Oregon State University

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October 22, 2021

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

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

In accordance with section 6.7.1 of the OSTR Technical Specifications, we are hereby submitting the Oregon State University Radiation Center and OSTR Annual Report for the period July 1, 2020 through June 30, 2021.

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

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 10/22/21

Sincerely,

Steven R. Reese
Director

Cc: Michael Balazik, USNRC
Kevin Roche, USNRC
Maxwell Woods, ODOE
Dr. Irem Tumer, OSU
Dan Harlan, OSU

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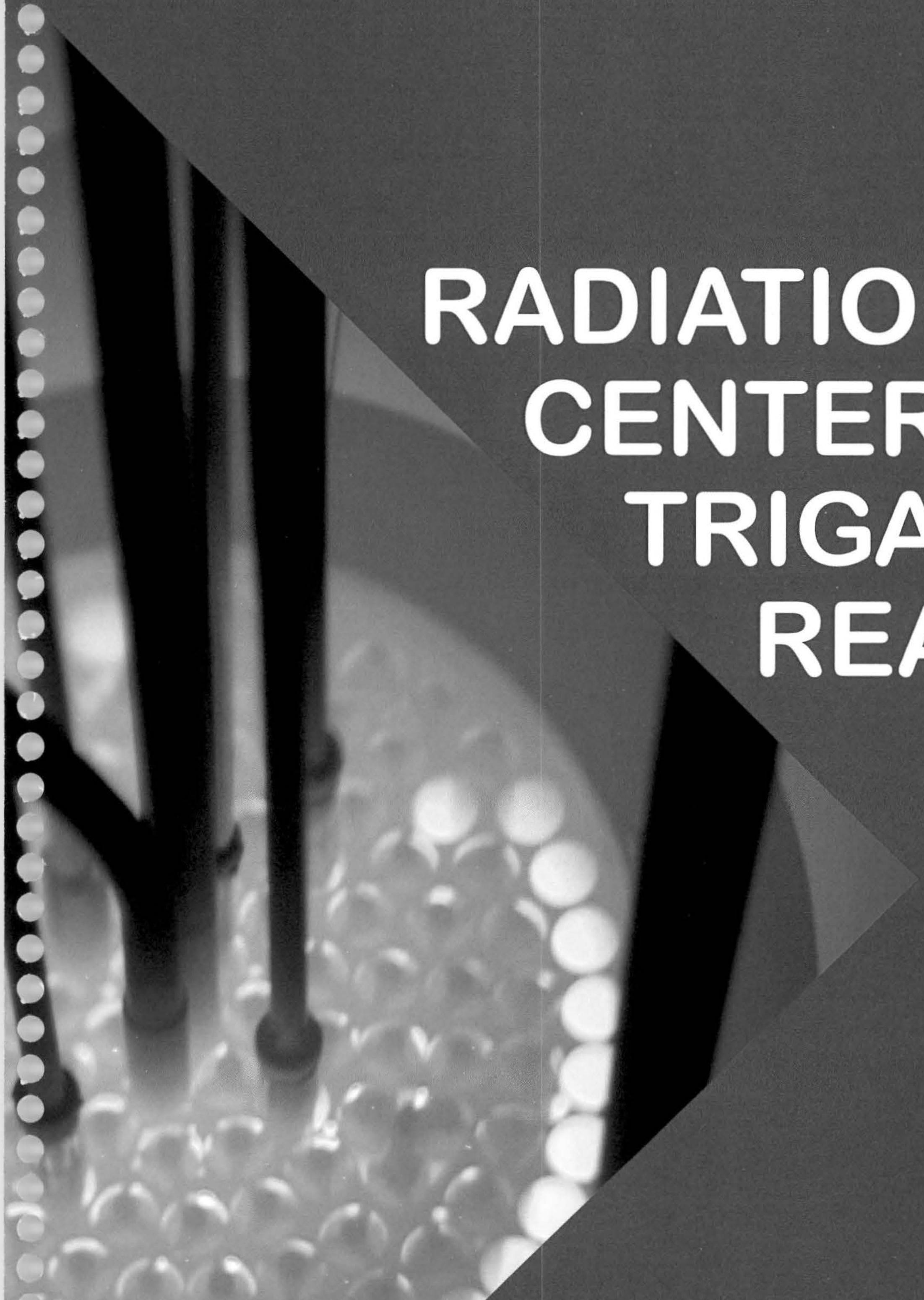
NRR



RADIATION CENTER AND TRIGA® REACTOR

ANNUAL REPORT

JULY 1, 2020 - JUNE 30, 2021

Oregon State University

Submitted by:
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To satisy the requirements of :

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

B. Battelle Energy Alliance, LLC; Subcontract Award No. 00074510.

C. Oregon Department of Energy, OOE Rule No. 345-030-010.

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Overview

Executive Summary

The data from this reporting year shows that the use of the Radiation Center and the Oregon State TRIGA® reactor (OSTR) was dramatically affected by the COVID-19 pandemic. Not only were just about every metric accross the board lower this year, all academic courses were virtual and did not involve the use of Radiation Center facilities, even laboratory classes.

Of the work performed, eighty-four percent (84%) of the OSTR research hours were in support of off-campus research projects, reflecting the use of the OSTR nationally and internationally. Radiation Center users published or submitted 107 articles this year, and made 15 presentations on work that involved the OSTR or Radiation Center. The number of samples irradiated in the reactor during this reporting period was 876. Funded OSTR use hours comprised 85% of the research use.

Personnel at the Radiation Center conducted 17 tours of the facility, accommodating 45 visitors, down considerably due to university restrictions on visitors. The visitors included elementary, middle school, high school, and college students; relatives and friends; faculty; current and prospective clients; national laboratory and industrial scientists and engineers; and state, federal and international officials. The Radiation Center is a significant positive attraction on campus because visitors leave with a good impression of the facility and of Oregon State University.

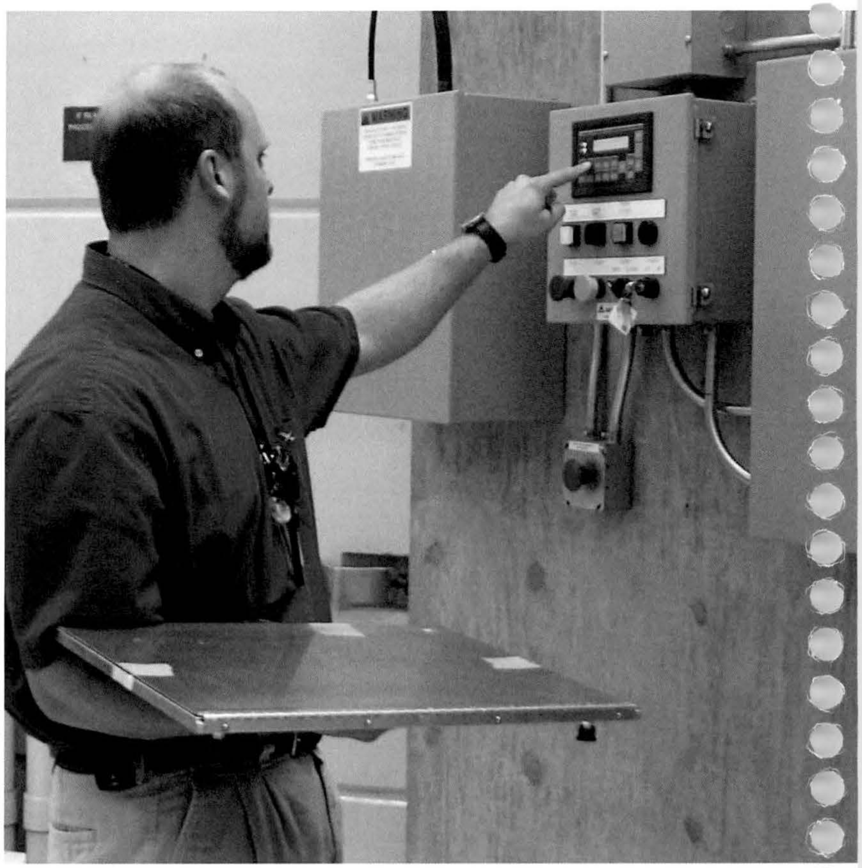
The Radiation Center projects database continues to provide a useful way of tracking the many different aspects of work at the facility. The number of projects supported this year was 116. Reactor related projects comprised 77% of all projects. The total research dollars in some way supported by the Radiation Center, as reported by our researchers, was $16.3 million. The actual total is likely higher. This year the Radiation Center provided service to 73 different organizations/institutions, 41% of which were from other states and 41% of which were from outside the U. S. and Canada. So, while the Center's primary mission is local, it is also a facility with a national and international clientele.

