agency Corvallis, Oregon	1	0	0	4
CH^2M Hill Corvallis, Oregon	1	0	0	2
Corvallis Clinic Corvallis, Oregon	1	0	0	8
M. Bloomfield Corvallis, Oregon	1	1	0	2
U.S. Bureau of Mines Albany, Oregon	1	0	0	1
Oregon Department of Energy Salem, Oregon	1	0	0	6
Sun Seeds Brooks, Oregon	1	0	0	4
*University of Oregon Eugene, Oregon	13	14	9	18
Springfield Utility Board--Water Dept. Springfield, Oregon	1	0	0	1
U.S. Environmental Protection Agency Newport, Oregon	1	1	0	1
Levitronics, Inc. Tualatin, Oregon	1	0	0	1
*NEA, Inc. Beaverton, Oregon	1	0	0	4
*Intel Corporation Hillsboro, Oregon	1	0	0	2
ion Health Sciences University land, Oregon	3	5	0	23
nstitute, OHSU rtland, Oregon	1	1	0	3

ne OSTR.

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

Table VI.C.1 (Continued)

Institution	Number of Projects	Number of Faculty Involved	Number of Students Involved	Number of Uses of Center Facilities
Reed College Portland, Oregon	1	2	1	1
Oregon State Health Division Portland, Oregon	1	0	0	3
Oregon State Police Portland, Oregon	1	0	0	1
W. Chism Vancouver, Washington	1	0	0	3
Southern Oregon State College Ashland, Oregon	1	1	1	1
*University of Washington Seattle, Washington	3	3	8	5
*Battelle Pacific Northwest Laboratories Richland, Washington	3	0	0	3
*Westinghouse Hanford Richland, Washington	1	0	0	1
*M.B. Research Burnaby, BC, Canada	1	0	0	1
*Humboldt State University Arcata, California	2	1	1	2
*Lawrence Berkeley Laboratory Berkeley, California	1	1	0	1
*Stanford University Stanford, California	1	1	1	1
*Brigham Young University Provo, Utah	1	1	0	2
*Univ. of California, Santa Barbara Santa Barbara, California	2	2	1	2
*Univ. of California, Los Angeles Los Angeles, California	1	1	1	1
*University of Wyoming Laramie, Wyoming	2	4	0	11
*U.S. Geological Survey Denver Colorado	1	0	0	1

* Used 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
*South Dakota School of Mines and Technology, Rapid City, S. Dakota	1	2	1	1
*Texas Tech. University Lubbock, Texas	2	1	1	2
*University of Texas--Arlington Arlington, Texas	2	2	0	2
*Rice University Houston, Texas	2	3	1	2
*Trinity University San Antonio, Texas	1	1	1	1
*Louisiana State University Baton Rouge, Louisiana	4	3	3	4
*University of Tennessee Knoxville, Tennessee	1	1	0	2
*University of Rochester Rochester, New York	2	2	2	2
*City University of New York New York, New York	1	1	0	1
*State University of New York Albany, New York	1	1	0	1
*National Institute of Standards and Technology, Washington, D.C.	1	0	0	1
*University of North Carolina Greensboro, North Carolina	1	1	1	1
*North Carolina State University Raleigh, North Carolina	1	2	1	1
*Rensselaer Polytechnic Institute Troy, New York	3	3	0	5
*University of Florida Gainesville, Florida	2	1	2	4
*Dartmouth College Hanover, New Hampshire	1	2	0	1
*Australian Museum Sydney, Australia	1	0	0	1
TOTALS	129	123	103	355

* Used the OSTR.

Table VI.C.2

Graduate Student Thesis Research Which Utilized the Radiation Center

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
OREGON STATE UNIVERSITY				
Al-Baroudi, D.	PhD	Nuclear Engineering	Klein	Heat Rejection System in Space Reactors
Ala, A.	PhD	Nuclear Engineering	Reyes	An Experimental Investigation of Two-Phase Natural Circulation in a Passively Safe Reactor System
Almarshad, A.	PhD	Nuclear Engineering	Klein	Modeling of Oxide Growth on Ziraloy Fuel Rod Cladding
Almasoumi, A.	PhD	Nuclear Engineering	Binney	Monte Carlo Design of Seafloor Core Analysis System
Anand, A.	PhD	Nuclear Engineering	Binney	Design of Marine Sample Analysis Systems
Baik, S.	MS	Radiation Health	Higginbotham	$^{90}Sr/^{90}Y$ Quantification in Environmental Samples Using Beta Particle Spectroscopy with Active Gamma Ray Discrimination
Bukar, K.	MS	Nuclear Engineering	Robinson	Comparison of Various Flux Calculational Methods in Nodal Codes
Cho, B.	MS	Nuclear Engineering	Robinson	Nodal Methods for Calculating Nuclear Reactor Transients, Control Rod Patterns, and Fuel Pin Powers
*Davidson, G.	MS	Geosciences	Lawrence	Geochemical Characterization of Two Suture Zones (for Process Comparison)
*Dundon, L.	PhD	Physics	Gardner	High Pressure Perturbed Angular Correlation--ZrO_2
Eichenberg, T.	MS	Nuclear Engineering	Reyes	Numerical Analysis of Condensation Induced Water-Hammers in Horizontal Piping Systems
Fu, Yingxian	MS	Chemistry	Daniels	Time-Resolved Laser Spectroscopy of Nucleic Acids
*Fuchs, H.	MS	Physics	Gardner	Pertubated Angular Correlation Spectroscopy of Condensed Matter (at Elevated Temp)
*Greek, K.	PhD	Nuclear Engineering	Robinson	Development of an Object Oriented Expert System for PWR Core Reload
Greene, K.	PhD	Nuclear Engineering	Robinson	Process Monitoring and Control with Expert Systems in Nuclear Engineering
Gulshan-Ara, Z.	MS	Nuclear Engineering	Klein	Space Nuclear Reactor
*Gummin, W.	PhD	Physics	Krane	γ-γ Angular Correlations for ^{172}Er

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
Gutenberger, S.	PhD	Microbiology	Rohevec	Killing of Bacterial Kidney Disease
Heaberlin, J.	PhD	Nuclear Engineering	Robinson	A Knowledged-Based Approach for Monitoring and Situation Assessment at Nuclear Power Plants
Hicks, T.	MS	Radiation Health	Dodd	Radiation Protection Optimization of a Broad License Facility
*Hill, B.	PhD	Geosciences	Taylor	Controls on Silicic Magma Evolution in the Central High Cascades of Oregon
Jordheim, D.	MS	Nuclear Engineering	Binney	Production of ^{238}Pu
*Kausar, A.	MS	Geosciences	Dilles	Trace Element Contents from Various Ore Deposits in Pakistan
King, J.	MS	Nuclear Engineering	Reyes	A Study of Buoyant Backflow Instabilities in a 1/5 Scale Reactor Geometry
Lafi, A.	PhD	Nuclear Engineering	Reyes	A General Theory for Flooding Implementing the Cuspoid Catastrophe
Lee, H.	MS	Nuclear Engineering	Klein	Systems Analysis for an Advanced Thermionic Reactor
Leung, K.	PhD	Microbiology	Bottomley	Rhizobium Ecology
Lewis, B.	MS	Nuclear Engineering	Klein	In-Core Neutronic Analysis of an Advanced Thermionic Reactor
*Liu, Y.	PhD	Nuclear Engineering	Schmitt	A Chemical and Petrographic Study of Refractory Inclusion From KABA (CV3) Chondrite
Luick, B.	PhD	Food Science & Tech.	Penner	Passage of Food Components Through the GI Tract of a Rat
Marks, T.	MS	Nuclear Engineering	Klein	Space Reactors
*Mathis, A.	MS	Geosciences	Grunder	Age, Stratigraphy and Petrogenesis of Rock from Hart Mountain
Miles, T.	MS	Nuclear Engineering	Binney	MCNP KCODE Calculations
Pauley, K.	MS	Nuclear Engineering	Klein	Fluid and Thermal Calculations for Bubble Membrane Radiation for Space Nuclear Power Applications
Pawlowski, R.	MS	Nuclear Engineering	Klein	Temperature and Power Performance for Thermionic Fuel Elements in an Advanced Space Power Plant
Piepmeier, E.	PhD	Pharmacy	Ayres	In Vivo Behavior of Detergent Solubilized Purified Thrombomodulin on Intravenous Injection Into Rats