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

Introduction

The current annual report of the Oregon State University Radiation Center and TRIGA® Reactor follows the usual format by including information relating to the entire Radiation Center rather than just the reactor. However, the information is still presented in such a manner that data on the reactor may be examined separately, if desired. It should be noted that all annual data given in this report covers the period from July 1, 2020 through June 30, 2021. Cumulative reactor operating data in this report relates only to the LEU fueled core. This covers the period beginning July 1, 2008 to the present date. For a summary of data on the reactor's two other cores, the reader is referred to previous annual reports.

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, 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.



Overview of the Radiation Center

The Radiation Center is a unique facility which serves the entire OSU campus, all other institutions within the Oregon University System, and many other universities and organizations throughout the nation and the world. The Center also regularly provides special services to state and federal agencies, particularly agencies dealing with law enforcement, energy, health, and environmental quality, and renders assistance to Oregon industry. In addition, the Radiation Center provides permanent office and laboratory space for the OSU School of Nuclear Science and Engineering, the OSU Institute of Nuclear Science and Engineering, and for the OSU nuclear chemistry, radiation chemistry, geochemistry and radiochemistry 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 many items of specialized equipment and unique teaching and research facilities.

They include a TRIGA® Mark II research nuclear reactor; a ^{60}Co gamma irradiator; a large number of state-of-the art computer-based gamma radiation spectrometers and associated high purity germanium detectors; and a variety of instruments for radiation measurements and monitoring. Specialized facilities for radiation work include teaching and research laboratories with instrumentation and related equipment for performing neutron activation analysis and radiotracer studies; laboratories for 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.

Also housed in the Radiation Center is the Advanced Thermal Hydraulics Research Laboratory (ATHRL), which is used for state-of-the-art two-phase flow experiments. Within ATHRL is located the NuScale Integral Systems Test-2 (NIST-2) facility is a nuclear power plant test facility that is instrumental in the design certification of the NuScale small modular reactor. The NIST-2 facility is constructed of all stainless-steel components and is capable of operation at full system pressure (1500 psia), and full system temperature (600°F).

All components are 1/3 scale height and 1/254.7 volume scale. The current testing program is examining methods for natural circulation startup, helical steam generator heat transfer performance, and a wide range of design basis, and beyond design basis, accident conditions.

The Advanced Nuclear Systems Engineering Laboratory (ANSEL) is the home to two major thermal-hydraulic test facilities—the High Temperature Test Facility (HTTF) and the Hydro-mechanical Fuel Test Facility (HMFTF). The HTTF is a 1/4 scale model of the Modular High Temperature Gas Reactor. The vessel has a ceramic lined upper head and shroud capable of operation at 850°C (well mixed helium). The design will allow for a maximum operating pressure of 1.0MPa and a maximum core ceramic temperature of 1600°C. The nominal working fluid will be helium with a core power of approximately 600 kW (note that electrical heaters are used to simulate the core power). The test facility also includes a scaled reactor cavity cooling system, a circulator and a heat sink in order to complete the cycle. The HTTF can be used to simulate a wide range of accident scenarios in gas reactors to include the depressurized conduction cooldown and pressurized conduction cooldown events. The HMFTF is a testing facility which will be used to produce a database of hydro-mechanical information to supplement the qualification of the prototypic ultrahigh density U-Mo Low Enriched Uranium fuel which will be implemented into the U.S. High Performance Research Reactors upon their conversion to low enriched fuel. This data in turn will be used to verify current theoretical hydro- and thermo-mechanical codes being used during safety analyses. The maximum operational pressure of the HMFTF is 600 psig with a maximum operational temperature of 450°F.

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

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

People

This section 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.

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

Radiation Center Staff

Steve Reese, Director

Dina Pope, Office Manager

Matthew Berry, Business Manager

Erica Emerson, Receptionist

S. Todd Keller, Reactor Engineer, Senior Reactor Operator

Celia Oney, Reactor Supervisor, Senior Reactor Operator

Robert Schickler, Reactor Administrator/Assistant Director, Senior Reactor Operator

Scott Menn, Senior Health Physicist

Taighlor Story, Health Physicist

Leah Minc, Neutron Activation Analysis Manager

Steve Smith, Development Engineer, Senior Reactor Operator

Chris Kulah, Senior Reactor Operator

Dan Sturdevant, Custodian

Emory Colvin, Reactor Operator (Student)

Maggie Goodwin, Senior Reactor Operator (Student)

Angelo Camargo, Reactor Operator (Student)

Lucia Gomez Hurtado, Reactor Operator (Student)

Griffen Latimer, Reactor Operator (Student)

Tracey Spoerer, Reactor Operator (Student)

Scott Veldman, Reactor Operator (Student)

Nathan Wiltbank, Reactor Operator (Student)

Gordon Kitchener, Reactor Operator (Student)

Lucien Litteral, Reactor Operator (Student)

Logan Schoening, Reactor Operator (Student)

Stephanie Juarez, Health Physics Monitor (Student)

Brandon Farjardo, Health Physics Monitor (Student)

Taighlor Story, Health Physics Monitor (Student)

Nicolaas VanDerZwan, Health Physics Monitor (Student)

Reactor Operations Committee

Dan Harlan, Chair
OSU Radiation Safety

Leo Bobek
UMass Lowell

Samuel Briggs
OSU School of Nuclear Science and Engineering

Abi Tavakoli Farsoni
OSU School of Nuclear Science and Engineering

Scott Menn
OSU Radiation Center

Celia Oney ***(not voting)***
OSU Radiation Center

Steve Reese ***(not voting)***
OSU Radiation Center

Robert Schickler
OSU Radiation Center

Julie Tucker
OSU Mechanical, Industrial and Manufacturing Engineering

Haori Yang
OSU School of Nuclear Science and Engineering

Professional and Research Faculty

Tony Alberti
Postdoctoral Scholar, Nuclear Science and Engineering

Samuel Briggs
Assitant Professor, Nuclear Science and Engineering

Tianyi Chen
Assistant Professor, Nuclear Science and Engineering

Abi Farsoni
Associate Professor, Nuclear Science and Engineering

Izabela Gutowska
Assistant Professor, Senior Research, Nuclear Science and Engineering

David Hamby
Professor Emeritus, Nuclear Science and Engineering

Kathryn Higley
School Head, Professor, Nuclear Science and Engineering

Todd S. Keller
Reactor Engineer, Radiation Center

Walter Loveland
Professor, Chemistry

Wade Marcum
Associate Professor , Nuclear Science and Engineering

Mitch Meyer
Professor of Practice, Nuclear Science and Engineering

Scott Menn
Senior Health Physicist, Radiation Center

Leah Minc
Associate Professor, Anthropology

Guillaume Mignot
Assistant Professor, Senior Research, Nuclear Science and Engineering

Celia Oney
Reactor Supervisor, Radiation Center

Camille Palmer
Research Faculty and Instructor, Nuclear Science and Engineering

Todd Palmer
Professor, Nuclear Science and Engineering

Alena Paulenova
Associate Professor, Nuclear Science and Engineering

Dina Pope
Office Manager, Radiation Center

Leila Ranjbar
Instructor, Nuclear Science and Engineering

Steven Reese
Director, Radiation Center

Robert Schickler
Reactor Administrator/Assistant Director, Radiation Center

Aaron Weiss
Sr. Faculty Research Assistant, Nuclear Science and Engineering

Brian Woods
Professor, Nuclear Science and Engineering

Qiao Wu
Professor, Nuclear Science and Engineering

Haori Yang
Assistant Professor, Nuclear Science and Engineering

Facilities

Research Reactor

The Oregon State University TRIGA Reactor® (OSTR) is a water-cooled, swimming pool type 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. The reactor is licensed by the U.S. Nuclear Regulatory Commission to operate at a maximum steady state power of 1.1 MW and can also be pulsed up to a peak power of about 2500 MW.

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

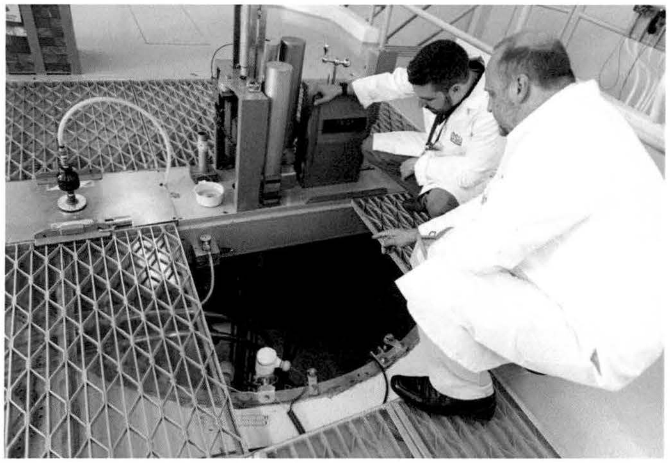
The **pneumatic transfer facility** (called a Rabbit) enables samples to be inserted and removed from the core in four to five seconds. Consequently, this facility is normally used for neutron activation analysis involving short-lived radionuclides. On the other hand, the **rotating rack** is used for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

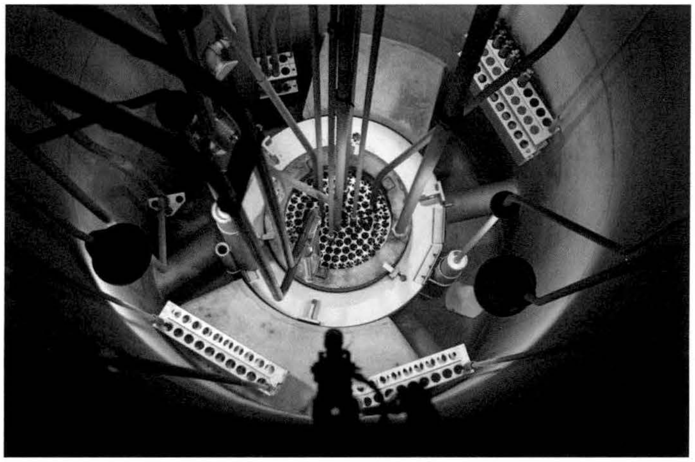
The reactor's **thermal column** consists of a large stack of graphite blocks which slows down neutrons from the reactor core in order to increase thermal neutron activation of samples. Over 99% of the neutrons in the thermal column are thermal neutrons. Graphite blocks are removed from the thermal column to enable samples to be positioned inside for irradiation.

The **beam ports** are tubular penetrations in the reactor's main concrete shield which enable neutron and gamma radiation to stream from the core when a beam port's shield plugs are removed. The neutron radiography facility utilized the tangential beam port (beam port #3) to produce ASTM E545 category I radiography capability. The other beam ports are available for a variety of experiments.

If samples irradiated require a large neutron fluence, especially from higher energy neutrons, they may be placed in the **in-core irradiation tube (ICIT)**, located in one of several in-core lattice positions.

The **cadmium-lined in-core irradiation tube (CLICIT)** enables samples to be irradiated in a high flux region near the center of the core. The cadmium lining in the facility eliminates thermal neutrons and thus permits sample exposure to higher energy neutrons only. The cadmium-lined end of this air-filled aluminum irradiation tube is inserted into an inner





grid position of the reactor core which would normally be occupied by a fuel element. It is the same as the ICIT except for the presence of the cadmium lining.

Instructional Uses of the OSTR

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

The second instructional application of the OSTR involves educating reactor operators, operations managers, and 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 of this report.

During this reporting period the OSTR accommodated a number of different OSU academic classes and other academic programs. In addition, portions of classes from other Oregon universities were also supported by the OSTR.

Research Uses of the OSTR

The OSTR is a unique and valuable tool for a wide variety of research applications and serves as an excellent source of neutrons and/or gamma radiation. The most commonly used experimental technique requiring reactor use is instrumental neutron activation analysis (INAA). This is a particularly sensitive method of elemental analysis which is described in more detail in Part VI.

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 INAA, but also for other experimental purposes such as the ^{39}Ar/^{40}Ar ratio and fission track methods of age dating samples.

Analytical Equipment

The Radiation Center has a large variety of radiation detection instrumentation. This equipment is upgraded as necessary, especially the gamma ray spectrometers with their associated computers and germanium detectors. Additional equipment for classroom use and an extensive inventory of portable radiation detection instrumentation are also available.

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

Radioisotope Irradiation Sources

The Radiation Center is equipped with a Gammacell 220 ^{60}Co irradiator which is capable of delivering high doses of gamma radiation over a range of dose rates to a variety of materials.

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

During this reporting period there was a diverse group of projects using the ^{60}Co irradiator. These projects included the irradiation of a variety of biological materials including different types of seeds.

In addition, the irradiator was used for sterilization of several media and the evaluation of the radiation effects on different materials. Table III.1 provides use data for the Gammacell 220 irradiator.

Laboratories and Classrooms

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

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

In addition to these dedicated instructional facilities, many other research laboratories and pieces of specialized equipment are regularly used for teaching. In particular, classes are routinely given access to gamma spectrometry equipment located in Center laboratories. A number of classes also regularly use the OSTR and the Reactor Bay as an integral part of their instructional coursework.