* Thesis research which utilized the OSTR

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
*Pratt, D.	MS	Radiation Health	Johnson	Undecided
*Pyle, D.	PhD	Oceanography	Christie/Collier	Trace Element Analysis of Basaltic Glasses--Southeast Indian Ridge
Saleh, H.	PhD	Nuclear Engineering	Binney	Filtering of NaI Detector Output
*Schilk, A.	PhD	Chemistry	Schmitt	INAA of Meteorite Materials
*Schwenker, R.	MS	Physics	Gardner	Angular Correlation Exp. Within the PAC Program
*Turner, S.	MS	Nuclear Engineering	Binney	Production of Medical Radioisotopes
Van Winkle, J.	MS	Nuclear Engineering	Klein	Oxidation of Zircalloy-4 in Pressurized Water Reactor Conditions
*Walker, R.	PhD	Geosciences	Field	Magmatism and Mineralization of the Ash Peak area, Arizona; Petrochemical Interpretations
*Yousef, S.	MS	Nuclear Engineering	Higginbotham	INAA of Biological Material for Selenium
Zahm, L.	MS	Nuclear Engineering	Klein	Cold Fusion Experiments
UNIVERSITY OF OREGON				
*Brandon, A.	PhD	Geosciences	Goles	Late Cretaceous Granites of Southeastern British Columbia
Bryson, R.	MA	Anthropology	Ayres	Geochemical Sourcing of Lithic Materials from Pohnpei Island, Micronesia
Kataoka, O.	MA	Anthropology	Ayres	Geochemical Sourcing of Lithic Materials from Pohnpei Island, Micronesia
Mauricio, R.	MA	Anthropology	Ayres	Geochemical Sourcing of Lithic Materials from Pohnpei Island, Micronesia
Olmo, R.	MA	Anthropology	Ayres	Geochemical Sourcing of Lithic Materials from Pohnpei Island, Micronesia
*Radosevich, S.	PhD	Anthropology	Lukacs	Trace Elements in Ancient Human Bone
*Skinner, C.	PhD	Anthropology	Aikens	Geologic and Archaeological Obsidian From Western Oregon
*Sonnenthal, E.	PhD	Geosciences	McBirney	Geochemical Evaluation of the Skaergaard Intrusion, East Greenland

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
HUMBOLDT STATE UNIVERSITY				
*Elder, D.	MS	Geology	Cashman	Redefinition of Early Mesosoic Terranes, Central Klamath Mountains, California
STANFORD				
*DeBari, S.	PhD	Geosciences	Mahood	Petrogenesis and Physical Evolution of the Fiambala Gabbronorite, Northwestern Argentina
UNIVERSITY OF CALIFORNIA--SAN FRANCISCO				
Williard, R	PhD		Hunt	Not known.
UNIVERSITY OF CALIFORNIA--SANTA BARBARA				
*Hoernle, K.	PhD	Geology	Tilton	Petrochemistry of Volcanic Rocks From the Canary Islands
UNIVERSITY OF CALIFORNIA--LOS ANGELES				
*Nelson, S.	PhD	Earth & Space Science	Davidson	Tertiary Magmatism of the Colorado Plateau
UNIVERSITY OF COLORADO				
*Ball, T.	PhD	Geology	Farmer	Isotopic Study of Early Protozoic Crustal Growth in Southern Wyoming
*Harrington, R.	PhD	Geosciences	Stern	Pliocene and Quaternary Volcanics of the Southern Andes in Central Chile
UNIVERSITY OF NEW MEXICO				
*Bryan, C.	PhD	Geology	Elston	Petrogenesis of Volcanic Rocks, SW New Mexico and SE Arizona

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY				
*Fritch, E.	MS		Shearer/Patterson	Petrogenetic Relations Between Gold Mineralization and Igneous Intrusions in the Black Hills, South Dakota
TEXAS TECH. UNIVERSITY				
*Johnson, K.	MS	Geosciences	Barnes	Origin of Gabbro and Peraluminous Granites, Klamath Mountains, California
RICE UNIVERSITY				
*Closman, C.	MS	Geology	Olsen	Determine Element Mobility in the Formation of Migmatites
TRINITY UNIVERSITY				
*Pearce, P.	BS	Geology	Smith	Investigation into Crystal Fractionation and Magma Mixing
LOUISIANA STATE UNIVERSITY				
*Sweeney, K.	MS	Nuclear Science Center	Knaus	Recent Sediments From Wetlands Bordering Northern Gulf of Mexico
UNIVERSITY OF ROCHESTER				
*Faggart, B.	PhD	Geosciences	Basu	Crust-Mantle Geochemical Interactions
*Ridgway, K.	PhD	Geosciences	DeCelles	Determine Source Areas of Sediment Filling Along Denali Fault, Yukon Territory, Canada
UNIVERSITY OF NORTH CAROLINA				
*Miller, J.	PhD	Geology	Glazner	Cenozoic Magmatism of the SW United States

* Thesis research which utilized the OSTR.

Table VI.C.2 (Continued)

Student's Name	Program	Academic Department	Faculty Advisor	Thesis Topic
NORTH CAROLINA STATE UNIVERSITY				
*Gandhok, G.	MS	Marine, Earth and Atmospheric Science	Fodor	Mantle Characteristics Beneath Northern Brazil
UNIVERSITY OF FLORIDA				
*Murphy, J.	MS	Geology	Mueller	Madison Range Archean Rocks from Southern Montana
*Weyand, E.	MS	Geology	Mueller	Madison Range Archean Rocks from Southern Montana

* Thesis research which utilized the OSTR.

Table VI.C.3

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

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
118	G. Larson	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.
192	N. Kerkvliet	Vet Medicine, OSU	Mice Irradiation	Irradiation of mice in ^{60}Co irradiator.	Vet Medicine
*231	H. Wollenberg S. Flexser	Lawrence Berkeley Laboratories	GRP Project	Fission track determination of uranium distribution and abundance in fractured heated rock.	Lawrence Berkeley Laboratories
*321	J. Steidtmann P. Groll G. LeFebre	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	M. Roden R. Donelick D.S. 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
*374	K. Tabbutt	Earth Science, Dartmouth College	Fission Track Studies	Fission track irradiations in the thermal column.	Dartmouth College
*377	B. Idleman	Dept. of Earth Sciences, Western Carolina University	Fission Track Age Dating	Fission track irradiations of apatites and zircons in the thermal column for age dating.	Western Carolina University
*398	R.A. Schmitt S.S. Hughes	Chemistry, Geology, OSU	High Cascade Mafic Platform	INAA of minerals separated from eclogite rock samples from Africa.	Radiation Center, OSU (Unfunded Research)
*415	R.A. Schmitt S.S. Hughes	Radiation Center, Geology, OSU	Pakistan Thrust Belt	INAA study of major and trace elements in Himalayan rocks from the fold-and-thrust belt in Northern Pakistan.	Joint Radiation Center, OSU and NSF Grant

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
422	S. Kaattari M. Arkoosh	Microbiology, OSU	Fish Lymphoctye Irradiation	Irradiation of fish lymphocytes in the ^{60}Co irradiator.	Microbiology
*427	J. White	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
*433	J. Longshore	Humboldt State University	Trace Element Analysis of Basalts and Rhyolites	Petrological and structural interpretation of volcanic rocks from N. California and S. Oregon.	USDOE (Reactor Use Share)
*441	P. DeCelles	Geological Sciences, University of Rochester	Miocene Volcanic Influences on Sedimentation	Use of INAA to study miocene volcanic influences on sedimentation in S. California.	USDOE (Reactor Use Share)
*442	D. Miller M. Roden R. Donelick	Geology, Rensselaer Polytechnic Institute	Thermal History and Age Determination in Rocks	Use of fission track analysis to determine age of rocks.	USDOE (Reactor Use Share)
*443	J. Gardner	Physics, OSU	^{181}Hf Angular Correlation Experiment	Perturbed angular correlation measurements of condensed matter.	Physics
*444	R. Duncan	Oceanography, OSU	^{40}Ar-^{39}Ar Dating	Produce ^{39}Ar from ^{39}K to measure radiometric ages on basaltic rocks from ocean basins.	Oceanography
*445	R. Schmitt A. Schilk	Geology/Chemistry, OSU	INAA of Meteorite Materials (Mokoia)	Determination of chemical composition for purposes of genetic modelling/trace element behavior.	NASA
*452	R. Schmitt Y.-G. Liu	Chemistry, OSU	NAA of Sediment Samples	Determine Al content in selected sediment samples from the Pacific Ocean.	NASA
*455	S. Radosevich J. Lukacs	Anthropology, University of Oregon	INAA of 20 TUFT samples	Determination of trace element contents in TUFT samples.	USDOE (Reactor Use Share)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*461	C. Aikens C. Skinner	Anthropology, University of Oregon	Characterization of W. Oregon Obsidian Artifacts	Characterization of Western Oregon obsidian artifacts by INAA of obsidian archaeological material.	USDOE (Reactor Use Share)
*462	C. Hull	Geology, University of Oregon	Basaltic Feeder Dikes for Picture Gorge Basalt Flows	INAA to determine minor and trace element content of Picture Gorge basalt samples.	USDOE (Reactor Use Share)
467	R. Knaus	Nuclear Science Center, Louisiana State University	Soil Horizon Markers in Fresh Water Wetlands	INAA of Sm and Dy tracers in fresh water wetland habitat--peat samples.	USDOE (Reactor Use Share)
475	W. Ayres	Anthropology, University of Oregon	Geochemical Sourcing of Lithic Materials from Pohnpei Island, Micronesia	INAA of basaltic building and quarry materials for geochemical characterization.	USDOE (Reactor Use Share)
*476	G. Farmer	Institute for Research in Environmental Science, University of Colorado	Cenozoic Volcanic Rocks in the Mojave Desert	Characterization of mantle sources for magmas contributing to Mojave Desert volcanic rocks.	USDOE (Reactor Use Share)
*478	A. Johnson	Radiation Center	Radiation Center Tours	Tours of the Radiation Center and reactor for various school (non-OSU) groups on an as-requested basis.	USDOE (Reactor Use Share)
479	D. Livesay	CH_2M-Hill	Liquid Scintillation Counting (LSC)	LSC counting of samples for gross α and β.	CH_2M-Hill
480	A. Johnson B. Dodd J. Higginbotham	Radiation Center	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
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

* Projects which utilized the OSTR.

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
483	J. Betschart	Nuclear Engineering, OSU	Environmental Radiation Monitoring at Coal and Nuclear Plants–Honors	Perform environmental radiation measurements using and other techniques.	Radiation Center and Honors Program
484	J. Higginbotham S. Yousef	Radiation Center, OSU	NAA Applications of a Cf Sealed Source	Investigations into the utilization of a Cf neutron source for Neutron Activation Analysis.	Radiation Center
*486	B. Singer	Geology and Geophysics, University of Wyoming	Irradiation of Geological Samples	Irradiate and ship rock samples to University of Wyoming	University of Wyoming
488	G. Little	Radiation Safety Office, OSU	Calibration of Portable Survey Instruments	Calibrate portable radiation survey instruments for radiation users on OSU campus.	Radiation Center
489	N. Goevelinger	Oregon State Health Division, Radiation Control Section	Calibration of Radiation Control Section Portable Survey Instruments	Calibrate portable radiation survey instruments for Oregon Radiation Control Section.	Radiation Control Section, OSHD
*491	R. Walker	Geology, OSU	Taylor Creek Rhyolites	Determination of partition coefficients for sanidines from the Taylor Creek rhyolites, New Mexico.	Radiation Center (Unfunded Research)
*496	G. Goles E. Sonnenthal	Geological Science, University of Oregon	Picture Gorge Basalt Geochemistry	Geochemical study of melt segregation in thick differential flows of Picture Gorge basalt.	USDOE (Reactor Use Share)
*499	P. DeCelles	Geological Science, University of Rochester	Paleocene to Eocene Synorganic Sedimentary Rocks in Wyoming	INAA of shale samples from Southeast Beartooth uplift and Bighorn Basin, Wyoming.	USDOE (Reactor Use Share)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*501	C. Hull	Geological Science, University of Oregon	Disequilibrium Dating of Hydrothermal Calcite	Pilot study to determine the feasibility of disequilibrium dating of hydrothermal calcites.	Geological Science, University of Oregon
*504	B. Nelson	Geological Sciences, University of Washington	Chemical Evolution of Metamorphosed Sediments and Basalts	INAA to characterize the western margin of the U.S.	USDOE (Reactor Use Share)
506	J. Gardner H. Fuchs R. Schwenker	Physics, OSU	[illegible]e of Angular Correlation in Studies of Zirconia and Zirconia Alloys	Investigate microscopic structures and defect dynamics of zirconia and its alloy by PAC.	Physics, OSU
509	W. Barbat	Levitronics (II)	Enhanced Electrical Conductance in Metal	Irradiation of phosphor bronze wire with X/γ radiation to induce enhanced electrical conductance.	Radiation Center
*512	J. Higginbotham S. Yousef	Nuclear Engineering, OSU	Selenium Concentration in Oregon Subsurface Ground Waters.	NAA of water sampler after physical and chemical concentration of selenium in the samples.	Radiation Center
515	M. Penner B. Luick	Food Science and Technology, OSU	Passage of Food Components Through the GI Tract of a Rat	INAA of rat feces to assess the rate of passage of Co and Cr labelled food substances through the GI tract.	Food Science and Technolgy, Radiation Center
*516	W. Leeman	Earth Sciences Div., Rice University	Cascade Range Lavas	INAA to assess time-dependent compositional variations.	National Science Foundation
519	B. Livingstone J. Gile P. Monaco	USEPA--Corvallis	Instrument Calibration	Calibrate 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 fracks in catcher foils for dating.	University of Washington, Dept. of Geological Science

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*522	S. Hughes	Geology/Chemistry, OSU	Characterization of OSTR In-Core Cd-Lined Irradiation Tube	Evaluate neutron flux intensities, flux gradients and temperatures inside Cd-lined irradiation tube.	Radiation Center
*524	L. Taylor	University of Tennessee	Elemental Characterization of Mineral Separates and Bulk Rocks	INAA of geological samples for all detectable elements.	University of Tennessee-Geological Science
*530	L. Duncan R. Hogue	U.S. Forest Service Bureau of Land Management	Forest Fire Investigation	INAA of one metal fragment and samples to be removed from chain saw.	Bureau of Land Management
*533	R. Collier R. Conard	Oceanography, OSU	Sediments and Crust Materials from Crater Lake	INAA for trace elements in Crater Lake sediments and crust materials.	Oceanography
535	B. Nash	U.S. Bureau of Mines--Albany	Instrument Calibration	Calibrate Bureau of Mines portable radiation survey meters.	U.S. Bureau of Mines--Albany Research Center
*536	K. Krane W. Loveland	Physics, OSU	γ-γ Angular Correlations for ^{172}Er	Prepare Er, Tm tracers for test chemical separations for use in ^{172}Er γ-γ angular correlation study.	USDOE (Reactor Use Share)
*537	R. Schmitt B. O'Connor	U.S. Bureau of Mines	Gold in Novaculite	INAA for determination of gold content in novaculite from Arkansas.	U.S. Bureau of Mines
*541	B. Collier B. Conard	Marine Geology, Oceanography, OSU	Trace Elements in Sediment Cores from Southern Oregon Coast	INAA for trace elements in southern Oregon Coast sediment cores.	Oceanography
*542	R. Lawrence	Geology, OSU	Pakastani Granites	INAA to determine major and trace element content of granites from Pakistan.	Geology, OSU
*544	B. Tansy	NEA, Inc.	Reactor Irradiation of Samples for INAA	Irradiation of sediments and filter papers, followed by shipment or on-site analysis, as appropriate).	NEA, Inc.

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*545	P. Mueller	Geology, University of Florida	Complete INAA of Geologic Samples	Perform complete INAA on nin_ geologic samples.	University of Florida
*546	J. Doerges	Radiation Safety anu Hazardous Materials Office, University of Wyoming	Tantalum Wire Activation for Implanting in Toads (for Tracking)	Irradiate 10 pieces of 1 mm diameter Ta-181 wire to achieve Ta-182 activity of 100 μCi per wire station.	University of Wyoming
547	B. Boese	EPA, Newport	Survey Instrument Calibration	Calibrate 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
549	G. Little	Radiation Safety, OSU	Radiation Protection	^{75}Se shipping package swipe activity determination.	Radiation Center
*550	R. Walker K. Hoernle	Radiation Center, OSU Univ. of California, Santa Barbara	Petrochemistry of Volcanic Rocks Associated with the Canary Island's Hot Spot	Trace element determination of alkali basalt nephelinite, tholeiite, basanite, magearite, and carbonatite lavas from the Canary Islands.	Radiation Center
551	G. Keller	V.P. for Research and Graduate Studies, OSU	Kiev Soil Analysis	Gamma spectroscopy of soil from Kiev, USSR.	Radiation Center
552	R. Muren	Sun Seeds	Egg Transformation in Onion Flowers via Co-60 Irradiation	Irradiate onion flowers using Co-60 to induce changes in cell nuclei.	Sun Seeds
553	P. Bottomley	Microbiology, OSU	Rhizobium Ecology	Soil sterilization via irradiation in Co-60.	Microbiology
554	B. Robison D. Smith	Oregon Department of Energy	Instrument Calibration for Oregon Dept. of Energy	Instrument calibration of survey meters for PUC truck inspectors.	Oregon Dept. of Energy