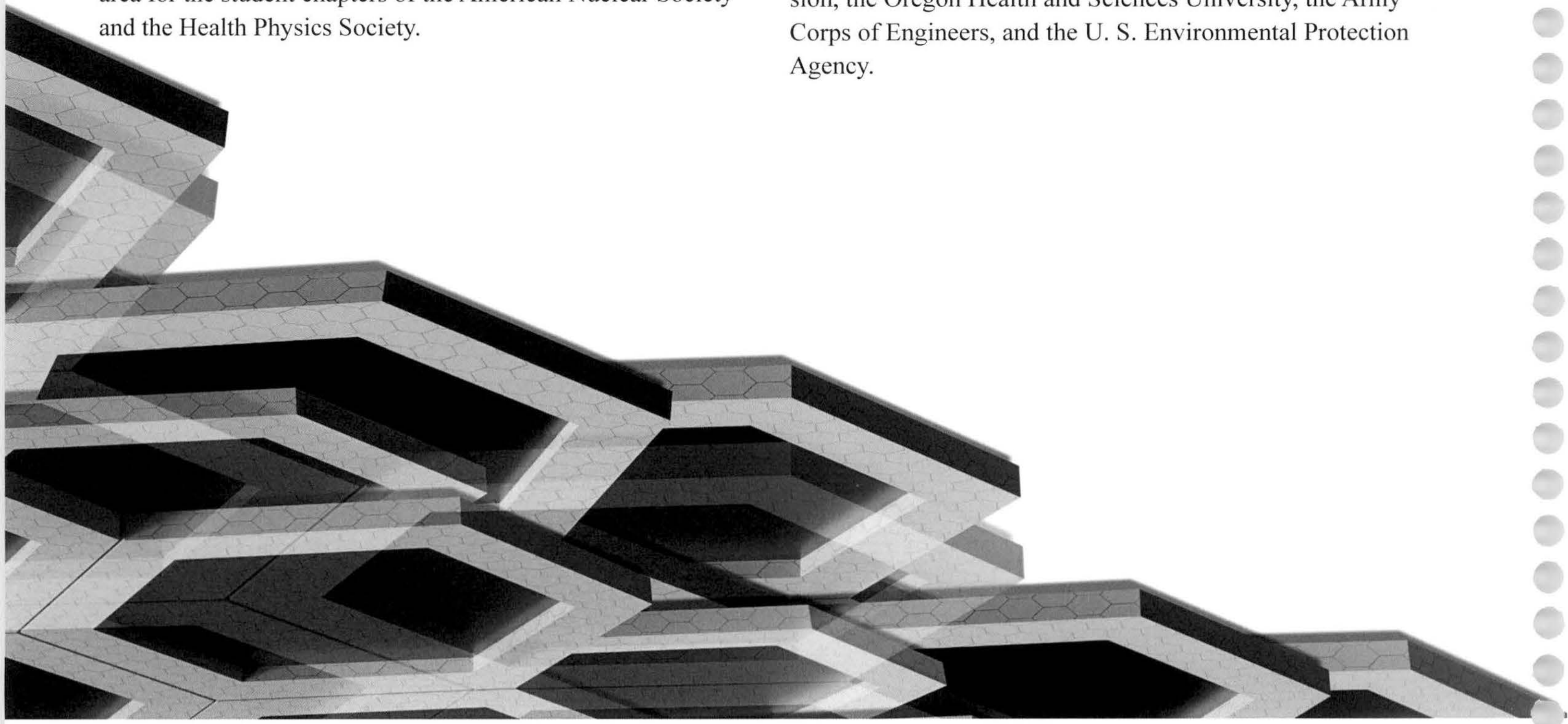
There are two classrooms in the Radiation Center which are capable of holding about 35 and 18 students. In addition, there are two smaller conference rooms and a library suitable for graduate classes and thesis examinations. As a service to the student body, the Radiation Center also provides an office area for the student chapters of the American Nuclear Society and the Health Physics Society.

All of the laboratories and classrooms are used extensively during the academic year. A listing of courses accommodated at the Radiation Center during this reporting period along with their enrollments is given in Table III.2.

Instrument Repair & Calibration Facility

The Radiation Center has a facility for the repair and calibration of essentially all types of radiation monitoring instrumentation. This includes instruments for the detection and measurement of alpha, beta, gamma, and neutron radiation. It encompasses both high range instruments for measuring intense radiation fields and low range instruments used to measure environmental levels of radioactivity.

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



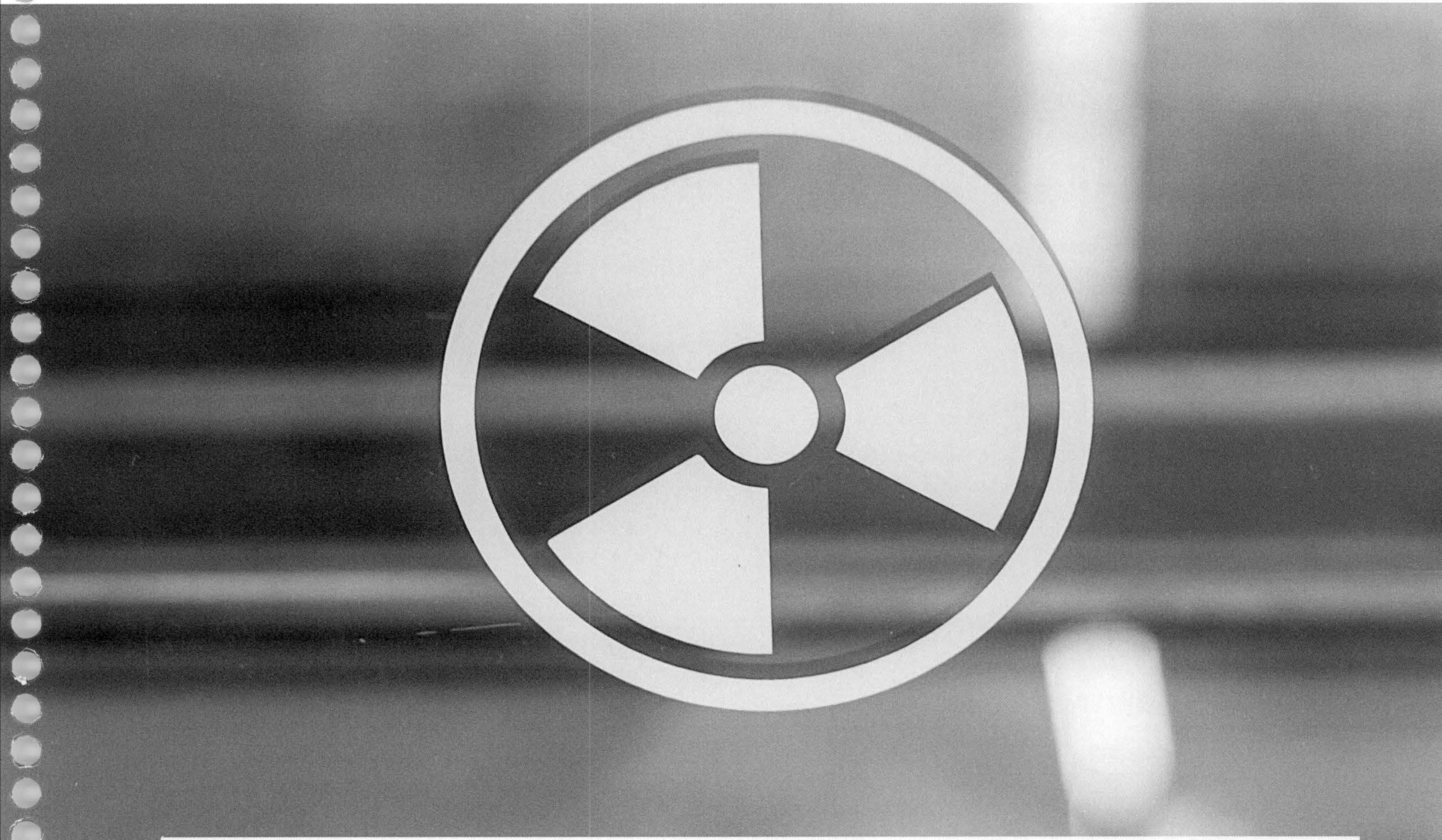


Table III.1

Gammacell 220 ^{60}Co Irradiator Use

Purpose of Irradiation	Samples	Dose Range (rads)	Number of Irradiations	Use Time (hours)
Sterilization	wood, soil, mouse diet, chitosan, biochar	1.5×10^{6} to 5.0×10^{6}	19	145.94
Material Evaluation	silcon sensor, polymers, medical devices, crystals	1.0×10^{4} to 2.2×10^{8}	12	1,221.40
Botanical Studies	wheat seeds, seeds	1.5×10^{4} to 5.0×10^{4}	7	.55
Totals			38	1367.89

Reactor

Operating Statistics

During the operating period between July 1, 2020 and June 30, 2021, the reactor produced 1,193 MWH of thermal power during its 1,258 critical hours.