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*555	C. Bennett	Intel Corporation	Quantification of Trace Amounts of Phosphorus in Silicon Semiconductor Materials	Quantify trace amounts of P in the presence of As in pure silicon semiconductors.	Intel Corporation
556	B. Wilson	Southern Oregon State College, Physics	Neutron Survey Instrumentation for Surveying Radioactive Material Shipments	Use of BF_3 neutron survey meter to determine surface dose rates on shipping container containing a 500 mCi AmBe neutron source.	Radiation Center
*557	R. Walker D. Becker	Radiation Center, National Institute of Standards and Technology	ASTM Task Group's Biological Material Quality Assurance Intercomparison	Standardization of peach and apple leaves for use as standard reference materials.	Radiation Center
*558	W. Loveland	Chemistry, OSU	Vial Certification	Test screwtop vials for use in the OSU TRIGA reactor.	Radiation Center
*559	J. Schmitt J. Laul	Battelle Northwest Lab.	INAA of Katmai Fumur[illegible]ul Suite	Elemental analysis of granitite rock samples via INAA.	Battelle NW Lab.
*560	D. Pyle	Oceanography, OSU	Trace Element Chemistry of Basaltic Glasses from the Southeast Indian Ridge	Irradiation of basalt samples to determine trace element chemistry.	Oceanography
*561	W. Sandine	Microbiology, OSU	Patent Infringement Investigation	INAA of a powdered chemical for Mg.	Microbiology
*562	H. Brager	Westinghouse Hanford	Tantalum Content of Yttrium	Determination of Ta content of Y metal or Y hybrid.	Westinghouse Hanford
*563	D. Miller	Rensselaer Polytechnic Institute	Thermal History of Sedimentary Basins	Analysis of U content of apatite and zircon for use in fission track age determinations.	USDOE (Reactor Use Share)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*564	C. Hull	Geological Sciences, University of Oregon	Petrochemistry of Feeder Dikes for the Picture Gorge Basalts, Oregon	Determination of feeder dikes for the Picture Gorge basalt by use of trace element characterization.	USDOE (Reactor Use Share)
*565	G. Goles M. Patino-Douce	Geological Sciences, University of Oregon	Geochemistry of Granites from the Achala Batholith, Southeastern Sierras Pampeanas, Argentina	Geochemical characterization of granitic rocks to establish their petrogenesis and the tectonic implications of their formation.	USDOE (Reactor Use Share)
*566	G. Goles A. McBirney E. Sonnenthal	Geological Sciences, University of Oregon	Geochemical Evolution of the Skaergaard Intrusion, East Greenland	Investigation of the transport of elements by chlorine and sulfur-rich fluids after the magmatic stage of the intrusion has culminated.	USDOE (Reactor Use Share)
*567	G. Goles R. Page S. Poma	Geological Sciences, University of Oregon	Geochemical Characterization of a Basalt-Trachyte Suite from the Talagapa Volcanic Field, Argentina	Petrochemical determination of basalts and trachytes from the Talagapa Volcanic Field to compare them with basalt-trachyte suites from other tectonic settings.	USDOE (Reactor Use Share)
*568	G. Goles	Geological Sciences, University of Oregon	Geochemical Characterization of Igneous Rocks from Pohnpei, Federated States of Micronesia	Petrochemical determination of igneous rocks from the archaeological site of Pohnpei.	USDOE (Reactor Use Share)
*569	C. Stern R. Harrington	Geological Sciences, University of Colorado	Pliocene and Quaternary Volcanics of the Southern Andes in Central Chile	Interpretation of temporal changes in magma-genesis processes and their relation with tectonics along the Southern Chilean oceanic-continental convergent plate boundary.	USDOE (Reactor Use Share)
*570	W. Leeman	Geology and Geophysics, Rice University	Geochemical Studies of a Primitive Oceanic Island Arc--South Sandwich Islands	Evaluation of a primitive intra-oceanic arc setting to determine the subduction component of the magmas without the interference of a sialic contaminant.	USDOE (Reactor Use Share)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*571	C. Skinner	Anthropology, University of Oregon	Geochemical Characterization and Correlation of Geologic and Archaeological Obsidian from Western Oregon	Use of abundances of trace elements in obsidian artifacts as fingerprints to determine the source locations and identify trading routes.	USDOE (Reactor Use Share)
*572	B. Nelson	Geological Sciences, University of Washington	Geochemical Characteristics of the Variscan Granites	Identification of the African and European continental margin origins by comparing the Carboniferous to Devonian age Variscan granites.	USDOE (Reactor Use Share)
*573	J. Schieber	Geology, University of Texas–Arlington	Geochmistry of Shales from the Western and Central Belt Basin, Montana	Determine source terranes, fractionation of elements during transport, and variations in weathering intensity of the Proterozoic Belt Supergroup, Montana.	USDOE (Reactor Use Share)
*574	J. Schieber R. Schmerold	Geology, University of Texas–Arlington	A Geochemical Survey of Proterozoic Metasediments and Metavolcanics from Central Ethiopia	Determine tectonic setting and igneous environment of volcanic rocks and the source areas of the sedimentary rocks. This should elucidate early crustal history of East African craton.	USDOE (Reactor Use Share)
*575	P. Mueller J. Murphy E. Weyand	Geology, University of Florida	Madison Range Archean Rocks from Southern Montana	Investigation of Archean rocks from the Madison Range to determine if they are an ancient analog of a modern convergent plate margin.	USDOE (Reactor Use Share)
*576	K. Hoernle G. Tilton H. Schmincke	Geology, University of California, Santa Barbara	Geochemistry of Basalts on Gran Canaria, Canary Islands	Development of petrogenetic models for the Gran Canaria picrite-tholeiite through melilitite suite, particularly if batch or fractional melting models are more appropriate.	USDOE (Reactor Use Share)
*577	J. Steiner R. Walker	Earth and Planetary Science, City College of City University of New York; Radiation Center, OSU	Geochemistry of the Palisades Sill in the Area of Nyack, New York	Trace element characterization of various phases of the Palisades Sill to determine the origin of the magma and constrain the crystallization history of the Sill.	Radiation Center (Unfunded Research)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*578	C. Barnes	Geosciences, Texas Tech University	Trace Element Geochemistry of Basalts from the High Cascade Range, Southern Oregon	Trace element investigation to determine the geochemical characteristics of the sources of basaltic lavas and constrain the composition of parental magmas of the andesitic lavas found in the southern High Cascades.	USDOE (Reactor Use Share)
*579	P. Verplanck G. Davidson	CIRES, University of Colorado; USGS, Denver; Geosciences, OSU	Comparison of the Salmon River Suture, Idaho with the Indus Suture, northern Pakistan	Both zones consist of suturing island arc terranes with continental terranes, the geochemical characterization of the two suture zones will allow comparison of similarities and differences between the processes.	USDOE (Reactor Use Share)
*580	G. Farmer T. Ball	Geological Sciences and CIRES, University of Colorado	A Nd Isotopic Study of Early Proterozoic Crustal Growth in Southern Wyoming	To constrain models for the genesis of Proterozoic continental crust and for the accretion of these crustal segments to the margins of pre-existing Archean continental cratons.	USDOE (Reactor Use Share)
*581	W. Elston C. Bryan	Geology, University of New Mexico	Geochemistry and Petrogeneisis of Mid-Tertiary Volcanic Rocks, Southwestern New Mexico and Southeastern Arizona	To constrain the chemical histories of early versus late-erupted volcanic rocks and to develop petrogenetic models involving partial melting of lower crustal rocks.	USDOE (Reactor Use Share)
*582	J. Longshore S. Cashman D. Elder	Humboldt State University	Redefinition of Early Mesozoic Terranes, Central Klamath Mountains, California	Reexamination of the volcanic units in the Klamath Mountains to establish inter-terrane correlations and determine tectonic setting of volcanic rocks.	USDOE (Reactor Use Share)
*583	R. Walker	Radiation Center	Petrochemical Comparison of the Sonya Creek and Sanford Eruptive Centers, Alaska	An investigation using trace element contents of the 20 my old Sonya Creek eruptive center and the 0.8 my old Sanford volcano to characterize the volcanism of the Wrangell area of southeast Alaska.	Radiation Center (Unfunded Research)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*584	A. Johnson	Radiation Center	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 Share)
*585	S. Lewis M. Bartholomew	Geology, Montana College of Mineral Science and Technology	Correlation of Precambrian Crystalline Massifs in the Appalachian Mountains, Eastern United States	To establish geochemical criteria for the comparison of Precambrian crystalline massifs that underlie metamorphic and plutonic rocks of the Appalachian orogen.	USDOE (Reactor Use Share)
*586	S. Hughes	Chemistry, Montana College of Mineral Science and Technology	Petrology and Geochemistry of Columbia River Basalt Feeder Dikes in Eastern Oregon	To evaluate the petrogenesis of magma types associated with CRB feeder dikes, to study the tectonic relations of early CRB eruptions in eastern Oregon, and to gain knowledge of feeder dike interaction with the country rock through which they erupted.	USDOE (Reactor Use Share)
*587	J. Davidson J. Nelson	Earth and Space Sciences, Univ. of California, Los Angeles	Tertiary Magmatism of the Colorado Plateau	To evaluate the differentiation histories and degree of crustal interaction of volcanic rocks from the Henry and La Sal Mountains, Utah.	USDOE (Reactor Use Share)
*588	J. Steiner	Dept. of Earth and Planetary Sciences, City College of City University of New York	REE Characteristics of the Palisades Magma Pulses, New York and New Jersey	To map the various magmatic pulses of the Palisades Sill using REE content, to identify the initial chemical signature of the pulses, and to establish chemical variations resulting from internal differentiation following emplacement.	USDOE (Reactor Use Share)
*589	G. Goles R. Bryson	Geological Sciences, Anthropology, University of Oregon	Relationships Between Ceramics and Political Organization in Prehistoric Pohnpei, Micronesia	Geochemical characterization of ceramic artifacts from Nan Madol archaeological complex to trace trading routes and establish political boundaries and interactions.	USDOE (Reactor Use Share)
*590	G. Goles A. Brandon	Geological Sciences, University of Oregon	Late Cretaceous Granites of Southeastern British Columbia	Geochemical characterization of accreted terranes and the petrogenesis of plutons that mark the suture boundaries.	USDOE (Reactor Use Share)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*591	A. Basu B. Faggart, Jr.	Geological Sciences, University of Rochester	Nd-Sr and Pb-Isotope Geochemistry in Crust-Mantle Evolution! Selected Studies from the Kings Mountain Belt of the Carolinas and from the Adirondacks in New York	To evaluate crust-mantle geochemical interactions.	USDOE (Reactor Use Share)
*592	A. Glazner J. Miller	Geology, University of North Carolina	Geochemistry, Isotopic Composition, and Age of Mesozoic Plutonic Rocks in the Western and Central Mojave Desert	Trace element data to constrain models for the Mesozoic tectonic evolution and possible source rocks for Cenozoic magmatism of the southwestern United States.	USDOE (Reactor Use Share)
593	N. Kerkvliet	Veterinary Medicine, OSU	Behavior of Filler Cells for T-Enzymes	Irradiation of filler cells in ^{60}Co facility.	Veterinary Medicine
594	B. Grappi C. Kelly	Society of American Military Engineers, OSU	Use of Radiation in Geology	Lecture to SAME on the applications of NAA in the geological sciences.	Radiation Center (Unfunded Research)
*595	C. Barnes M. Barnes K. Johnson	Geosciences, Texas Tech University	Origin of Gabbro and Peraluminous Granites, Klamath Mountains, California	Trace element investigation to model the differentiation history of the Vesa Bluffs pluton, ultimately to provide information concerning the origin of peraluminous granites (e.g. crystal fractionation vs. crustal melting).	USDOE (Reactor Use Share)
596	G. Davies J. Bentley	Oregon Health Sciences University	Gamma Ray Irradiation of Dried Protein (Collagen)	Collagen irradiated to a gamma dose of 2.5 Mrads.	Oregon Health Sciences University
*597	J. Laul J. Schmitt	Battelle Northwest Lab.	Rare Earth Tracer Study	Activation of liquid tracer samples to assess rare earth content and shipment to BNW for counting.	USDOE, Battelle

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
598	R. Knaus	Louisiana State University	Gamma Spectroscopy of Barnacle Samples	Count two barnacle samples to assess radionuclide uptake from environment.	Radiation Center (Unfunded Research)
*599	A. Robinson R. Abdur	Nuclear Engineering, OSU; International Atomic Energy Agency	Study of Instrumentation and Control Related to a Research Reactor	Familiarization with reactor operation and concepts.	International Atomic Energy Agency
*600	B. Patrick	Geoscience, New Mexico Tech	Fission Track Dating of Geological Samples	Irradiation of zircons and apatites in thermal column for age dating of geologic samples.	New Mexico Tech
*601	M. Samuelson	OreMet Titanium	Radiography Training	Research reactor orientation and introduction to capabilities of neutron radiography.	Radiation Center
602	M. Bloomfield		Text review, advice, consultation by Dr. Dodd	A review of the radiological portions of the text for the fifth edition of "Chemistry and the Living Organism" by Bloomfield.	Radiation Center
*603	G. Goles R. Wilen	Geological Sciences, Anthropology, University of Oregon	Elemental Composition of Ceramic Pastes from the Huay Sai Khao Basin, Northeast Thailand	Chemical characterization of prehistoric potshards from northeast Thailand to determine if distinctive ceramic traditions were executed using specific clay sources.	USDOE (Reactor Use Share)
*604	G. Goles W. Ayres R. Mauricio	Geological Sciences, Anthropology, University of Oregon	Elemental Composition of Stone Building Material from Nan Madol, Pohnpei Island, Micronesia	Chemical characterization of prehistoric building material from Nan Madol archaeological site Pohnpei Island to determine the provenance of the stone.	USDOE (Reactor Use Share)
*605	A. Mathis	Geosciences, OSU	Age, Stratigraphy, and Petrogenesis of Volcanic Rocks from Hart Mountain, Southeastern Oregon	Using geochemical data, especially trace elements, to determine the age, stratigraphy, and plausible petrogenetic models for Basin and Range volcanic rocks from Hart Mountain, southeastern Oregon.	Radiation Center (Unfunded Research)

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
•606	F. Sutherland	Australian Museum	Trace Element Characterization of Australian Gem Quality Zircons	Determine the range of trace element contents of the various groups of zircons from Australia. This information could provide important information concerning zircon crystallization and sources.	Radiation Center (Unfunded Research)
•607	A. Babb	Nuclear Engineering, University of Washington	TRIGA Reactor Operator Training	Operation of the OSU TRIGA reactor for training purposes.	USDOE (Reactor Use Share)
•608	R. Knaus D. Van Gent K. Sweeney	Nuclear Science Center, Louisiana State University	Wetland Accretion and Erosional Processes	Determination of soil movement using stable REE tracers during the enlargement of "holes" in brackish water wetlands in south Louisiana.	USDOE (Reactor Use Share)
•609	R. Fodor A. Sial G. Gandhok	Marine, Earth and Atmospheric Sciences, North Carolina State Univ.	Petrology of Tertiary Basalt and Ultramfaic Xenoliths and Megacrysts: Mantle Characteristics Beneath Northern Brazil	Trace element contents of xenoliths and megacrysts to determine mantle heterogeneity beneath northern Brazil and of basalts to distinguish between continental and oceanic magmatism.	USDOE (Reactor Use Share)
•610	P. DeCelles K. Ridgway	Geological Sciences, University of Rochester	Middle Tertiary Sedimentation in Strike-Slip Basins Along the Denali Fault, Yukon Territory, Canada	Trace element contents of sandstones and conglomerates that fill small basins along the Denali fault in Yukon Territory to correlate with nearby source areas and establish provenance.	USDOE (Reactor Use Share)
•611	D. Smith P. Pearce	Geology, Trinity University	Petrologic and Geochemical Characteristics of Cretaceous Hypabyssal Intrusions in Central Montana and Precambrian Granitoids from Central Texas	The determination of trace element contents to constrain possible petrogenetic processes such as crystal fractionation or magma mixing.	USDOE (Reactor Use Share)

• Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*612	F. Beardsley	Anthropology, University of Oregon	Easter Island Obsidian Studies: Research on Source Variability and Artifact Distribution	The determination of trace element contents of obsidians from Easter island to establish source areas and trading routes of artifacts.	USDOE (Reactor Use Share)
*613	V. Sisson	Geology and Geophysics, Rice University	Trace Element Modelling of Open and Closed System Migmatites	The determination of trace element contents of different types of migmatite to establish characteristics of movement for various elements during formation.	USDOE (Reactor Use Share)
*614	G. Goles J. Stimac	Geological Sciences, University of Oregon	Tectonic Implications of Structural and Paleomagnetic Features of Late Miocene Ash-Flow Tuffs of Eastern Oregon	Geochemical characterization of the latterally extensive ash-flow tuff units of the Owyhee Uplands of eastern Oregon.	USDOE (Reactor Use Share)
*615	S. DeBari	Geology, Stanford University	Petrogenesis and Physical Evolution of the Fiambala Gabbronorite, Northwestern Argentina	The chemical evolution of a mantle-derived mafic intrusion from its earliest crystallization through extensive fractionation and assimilation of country rock.	USDOE (Reactor Use Share)
*616	J. Gardner L. Dundon	Physics, OSU	High Pressure Perturbed Angular Correlation (PAC)	Irradiation of ZrO_2 to assess properties under high pressure using PAC.	Physics
*617	J. Laul J. Schmitt	Battelle Northwest Lab.	INAA of Katmai Fumarole and Howardite Meteorites	Irradiation of geologic and meteoritic samples for INAA determination of trace elements and rare earths.	Battelle NW Lab.
*618	K. McDonald	Applied Chemistry, MB Research	Feasibility Study--INAA Measurement of Iodine-containing Wood Preservative	Develop a fast and cost-effective INAA procedure for measurement of iodine on wood samples.	Radiation Center

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
619	G. Little R. Farmer	Radiation Safety Office, OSU	Gamma Screening of Swipes	Screen samples for possible gamma radiation.	Radiation Center
*620	R. Schmitt L. Taylor	Chemistry, OSU University of Tennessee	INAA of Standard Lunar Samples	Irradiation of (non-glass) standard lunar samples for subsequent INAA.	NASA, University of Tennessee
621	B. Stevenson	Reed College	Chemical Dosimetry	Irradiation of a chemical dosimeter to 500-1000 Gy using the ^{60}Co irradiator.	Reed College
622	W. Chism		^{60}Co Irradiation of Wood Samples	Irradiate wood samples to be used in violin bridges in ^{60}Co irradiator.	Radiation Center (Unfunded Research)
623	S. Gutenberger	Microbiology, OSU	Gamma Irradiation of Bacteria	Irradiation of bacterial culture to 4.5 x 10^6 rads.	Microbiology
624	R. Eastburn	Corvallis Clinic	Thyroid Bioassay by Counting	Monitor thyroids of 6-8 people from the Corvallis Clinic on 2/6/90.	Radiation Center
*625	A. Klein	Nuclear Engineering, OSU	Cold Fusion Cell Residues	Chemical identification of metallic residues found in cold fusion cells following experimental run.	Radiation Center (Unfunded Research)
*626	G. Goles R. Page	Geological Sciences, University of Oregon	Geochemical Characterization of a Basalt-Trachyte Suite from the Talagapa Volcanic Field, Argentina	Petrochemical determination of basalts and trachytes from the Talagapa Volcanic Field to compare them with basalt-trachyte suites from other tectonic settings.	Geological Sciences, University of Oregon
627	G. Little R. Farmer	Radiation Safety Office, OSU	Radiation Protection of OSU Research Personnel and Research Laboratory	Gamma analysis of one oceanic chimney sample to determine level of naturally-occurring radioactive material in the sample.	Radiation Center

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*628	G. Harper	Geological Sciences, State University of New York	Oceanic Faulting and Hydrothermal Metamorphism of the Josephine Ophiolite, and its Relation to Fractionation in Dikes and Lavas	The chemical evolution of the Josephine ophiolite, Klamath Mtns., California appears to be related to "freezing" of magma chambers, extensional faulting, and periodic eruption of lava. Trace element geochemistry may define the roles of these processes in the formation of oceanic crust.	USDOE (Reactor Use Share)
*629	C. Shearer C. Patterson E. Fritch	Inst. for the Study of Mineral Deposits, South Dakota School of Mines and Technology	Petrogenetic Relations Between Gold Mineralization and Igneous Intrusions in the Black Hills, South Dakota	Investigation of the role of spatially associated igneous intrusions with sedimentary hosted epithermal gold mineralization in the Black Hills, South Dakota. Is there a specific geochemistry of mineralizing magmas?	USDOE (Reactor Use Share)
*630	D. Parsons		Evaluaton of Radiation Levels for Irradiation Gemstones.	Irradiation of one topaz sample in a cadmium box for approximately 20 MW hours in the TRIGA reactor. Quantitative gamma analysis of the irradiated gemstone and one previously irradiated gemstone.	D. Parsons
631	M. Mok	Horticulture, OSU	Induction of somaclonal variation in quince.	Attempts are made to obtain mutants of quince with enhanced tolerance to low Fe (leaf discs are irradiated and plants are regenerated).	Horticulture
632	R. Thompson	Oregon State Police	Radiation Survey Instrument Calibration for Oregon State Police Crime Laboratory	Calibration services for portable radiation survey instruments.	Oregon State Police, Crime Laboratory
*633	J. Laul J. Schmitt	Battelle Northwest Lab.	Flood Basalts/Geochemical Migration	Activation of samples for INAA.	Battelle NW Lab.
*634	S. Binney	Nuclear Engineering	Production of Medical Radioisotopes	Determination of production rates and unknown or poorly known cross sections for radioisotopes of medical interest.	Nuclear Engineering

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
*635	J. Dilles	Geosciences, OSU	Ore Genesis, Examples from Pakistan	Determination of trace element contents of altered and unaltered geologic material from various ore deposits in Pakistan.	Geosciences, OSU
*636	A. Mathis	Geosciences, OSU	Age, Stratigraphy, and Petrogenesis of Volcanic Rocks from Hart Mountain, Southeastern Oregon	Use of geochemical data, especailly trace elements, to determine the age, stratigraphy, and plausible petrogenetic models for Basin and Range volcanic rocks from Hart Mountain, southeastern Oregon.	Radiation Center (Unfunded Research)
*637	M. Streck	Geosciences, OSU	Petrology and Geochemistry of the Rattlesnake Tuff, West Central Nevada	Use of geochemical data, especially trace elements, to determine the age, stratigraphy, and plausible petrogenetic models for the Rattlesnake Tuff.	Radiation Center (Unfunded Research)
*638	E. Schuetfort	Geosciences, OSU	Petrology and Geochemistry of the Cherry Creek Pluton, Whitepine County, Nevada	Use of geochemical data, especially trace elements, to determine plausible petrogenetic models for the Cherry Creek pluton.	Radiation Center (Unfunded Research)
*639	R. Collier B. 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
640	J. Higginbotham	Radiation Center, OSU	Investigation of the Response of Glass Calibration Capsules to High Energy Gamma Ray Irradiation	Dose response of glass personnel radiation dosimeters.	Radiation Center
641	J. Higginbotham J. Reyes	Nuclear Engineering, OSU; American Nuclear Society	Boy Scout Atomic Energy Merit Badge	Radiation Center equipment and personnel support for 6 hour Merit Badge class.	Radiation Center

* Projects which utilized the OSTR.

Table VI.C.3 (Continued)

Project Number	User(s) Name	Department and Institution	Project Title	Description	Funding Agency
642	J. Bentley G. Davies	Oregon Health Sciences University	Collagen Irradiation	Research and development of collagen for burn treatment.	Oregon Health Sciences University
*643	W. Sandine T. Whitehead	Microbiology, OSU	Patent Infringement Investigation	INAA of one powdered chemical sample "Biogen" for Al, Ca, and Mg.	Microbiology
644	J. Ayres E. Piepmeier	Pharmacy, OSU	In vivo behavior of detergent-solubilized purified thrombomodulin on intravenous injection into rats	Radiotracer study using ^{35}S and ^{125}I injected into laboratory rats.	Pharmacy
645	C. Davis	Springfield Utility Board-Water Dept.	Radon Measurements in Water	Assist Springfield Utility Board (Water Department) with radon measurements in water.	Radiation Center
646	U. Farber C. Gildersleeve	International Education, OSU	Radiological Risks of Living in Kiev	Evaluation of the radiological risk of living in Kiev, USSR. Write up two page letter. Present information and answer questions.	Radiation Center
647	J. Gardner	Physics, OSU	Radioactive Material Shipment	Shipment of approximately 1 mCi of ^{111}In to the University of Maryland.	Physics
*649	R. Seymour	EG&G Ortec	Software Beta Testing	Instrumental Neutron Activation Analysis (INAA) of 16 standards.	Radiation Center
650	J. Ayres	Pharmacy, OSU	In vivo behavior of detergent-solubilized purified thrombomodulin on intravenous injection into rats	Provide Radiation Center general orientation, supplemental radioactive material user orientation, and training in laboratory techniques (one week duration) for one gradute student.	Pharmacy

* Projects which utilized the OSTR.