Experiments Performed

During the current reporting period there were 5 approved reactor experiments available for use in reactor-related programs. They are:

A-1	Normal TRIGA Operation (No Sample Irradiation).
B-3	Irradiation of Materials in the Standard OSTR Irradiation Facilities.
B-29	Reactivity Worth of Fuel.
B-31	TRIGA Flux Mapping
B-36	Irradiation of fissionable materials in the OSTR.

Of these available experiments, four were used during the reporting period Table IV.4 provides information related to the frequency of use and the general purpose of their use.

Inactive Experiments

Presently 39 experiments are in the inactive file. This consists of experiments which have been performed in the past and may be reactivated. Many of these experiments are now performed under the more general experiments listed in the previous section. The following list identifies these inactive experiments.

A-2	Measurement of Reactor Power Level via Mn Activation.
A-3	Measurement of Cd Ratios for Mn, In, and Au in Rotating Rack.
A-4	Neutron Flux Measurements in TRIGA.
A-5	Copper Wire Irradiation.
A-6	In-core Irradiation of LiF Crystals.
A-7	Investigation of TRIGA's Reactor Bath Water Temperature Coefficient and High Power Level Power Fluctuation.
B-1	Activation Analysis of Stone Meteorites, Other Meteorites, and Terrestrial Rocks.
B-2	Measurements of Cd Ratios of Mn, In, and Au in Thermal Column.
B-4	Flux Mapping.
B-5	In-core Irradiation of Foils for Neutron Spectral Measurements.
B-6	Measurements of Neutron Spectra in External Irradiation Facilities.
B-7	Measurements of Gamma Doses in External Irradiation Facilities.
B-8	Isotope Production.
B-9	Neutron Radiography.
B-10	Neutron Diffraction.
B-11	Irradiation of Materials Involving Specific Quantities of Uranium and Thorium in Standard OSTR Irradiation Facilities. (Discontinued Feb. 28th, 2018)
B-12	Exploratory Experiments. (Discontinued Feb. 28th, 2018)
B-13	This experiment number was changed to A-7.
B-14	Detection of Chemically Bound Neutrons.
B-15	This experiment number was changed to C-1.
B-16	Production and Preparation of ^{18}F.
B-17	Fission Fragment Gamma Ray Angular Correlations.
B-18	A Study of Delayed Status (n, γ) Produced Nuclei.
B-19	Instrument Timing via Light Triggering.
B-20	Sinusoidal Pile Oscillator.
B-21	Beam Port #3 Neutron Radiography Facility.
B-22	Water Flow Measurements Through TRIGA Core.
B-23	Studies Using TRIGA Thermal Column. (Discontinued Feb. 28th, 2018)
B-24	General Neutron Radiography.
B-25	Neutron Flux Monitors.
B-26	Fast Neutron Spectrum Generator.
B-27	Neutron Flux Determination Adjacent to the OSTR Core.

B-28	Gamma Scan of Sodium (TED) Capsule.
B-30	NAA of Jet, Diesel, and Furnace Fuels.
B-32	Argon Production Facility.
B-33	Irradiation of Combustible Liquids in LS. (Discontinued Feb. 28th, 2018).
B-34	Irradiation of Enriched Uranium in the Neutron Radiography Facility. (Discontinued Feb. 28th, 2018).
B-35	Irradiation of Fissile Materials in the Prompt Gamma Neutron Activation Analysis (PGNAA) Facility. (Discontinued Feb. 28th, 2018).
C-1	PuO_2 Transient Experiment.

Unplanned Shutdowns

There were 9 unplanned reactor shutdowns during the current reporting period. Table IV.5 details these events.

Activities Pursuant to10 CFR 50-59

There was one safety evaluation performed in support of the reactor this year. It was:

21-01 RCHPP-39 Neutron Generator

Created a new Radiation Center Health Physics Procedure with instructions for using the neutron generator that is now how housed in the radiation center.

There were 9 new screens performed in support of the reactor this year. They were:

20-06 Changes to Radiation Center HVAC and Relevant OSTROP Revisions

Replaced all pneumatic components in the ventilation system with electrically operated components and made related updates to OSTROPs 1, 2, and 17..

20-06 Addendum: OSTROPs 16 and 17 Revision

Additional updates following the ventilation upgrades from Screen 20-06.

20-07 number not used

20-08 Upgrade to Reactor Bay Supply Fan Filtration

Installed a second set of air filters downstreeam of the first set on the ventilation supply fan to further reduce particulates going into the reactor bay.

20-09 Changes to OSTROPs 1 and 7

Minor updates and revisions to procedures for annunciator response and reactor water systems.

21-01 Revisions to OSTROPs 13, 26, and 31

Minor updates and revisions to procedures for monthly surveillance, background investigation, and archival storage of documents.

21-02 Bulk Shield Tank Cleanup Skid Upgrades and OSTROP 7 Revisions

Added a UV sanitizer to the bulk shield tank cleanup system to prevent biological growth, removed unnecessary valves, replaced other valves with stainless steel ball valves, and made related OSTROP revisions.

21-03 Changes to OSTROP 8: Reactor Power Calibration Procedures

Minor updates and revisions to the procedure for reactor power calibration.

21-04 Beam Port #4 Leak Repair and Modification

Install a sealed aluminum can in Beam Port #4 and inject epoxy around it in order to stop the water leak from that beam port while maintaining its usefulness for experimental facilities.

21-05 Changes to OSTROP 5: Procedure for Maintaining Reactor Operation Records

Minor updates and revisions to the procedure for operating records.

Surveillance and Maintenance

Non-Routine Maintenance

July 2020

- Cleaned Bulk Shield Tank water with temporary filtration system.

August 2020

- Replaced the ion exchange resin in the Bulk Shield Tank demineralizer tank.

September 2020

- Installed new electronic controllers for the ventilation system dampers.
- Emptied, cleaned, and refilled the cooling tower and secondary pump diffuser.

October 2020

- Installed a darkroom in the reactor bay for use by Neutron Radiography Facility experimenters.

- Replaced relief valve on Neutron Radiography Facility shutter.

November 2020

- Installed a second set of air filters on the ventilation supply fan.
- Cleaned the water level detector on the cooling tower.
- Repaired the preamplifier for the primary water activity monitor.

December 2020

- Replaced the batteries in the inverter.

March 2021

- Replaced the underwater lights in the tank with LEDs.
- Installed a UV sanitizer in the bulk shield tank cleanup system.
- Replaced bearings on the ventilation exhaust fan.

April 2021

- Cleaned shim rod electromagnet and armature.
- Installed grounding wire on the fission chamber to reduce electrical noise.

May 2021

- Re-soldered the resistor for the safety rod “DOWN” light.
- Replaced fan belts on several fans in the ventilation room.

June 2021

- Disassembled the PGNAA facility in preparation for Beam Port 4 repairs.
- Temporarily moved 43 fuel elements to the in-tank storage racks in preparation for Beam Port 4 repairs.
- Replaced the magnet in the shim rod drive.