1. Neutron Activation Analysis

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

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

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

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

2. Forensic Studies

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

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

3. Irradiations

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

4. Radiological Emergency Response Services

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

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 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. 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 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 four visiting scientists

and special trainees. One IAEA fellow underwent training in instrumentation and control for research reactors. This training was performed at the Radiation Center under the auspices of the Nuclear Engineering Department. The fellow was from Bangladesh and the total period of his fellowship was six months. In addition, two visiting scientists, one from Japan and one from Sweden, worked in the field of nuclear chemistry under the direction of Dr. Loveland. Finally, the last special trainee came from the Oregon Episcopal School and was trained to perform dose calculations arising from routine releases of airborne radioactive material.

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.

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.

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	87
Ion Chambers	31
Alpha Detectors	4
Neutron Detectors	6
Micro-R Meters	6
Mini Detectors	30
Civil Defense Detectors	28
Personnel Ion Chambers	113
Support Agency Instruments	
Corvallis Fire Department	4
Good Samaritan Hospital (Corvallis, OR)	3
TOTAL	312

Table VI.C.5

Summary of Radiological Instrumentation Calibrated
to Support Other Agencies

	Number of Calibrations
OSU Departments	
Agricultural Chemistry	1
Animal Sciences	1
Biological Chemistry	3
Botany	5
Crop Science	1
Fisheries and Wildlife	2
Food Science	1
Horticulture	1
Microbiology	1
Radiation Safety Office	7
Veterinary Medicine	2
Non-OSU Agencies	
U.S. Bureau of Mines	1
U.S. Environmental Protection Agency	5
U.S. Forest Service	2
Oregon Health Sciences University	16
Oregon State Health Division	3
Oregon Public Utilities Commission	5
Oregon Department of Energy	6
Oregon State Police Crime Lab	1
Vollum Institute, OHSU	3
TOTAL	67

PART VII

WORDS

A. Publications in Print

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*Su, H.T., R. Wang, H. Fuchs, J.A. Gardner, W.E. Evenson, J.A. Sommers, "Oxygen vacancy hopping and trapping in zirconia and ceria," J. Amer. Ceram. Soc. (submitted).

*Warner, R.D., D.S. Snipes, S.S. Hughes, R.A. Schmitt and J.C. Steiner, "Geochemistry and petrology of Mesozoic dikes in South Carolina," submitted to Geological Society of America Special Paper "Mesozoic Magmatism in Eastern North America" (J. Puffer and P. Ragland, editors).

* Indicates OSTR use.

D. Documents in Preparation

1. Publications

*Ayres, W.S., F.R. Beardsley and G.G. Goles, "The Characterization of Easter Island Obsidian Sources."

*Brandon, M.T., M.K. Roden and D.S. Miller, "Apatite Fission-track Thermochronology of the Olympic Subduction Complex, Washington State."

*Butcher, D.P., M. McCurry and G.L. Farmer, "Chemical, mineralogical and Nd-Sr isotopic zonation of the Organ Needle pluton and its extrusive equivalent."

*DeBari, S.M. and J.E. Wright, "Petrogenesis and physical evolution of the Fiambala gabbronorite, northwestern Argentina: Syntectonic magmatism in the deep crust of a continental margin arc," to be submitted to J. Geophys. Res.

*Desonie, D.L., R.A. Duncan and J. Natland, "Temporal and Geochemical Variability of Volcanism Over the marquesas Hotspot."

*Fodor, R.V., G. Ghondak and A.N. Sial, "Trace element analyses of ultramafic xenoliths and clinopyroxene megacrysts from basalts in Tertiary volcanic centers in Rio Grande do Norte state of northern Brazil," (abstract to be submitted in December 1990 to Kimberlite Conference in Brazil, June 1991).

*Roden, M.K. and D.S. Miller, "Apatite Fission-track Thermochronology of the Hartford Basin, Connecticut."

*Skinner, C.E. and S.R. Radosevich, "Maxama "Mimic" Mystery Tephra: A Geochemical Reassessment of Tephra from Vine Rockshelter (35LA304), Central Western Cascades, Oregon."

*Skinner, C.E., "Neutron Activation Analysis of Archaeological Obsidian from the Tahkenitch lake Site (35 DO 130), Oregon Central Coast."

*Skinner, C.E., "Geoarchaeological Investigations of an Unexpected Geologic Source of Obsidian in the Southwestern Willamette Valley, Oregon."

*Sisson, V.B., "Element mobility during regional amphibolite facies metamorphism in central Maine," to be submitted to Geochim. Cosmochim. Acta.

*Wyld, S.J., "Development of the early Mesozoic volcanic arc of the western U.S. Cordillera: A detailed study from northwest Nevada," in progress.

* Indicates OSTR use.

2. Theses

*D'Arcy, K., "Geochemistry and Geochronology of Precambrian Metamorphic Rocks of the Montana Metasedimentary Terrane," Ph.D. thesis, Geology Department, University of Florida.

*Ghondak, G., "Trace element analyses of ultramafic xenoliths and clinopyroxene megacrysts from basalts in Tertiary volcanic centers in Rio Grande do Norte state of northern Brazil," Masters thesis, North Carolina State University.

Hill, B.E., "Controls on Silicic Magma Evolution in the Central High Cascades of Oregon," Ph.D. dissertation, Department of Geosciences, Oregon State University.

*Murphy, G., "Geochemistry of Precambrian Metamorphic Rocks of the Gravelly Range, SW Montana," Masters thesis, Geology Department, University of Florida.

*Desonie, D.L., Ph.D. dissertation, Department of Oceanography, Oregon State University.

* Indicates OSTR use.

E. Presentations

Binney, S.E. and J.F. Higginbotham, "Neutron Detection and Spectrometry in Support of Cold Fusion Experiment," Health Physics Society Annual Meeting, Albuquerque, New Mexico, paper THPM-F01, 1989.

*Dodd, B., "Use of the OSU TRIGA Reactor for Education and Training," American Nuclear Society Annual Meeting, Atlanta, Georgia, 1989.

*Dodd, B., "Research Reactor Audit Checklist," TRTR-89, Raleigh, North Carolina, 1989.

Dodd, B., "Implementation of the IAEA Radiation Protection Optimization Principles at a Research Reactor Facility," 35th Annual Meeting of the Health Physics Society, Anaheim, California, 1990.

*Dodd, B. and T.V. Anderson, "Design, Construction, Commissioning and Use of a New Cadmium-Lined In-Core Irradiation Tube for the Oregon State University TRIGA Reactor," 12th TRIGA User's Conference, Austin, Texas, 1990.

*Elliott, W.C., J.L. Aronson, M.K. and D.S. Miller, "The formation of Illite in the Appalachian Basin: A test of the Fluid Expulsion Hypothesis," submitted to Geo. Soc. America Abstracts with Prog., 1990 Annual Meeting.

*Evenson, W.E., A.G. McKale, H.T. Su and J.A. Gardner, "PAC perturbation factor for spin 5/2 nuclei subject to a rapidly fluctuating EFG," presented at the International Conference on Hyperfine Interactions, Prague, August 1989.

*Evenson, W.E. and J.A. Gardner, "Defect hopping and trapping investigations by PAC," presented at the March meeting of the American Physical Society, Anaheim, California, March 1990.

*Evenson, W.E., "The relevance of PAC to studying the properties of ceramics," presented at the annual meeting of the American Ceramics Society, Dallas, Texas, April 1990.

*Gardner, J.A., "Application of nuclear hyperfine experiments to the study of defects in ceramics," presented at the annual meeting of the American Ceramics Society, Dallas, Texas, April 1990.

*Gardner, J.A., R. Wang, H. Fuchs, H.T. Su, W.E. Evenson and J.A. Sommers, "Exygen vacancy hopping and trapping in ceria, tetragonal zirconia and cubic zirconia," presented at the annual meeting of the American Ceramics Society, Dallas, Texas, April 1990.

*Han, W. and J.A. Gardner, "NMR relaxation in high temperature GaAs," presented at the March meeting of the American Physical Society, Anaheim, California, March 1990.