Table IV.1

Present OSTR Operating Statistics

Operational Data For LEU Core	Annual Values (2020/2021)	Cumulative Values
MWH of energy produced	1,193	16,642
MWD of energy produced	49.7	693.4
Grams ^{235}U used	69	952
Number of fuel elements added to (+) or removed(-) from the core	0	91
Number of pulses	0	325
Hours reactor critical	1,258	17,807
Hours at full power (1 MW)	1,190	16,530
Number of startup and shutdown checks	231	2,881
Number of irradiation requests processed	207	3,140
Number of samples irradiated	879	25,758

Table IV.2

OSTR Use Time in Terms of Specific Use Categories

OSTR Use Category	Annual Values (hours)	Cumulative Values (hours)
Teaching (departmental and others)	23	13,781
OSU research	702	24,981
Off campus research	2,798	60,352
Facility time	170	7,918
Total Reactor Use Time	3,693	107,032

Table IV.3

OSTR Multiple Use Time

Number of Users	Annual Values (hours)	Cumulative Values (hours)
Two	315	11,764
Three	325	6,680
Four	269	3,729
Five	129	1,604
Six	29	540
Seven	2	176
Eight or more	0	29
Total Multiple Use Time	1,069	24,522

Table IV.4
Use of OSTR Reactor Experiments

Experiment Number	Research	Teaching	Facility Use	Total
A-1	1	1	3	5
B-3	186	3	10	199
B-31	0	0	1	1
B-36	2	0	0	2
Total	189	4	14	207

Table IV.5
Unplanned Reactor Shutdowns and Scrams

Type of Event	Number of Occurrences	Cause of Event
Manual SCRAM	3	Response to Stack/CAM alarm.
Manual Shut down	1	Low secondary water flow due to low water level in cooling tower.
External SCRAM	2	Limit switch slow to engage when closing NRF door and opening Beam Port 4 shutter.
Manual SCRAM	1	Operator response to period alarm.
Safety Channel SCRAM	1	Small spike in power at full power.
Safety and High Voltage SCRAM (simultaneous)	1	Exceeded power during reactor startup.

Figure IV.1

Monthly Surveillance and Maintenance (Sample Form)

OSTROP 13, Rev. LEU-9 Surveillance & Maintenance for the Month of ________________ in the year of 20____

	SURVEILLANCE & MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]	LIMITS		AS FOUND		TARGET DATE	DATE NOT TO BE EXCEEDED *	DATE COMPLETED	REMARKS & INITIALS
1	REACTOR TANK HIGH AND LOW WATER LEVEL ALARMS	MAXIMUM MOVEMENT ± 3 INCHES		HIGH:________INCHES LOW:________INCHES ANN:____________					
2	REACTOR TANK TEMPERATURE ALARM CHECK	FUNCTIONAL		Tested @______					
3A	CHANNEL TEST OF STACK CAM GAS CHANNEL	$8.5x10^4$± 8500 cpm	Ann.?	___cpm	___Ann.				
3B	CHANNEL TEST OF STACK CAM PARTICULATE CHANNEL	$8.5x10^4$± 8500 cpm	Ann.?	___cpm	___Ann.				
3C	CHANNEL TEST OF REACTOR TOP CAM PARTICULATE CHANNEL	$8.5x10^4$± 8500 cpm	Ann.?	___cpm	___Ann.				
4	MEASUREMENT OF REACTOR PRIMARY WATER CONDUCTIVITY	<5 µmho\cm							
5	PRIMARY WATER pH MEASUREMENT	MIN: 5 MAX: 9					N/A		
6	BULK SHIELD TANK WATER pH MEASUREMENT	MIN: 5 MAX: 9					N/A		
7	CHANGE LAZY SUSAN FILTER	FILTER CHANGED					N/A		
8	REACTOR TOP CAM OIL LEVEL CHECK	OSTROP 13.8		NEED OIL?_____			N/A		
9	STACK CAM OIL LEVEL CHECK	OSTROP 13.9		NEED OIL?_____			N/A		
10	EMERGENCY DIESEL GENERATOR CHECKS	> 50% Visual	Oil ok? Hours				N/A N/A		
11	RABBIT SYSTEM RUN TIME	Total hours/Hours on current brushes					N/A		
12	OIL TRANSIENT ROD BRONZE BEARING	WD 40					N/A		
13	CRANE INSPECTION	Hooks	Hoist Rope				N/A		
14	WATER MONITOR CHECK	RCHPP 8 App. F.4					N/A		

* Date not to be exceeded is only applicable to shaded items. It is equal to the time completed last month plus six weeks.

Figure IV.2

Quarterly Surveillance and Maintenance (Sample Form)

OSTROP 14, Rev. LEU-6 Surveillance & Maintenance for the 1st / 2nd / 3rd / 4th Quarter of 20____

SURVEILLANCE & MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]		LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
1	REACTOR OPERATION COMMITTEE (ROC) AUDIT	QUARTERLY					
2	INTERNAL AUDIT OF OSTROPS	QUARTERLY					
3	QUARTERLY ROC MEETING	QUARTERLY					
4	ERP INSPECTIONS	QUARTERLY					
5	ROTATING RACK CHECK FOR UNKNOWN SAMPLES	EMPTY					
6	WATER MONITOR ALARM CHECK	FUNCTIONAL					
7A	CHECK FILTER TAPE SPEED ON STACK MONITOR	1”/HR ± 0.2					
7B	CHECK FILTER TAPE SPEED ON CAM MONITOR	1”/HR ± 0.2					
8	INCORPORATE 50.59 & ROCAS INTO DOCUMENTATION	QUARTERLY					
9	EMERGENCY CALL LIST	QUARTERLY					
10	ARM SYSTEM ALARM CHECKS	FUNCTIONAL					

ARM	1	2	3S	3E	4	5	7	8	9	10	11	12
AUD												
LIGHT												
PANEL												
ANN												

* Date not to be exceeded is only applicable to shaded items. It is equal to the time completed last quarter plus four months.

Figure IV.2 (continued)

Quarterly Surveillance and Maintenance (Sample Form)

OSTROP 14, Rev. LEU-6 Surveillance & Maintenance for the 1st / 2nd / 3rd / 4th Quarter of 20_____

SURVEILLANCE & MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]		LIMITS	AS FOUND	DATE COMPLETED	REMARKS & INITIALS
11	OPERATOR NAME	a) $\geq$4 hours: at console (RO), at console or as Rx. Sup. (SRO) b) Date Completed Operating Exercise	a) TOTAL OPERATION TIME	b) DATE OF OPERATING EXERCISE	REMARKS & INITIALS

Figure IV.3

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15, Rev. LEU-8

Surveillance & Maintenance for the 1st / 2nd Half of 20______

SURVEILLANCE & MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
1	CHANNEL TESTS OF REACTOR INTERLOCKS	NEUTRON SOURCE COUNT RATE INTERLOCK	NO WITHDRAW					
			≥5 cps					
		TRANSIENT ROD AIR INTERLOCK	NO PULSE					
		PULSE MODE ROD MOVEMENT INTERLOCK**	NO MOVEMENT					
		MAXIMUM PULSE REACTIVITY INSERTION LIMIT	≤ $2.25					
		TWO ROD WITHDRAWAL PRHOHIBIT	1 ONLY					
		PULSE PROHIBIT ABOVE 1 kW	≥1 kW					
2	TEST PULSE**	PREVIOUS PULSE DATA FOR COMPARION PULSE # ________ $______________ ______________MW ______________°C	≤20% CHANGE	PULSE # ______ $______________ ____________MW ____________°C				
3	CLEANING & LUBRICATION OF TRANSIENT ROD CARRIER INTERNAL BARREL							
4	LUBRICATION OF BALL-NUT DRIVE ON TRANSIENT ROD CARRIER							
5	LUBRICATION OF THE ROTATING RACK BEARINGS		WD-40					
6	CONSOLE CHECK LIST		OSTROP 15.V11					
7	INVERTER MAINTENANCE		See User Manual					
8	STANDARD CONTROL ROD MOTOR CHECKS		LO-17 Bodine Oil					

*Date not to be exceeded is only applicable to shaded items. It is equal to the date last time plus 7 1/2 months.

Figure IV.3 (continued)

Semi-Annual Surveillance and Maintenance (Sample Form)

OSTROP 15, Rev. LEU-8

Surveillance & Maintenance for the 1st / 2nd Half of 20______

SURVEILLANCE & MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
9	FUNCTIONAL CHECK OF HOLDUP TANK WATER LEVEL ALARMS		OSTROP 15.IX	HIGH ________ FULL________				
10	INSPECTION OF THE PNEUMATIC TRANSFER SYSTEM	BRUSH INSPECTION						
		SAMPLE INSERTION AND WITHDRAWAL TIME CHECK	Observed insertion/withdrawal time					

*Date not to be exceeded is only applicable to shaded items. It is equal to the date last time plus 7 1/2 months.