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*Higginbotham, J.F., D.S. Pratt and S.M. Cordell, "Calculated Offsite Dose Commitment Due to Routine Ar-41 Gaseous Effluent Releases," Health Physics Society Annual Meeting, Anaheim, California, June 1990.

*Higginbotham, J.F., D.S. Pratt and S.M. Cordell, "Off-site Dose Commitment Due to Intentional Releases of Argon-41," 12th TRIGA User's Conference, Austin, Texas, 1990.

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*Honjo, N. and W.P. Leeman (1990), "Style of silicic volcanism in the Snake River Plain--Yellowstone hotspot track: a petrologic overview," EOS 71, p. 964, Western Pacific Geophysics Meeting, Kanazawa, Japan, 21-25 August.

*Jaeger, H., H.T. Su, J.A. Gardner, I.W. Chen, J.C. Haygarth, J.A. Sommers and R.L. Rasera, "Aftereffects following beta-decay of 181-Hf," presented at the International Conference on Hyperfine Interactions, Prague, August 1989.

Klein, A.C., S.R. Gedeon and P.T. Choong, "Nuclear Design Analysis of In-core Thermionic Reactor Systems," Sixth Symposium on Space Nuclear Power Summaries, Albuquerque, New Mexico, January 1989.

Klein, A.C., K.A. Pauley and B.J. Webb, "Condensation Fluid Dynamics and Heat Transfer on Rotating Spherical Surfaces in a Microgravitational Field," Seventh Symposium on Space Nuclear Power Summaries, Albuquerque, New Mexico, January 1990.

Klein, A.C. and H.S. Bloomfield, "Scattered Neutron Radiation from a Nuclear Power Source Sited in a Lunar Excavation," Seventh Symposium on Space Nuclear Power Summaries, Albuquerque, New Mexico, January 1990.

Klein, A.C., "Microgravity Thaw Experiment (MITEX)," AIAA/ASME 6th Thermophysics and Heat Transfer Conference Proceedings, Seattle, Washington, June 1990.

*Leeman, W.P. (1990), "The utility of boron as a tracer of subduction processes: slab contributions to arc magmatism and implications for recycling of lithospheric material into the deep mantle," (abstract) Second V.M. Goldschmidt Conference, The Geochemical Society, 60 Hunt Valley, MD, 2-4 May).

*Leeman, W.P., A.E. Moran and V.B. Sisson (1990), "Compositional variations accompanying metamorphism of subducted oceanic lithosphere: implications for genesis of arc magmas and mantle replanishment," (abstract) 7th International Conf. Geochronology, Cosmochronology, and Isotope Geology, Canberra, Australia (24-29 September).

* Indicates OSTR use.

Loveland, W., K. Aleklett, J.O. Liljenzin, M. de Saint-Simon , G.T. Seaborg and L. Sihver, "Heavy Residue Spectra and Linear Momentum Transfer in Intermediate Energy Nucleus-Gold Collisions," 1989 International Nuclear Physics Conference, Sao Paulo, Brazil, August 1989.

Loveland, W., K. Aleklett, G.T. Seaborg and L. Sihver, "Heavy Residue Spectra and Linear Momentum Transfer in Intermediate Energy Nuclear Collisions," 1989 International Chemistry Congress of Pacific Basin Societies, Honolulu, Hawaii, December 1989.

*Moran, A.E., V.B. Sisson and W.P. Leeman (1990), "The fate of boron in subducted oceanic slab: effects of burial, metamorphism, and chemical processing," (abstract) Second V.M. Goldschmidt Conference, The Geochemical Society, 67 (Hunt Valley, MD, 2-4 May).

Reyes, J.N., A.C. Klein, M.A. Maguire, "Thermal Gradient Effects on the Oxidation of Zircaloy Fuel Cladding," IAEA Technical Committee Meeting on Fundamental Aspects of Corrosion of Zirconium-Base Alloys in Water Reactor Environments, Portland, Oregon, September 1989.

*Roden, M.K., M.T. Brandon and D.S. Miller, "Apatite Fission-track thermochronology of the Olympic Subduction Complex, Washington," submitted to Geol. Soc. America Abstracts with Prog., 1990 Annual Meeting.

*Schwenker, R., G. Weidlich, M. Geolz, R. Wang, W.E. Evenson, K. Keszler, J.A. Gardner and J.A. Sommers, "Structural and electronic properties of indium-doped $YBa_2Cu_3O_x$," presented at the March meeting og the American Physical Society, Anaheim, California, March 1990.

*Sisson, V.B., "Geochemical and fluid evolution of the southern Chujach Mountains, Alaska," presented at Geol. Soc. Amer. Penrose Conference.

*Skinner, C.T. and S.R. Radosevich, "Mazama "Mimin" Mystery Solved: A Geochemical Reassessment of the Volcanic Tephra from Vine Rockshelter," paper presented at 43rd Annual Northwest Anthropological Conference, Eugene, Oregon, March 22-24, 1990.

*Skinner, C.T. and S.R. Radosevich, "The Source of the Mazama "Mimic" Mystery Tephra: Geochemical Studies of Volcanic Tephra from Vine Rockshelter (35LA304), Central Western Cascades, Oregon," presented at 5th Annual Oregon Archaeological Conference, Eugene, Oregon, November 4, 1989.

*Su, H.T., J.A. Gardner, P. Carter and J.A. Sommers, "Oxygen vacancy trapping and hopping in lightly-doped tetragonal zirconia," presented at the International Conference on Science and Technology of Zirconia, Anaheim, California, October 1989.

* Indicates OSTR use.

*Wang, R., W.E. Evenson and J.A. Gardner, "Oxygen vacancy hopping and trapping by impurities in cerium oxide," presented at the March meeting of the American Physical Society, Anaheim, California, March 1990.

* Indicates OSTR use.

F. **Public Relations**

The continued interest of the general public in the TRIGA reactor is evident by the number of people who have toured the facility. In addition to many unscheduled visitors and interested individuals who stopped in without appointments because they were in the vicinity, a total of 883 people were given pre-planned and scheduled tours during this reporting period. See Table VII.F.1 for statistics on scheduled visitors.

Table VII.F.1

Summary of Visitors to the Radiation Center
For the Period July 1, 1989 through June 30, 1990

Date	No. of Visitors	Name
August 4, 1989	4	Golf group from Portland
August 29, 1989	3	Merlin Samuelson & Ormet . itanium
August 30, 1989	33	General Chemistry class (106)
September 14, 1989	1	Bechaida Rivera--OSU Public Health
September 28, 1989	12	Chemistry 461
October 5, 1989	4	Chemistry 461
October 19, 1989	34	OSU Public Health Class
October 24, 1989	4	Chemistry 461
November 7, 1989	45	North Albany Elementary School, 5th grade
November 9, 1989	14	Chemistry 107/207
November 20, 1989	38	Health and Human Performance--Public Health Class--Personal Health H170
November 21, 1989	4	Chemistry 461
January 3, 1990	7	Cub Scouts
January 8, 1990	15	North Bend High School Students
January 17, 1990	5	Reed College Reactor Operating Training Course
February 1, 1990	40	OSU Public Health Class (Man/Health and Environment H344)
February 2, 1990	10	Oregon Episcopal School
February 2, 1990	2	Dwight Baker & Jay Farr
February 3, 1990	180	Dad's Weekend Open House
February 13, 1990	52	Chemistry 202 students
February 19, 1990	3	Salem Boy Scouts
February 22, 1990	8	U of O Geology--Paleo. Course
February 26, 1990	50	Mark Twain School, 8th grade honor students

Table VII.F.1 (Continued)

Date	No. of Visitors	Name
February 27, 1990	8	U of O Geology--Paleo. Course
March 7, 1990	14	Oregon Episcopal School Science Students
March 29, 1990	12	Coquille H.S. Physics Class
April 4, 1990	20	LBCC Science Students
April 7, 1990	20	Beaver Open House
April 10, 1990	4	Honeywell Corporation
April 12, 1990	2	Corvallis Fire Dept.
April 18, 1990	20	Sweet Home H.S. Physics Class
April 26, 1990	12	Yamhill Carlton H.S. Physics Seniors
May 2, 1990	7	Jefferson H.S. Physics Students
May 5, 1990	10	Mom's Weekend Open House
May 10, 1990	20	Newport H.S. Advanced Science Class
May 12, 1990	26	Boy Scouts
May 15, 1990	3	OSU Students
May 5, 1990	31	Indonesian Group
May 21, 1990	41	4-H Extension Program (Summer Week)
May 22, 1990	5	General Atomic, Morocco group
TOTAL	883	