** These tests may be postponed while pulsing is precluded. If it has been more than 7.5 months since the previous test, the test shall be performed before resuming pulsing.

Figure IV.4

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16, Rev. LEU-8 Annual Surveillance and Maintenance for 20______

	SURVEILLANCE AND MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]						LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
1	BIENNIAL INSPECTION OF CONTROL RODS:	FFCRS					OSTROP 12.0					
		TRANS										
2	STANDARD CONTROL ROD DRIVE INSPECTON						OSTROP 16.2					
3	CONTROL ROD CALIBRATION:						OSTROP 9.0					
4	CONTROL ROD WITHDRAWAL INSERTION & SCRAM TIMES		TRANS	SAFE	SHIM	REG						
		SCRAM					≤2 sec					
		W/D					≤50 sec					
		INSERT					≤50 sec					
5	FUEL ELEMENT INSPECTION FOR SELECTED ELEMENTS						≥ 20% FE's inspected. No damage deterioration or swell.					
6	REACTOR POWER CALIBRATION						OSTROP 8					
7	FUEL ELEMENT TEMPERATURE CHANNEL CALIBRATION						Per Checklist					
8	CALIBRATION OF REACTOR TANK WATER TEMP TEMPERATURE METERS						OSTROP 16.8					
9	CONTINUOUS AIR MONITOR CALIBRATION	Particulate Monitor					RCHPP 18					
		Gas Monitor										
10	CAM OIL/GREASE MAINTENANCE											
11	STACK MONITOR CALIBRATION	Particulate Monitor					RCHPP 18 & 26					
		Gas Monitor										
12	STACK MONITOR OIL/GREASE MAINTENANCE											
13	AREA RADIATION MONITOR CALIBRATION						RCHPP 18					

* Date not be exceeded is only applicable to shaded items. It is equal to the date completed last year plus 15 months.
For biennial license requirements, it is equal to the date completed last time plus 2 1/2 years.

Figure IV.4 (continued)

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16, Rev. LEU-8

Annual Surveillance and Maintenance for 20______

SURVEILLANCE AND MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]			LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
14	CORE EXCESS		≤\$7.55	\$______				
15	REACTOR BAY VENTILATION SYSTEM SHUTDOWN TEST		DAMPERS CLOSE IN ≤5 SECONDS	1^{ST} FLOOR ___ 4^{TH} FLOOR ___				
16	CRANE INSPECTION		-	-	-	-	-	-
17	SNM PHYSICAL INVENTORY		N/A	N/A	OCTOBER			
18	MATERIAL BALANCE REPORTS		N/A	N/A	NOVEMBER			
19	EMERGENCY RESPONSE PLAN	CFD TRAINING						
		GOOD SAM TRAINING						
		ERP REVIEW						
		ERP DRILL						
		CPR CERT FOR:						
		CPR CERT FOR:						
		FIRST AID CERT FOR:						
		FIRST AID CERT FOR:						
		EVACUATION DRILL						
		AUTO EVAC ANNOUNCEMENT TEST						
		ERP EQUIPMENT INVENTORY						
		BIENNIAL SUPPORT AGREEMENTS						
20	PHYSICAL SECURITY PLAN	PSP REVIEW						
		PSP DRILL						
		OSP/DPS TRAINING						
		LOCK/SAFE COMBO CHANGES						
		AUTHORIZATION LIST UPDATE						

* Date not be exceeded is only applicable to shaded items. It is equal to the date completed last year plus 15 months.
For biennial license requirements, it is equal to the date completed last time plus 2 1/2 years.

Figure IV.4 (continued)

Annual Surveillance and Maintenance (Sample Form)

OSTROP 16, Rev. LEU-8 Annual Surveillance and Maintenance for 20______

	SURVEILLANCE AND MAINTENANCE [SHADE INDICATES LICENSE REQUIREMENT]	LIMITS	AS FOUND	TARGET DATE	DATE NOT TO BE EXCEEDED*	DATE COMPLETED	REMARKS & INITIALS
21	ANNUAL REPORT	NOV 1		OCT 1	NOV 1		
22	ANNUAL TEST OF RECORD RETRIEVABILITY	ANNUAL					
23	KEY INVENTORY	ANNUAL					
24	REACTOR TANK AND CORE COMPONENT INSPECTION	NO WHITE SPOTS					
25	EMERGENCY LIGHT LOAD TEST						
26	NEUTRON RADIOGRAPHY FACILTIY INTERLOCKS						
27	PGNAA FACILITY INTERLOCKS						

28	REACTOR OPERATOR LICENSE CONDITIONS	ANNUAL REQUALIFICATION				BIENNIAL MEDICAL		EVERY 6 YEARS LICENSE		
		WRITTEN EXAM		OPERATING TEST		DATE DUE	DATE COMPLETED	APPLICATION		EXPIRATION DATE
	OPERATOR NAME	DATE DUE	DATE PASSED	DATE DUE	DATE PASSED			DUE DATE	DATE MAILED	

* Date not be exceeded is only applicable to shaded items. It is equal to the date completed last year plus 15 months.
For biennial license requirements, it is equal to the date completed last time plus 2 1/2 years.

Radiation Protection

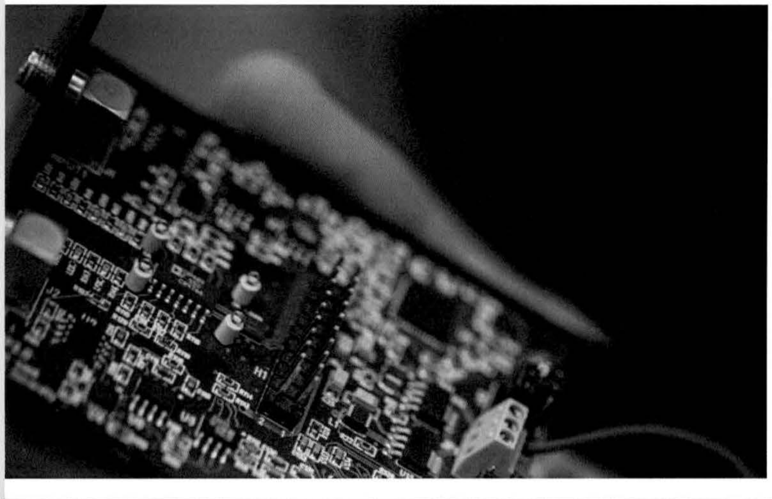
Introduction

The purpose of the radiation protection program is to ensure the safe use of radiation and radioactive material in the Center's teaching, research, and service activities, and in a similar manner to 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.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, and several part-time Health Physics Monitors (see Part II). 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 hav nb je 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.

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).



Environmental Releases

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

Liquid Effluents Released

Liquid Effluents

Oregon State University has implemented a policy to reduce the volume of radioactive liquid effluents to an absolute minimum. For example, water used during the ion exchanger resin change is now recycled as reactor makeup water. Waste water from Radiation Center laboratories and the OSTR is collected at a holdup tank prior to release to the sanitary sewer. Liquid effluent are analyzed for radioactivity content at the time it is released to the collection point. For this reporting period, the Radiation Center and reactor made seven liquid effluent releases to the sanitary sewer. All Radiation Center and reactor facility liquid effluent data pertaining to this release are contained in Table V.2.

Liquid Waste Generated and Transferred

Liquid waste generated from glassware and laboratory experiments is transferred by the campus Radiation Safety Office to its waste processing facility. The annual summary of liquid waste generated and transferred is contained in Table V.3.

Airborne Effluents Released

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

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.4.

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

Particulate Effluents

Evaluation of the detectable particulate radioactivity in the stack effluent confirmed its origin as naturally-occurring radon daughter products, within a range of approximately $3x10^{-11}$ µCi/ml to 1×10^{-9} µCi/ml. This particulate radioactivity is predominantly ^{214}Pb and ^{214}Bi, which is not associated with reactor operations.

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

Solid Waste Released

Data for the radioactive material in the solid waste generated and transferred during this reporting period are summarized in Table V.5 for both the reactor facility and the Radiation Center. Solid radioactive waste is routinely transferred to OSU Radiation Safety. 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 OSU Radiation Safety by transfer to the University's radioactive waste disposal vendor.

Personnel Dose

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

Facility operating personnel include the reactor operations and health physics staff. The dosimeters used to monitor these individuals include quarterly TLD badges, quarterly track-etch/albedo neutron dosimeters, monthly TLD (finger) extremity dosimeters, pocket ion chambers, electronic dosimetry.

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 quarterly TLD film badge and TLD (finger) extremity dosimeters. If the possibility of neutron exposure exists, researchers are also monitored with a track-etch/ albedo neutron dosimeter.

Facilities Services maintenance personnel are normally issued a gamma sensitive electronic dosimeter as their basic monitoring device.

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

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

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

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

An annual summary of the radiation doses received by each of the above six groups is shown in Table V.6. There were no personnel radiation exposures in excess of the limits in 10 CFR 20 or State of Oregon regulations during the reporting period.

Facility Survey Data

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

Area Radiation Dosimeters

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

The total dose equivalent recorded on the various reactor facility dosimeters is listed in Table V.7 and the total dose equivalent recorded on the Radiation Center area dosimeters is listed in Table V.8. Generally, the characters following the Monitor Radiation Center (MRC) designator show the room number or location.

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.9.

Environmental Survey Data

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

Gamma Radiation Monitoring

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 and nine environmental monitoring stations.

During this reporting period, each fence environmental station utilized an LiF TLD monitoring packet supplied and processed by Mirion Technologies, Inc., Irvine, California. Each packet contained three LiF TLDs and was exchanged quarterly for a total of 108 samples during the reporting period (9 stations x 3 TLDs per station x 4 quarters). The total number of TLD samples for the reporting period was 108. A summary of the TLD data is also shown in Table V.10.

From Table V.10 it is concluded that the doses recorded by the dosimeters on the TRIGA facility fence can be attributed to natural back-ground radiation, which is about 110 mrem per year for Oregon (Refs. 1, 2).

Off-site Monitoring

The off-site gamma environmental radiation monitoring program consists of twenty monitoring stations surrounding the Radiation Center (see Figure V.1) and six stations located within a 5 mile radius of the Radiation Center.

Each monitoring station is located about four feet above the ground (MRCTE 21 and MRCTE 22 are mounted on the roof of the EPA Laboratory and National Forage Seed Laboratory, respectively). These monitors are exchanged and processed quarterly, and the total number of TLD samples during the current one-year reporting period was 240 (20 stations x 3 chips per station per quarter x 4 quarters per year). The total number of TLD samples for the reporting period was 240. A summary of TLD data for the off-site monitoring stations is given in Table V.11.

After a review of the data in Table V.11, it is concluded that, like the dosimeters on the TRIGA facility fence, all of the doses recorded by the off-site dosimeters can be attributed to natural background radiation, which is about 110 mrem per year for Oregon (Refs. 1, 2).

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 annual 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.1 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.1.

There are a total of 22 sampling locations: four soil locations, four water locations (when water is available), and fourteen vegetation locations.

The annual 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.12. Calculation of the total net beta disintegration rate incorporates subtraction of only the counting system back-ground from the gross beta counting rate, followed by application of an appropriate counting system efficiency.

The annual 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.13 gives the concentration and the range of 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.12 it can be seen that the levels of radioactivity detected were consistent with naturally occurring radioactivity and comparable to values reported in previous years.

Radioactive Materials Shipments

A summary of the radioactive material shipments originating from the TRIGA reactor facility, NRC license R-106, is shown in Table V.14. A similar summary for shipments originating from the Radiation Center's State of Oregon radioactive materials license ORE 90005 is shown in Table V.15. A summary of radioactive material shipments exported under Nuclear Regulatory Commission general license 10 CFR 110.23 is shown in Table V.16.

References

1. U. S. Environmental Protection Agency, "Estimates of Ionizing Radiation Doses in the United States, 1960-2000," ORP/CSD 72-1, Office of Radiation Programs, Rockville, Maryland (1972).
2. U. S. Environmental Protection Agency, "Radiological Quality of the Environment in the United States, 1977," EPA 520/1-77-009, Office of Radiation Programs; Washington, D.C. 20460 (1977).

Table V.1

Radiation Protection Program Requirements and Frequencies

Frequency	Radiation Protection Requirement
Daily/Weekly/Monthly	Perform Routing area radiation/contamination monitoring
Monthly	Collect and analyze TRIGA primary, secondary, and make-up water. Exchange personnel dosimeters, and review exposure reports. Inspect laboratories. 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. Conduct orientations for classes using radioactive materials. Collect and analyze samples 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.
Annual	Calibrate portable radiation monitoring instruments and personnel pocket ion chambers. Calibrate reactor stack effluent monitor, continuous air monitors, remote area radiation monitors, and air samplers. Measure face air velocity in laboratory hoods and exchange dust-stop filters and HEPA filters as necessary. Inventory and inspect Radiation Center emergency equipment. Conduct facility radiation survey of the ^{60}Co irradiators. Conduct personnel dosimeter training. Update decommissioning logbook. Collect and process environmental soil, water, and vegetation samples.

Table V.2

Monthly Summary of Liquid Effluent Release to the Sanitary Sewer[1]

Date of Discharge (Month and Year)	Total Quantity of Radioactivity Released (Curies)	Detectable Radionuclide in the Waste	Specific Activity for Each Detectable Radionuclide in the Waste, Where the Release Concentration Was>1 x 10^{-7} (μCi ml^{-1})	Total Quantity of Each Detectable Radionuclide Released in the Waste (Curies)	Average Concentration Of Released Radioactive Material at the Point of Release (μCi ml^{-1})	Percent of Applicable Monthly Average Concentration for Released Radioactive Material (%)[2]	Total Volume of Liquid Effluent Released Including Diluent (gal)
August 2020	$5.98x10^{-5}$	H-3	H-3, $1.05x10^{-7}$	H-3, $5.98x10^{-5}$	H-3, $1.05x10^{-7}$	H-3, 0.0011	151,096
Annual Total for Radiation Center	$5.98x10^{-5}$	H-3	H-3, $1.05x10^{-7}$	H-3, $5.98x10^{-5}$	H-3, $1.05x10^{-7}$	H-3, 0.0011	151,096

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

(2) Based on values listed in 10 CFR 20, Appendix B to 20.1001 – 10.2401, Table 3, which are applicable to sewer disposal.

Table V.3

Annual Summary of Liquid Waste Generated and Transferred

Origin of Liquid Waste	Volume of Liquid Waste Packaged(1) (gallons)	Detectable Radionuclides in the Waste	Total Quantity of Radioactivity in the Waste (Curies)	Dates of Waste Pickup for Transfer to the Waste Processing Facility
TRIGA	77.5	Mn-54, Mn-56, Co-58, Co-60, Zn-65	6.76×10^{-4}	9/23/2020 2/25/2021
Radiation Center Laboratories	3.25	Cf-249, Cf-252, Bk-249	3.43×10^{-4}	9/23/2020 1/15/2021
TOTAL	**80.75**	**See above**	**1.02×10^{-3}**	

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

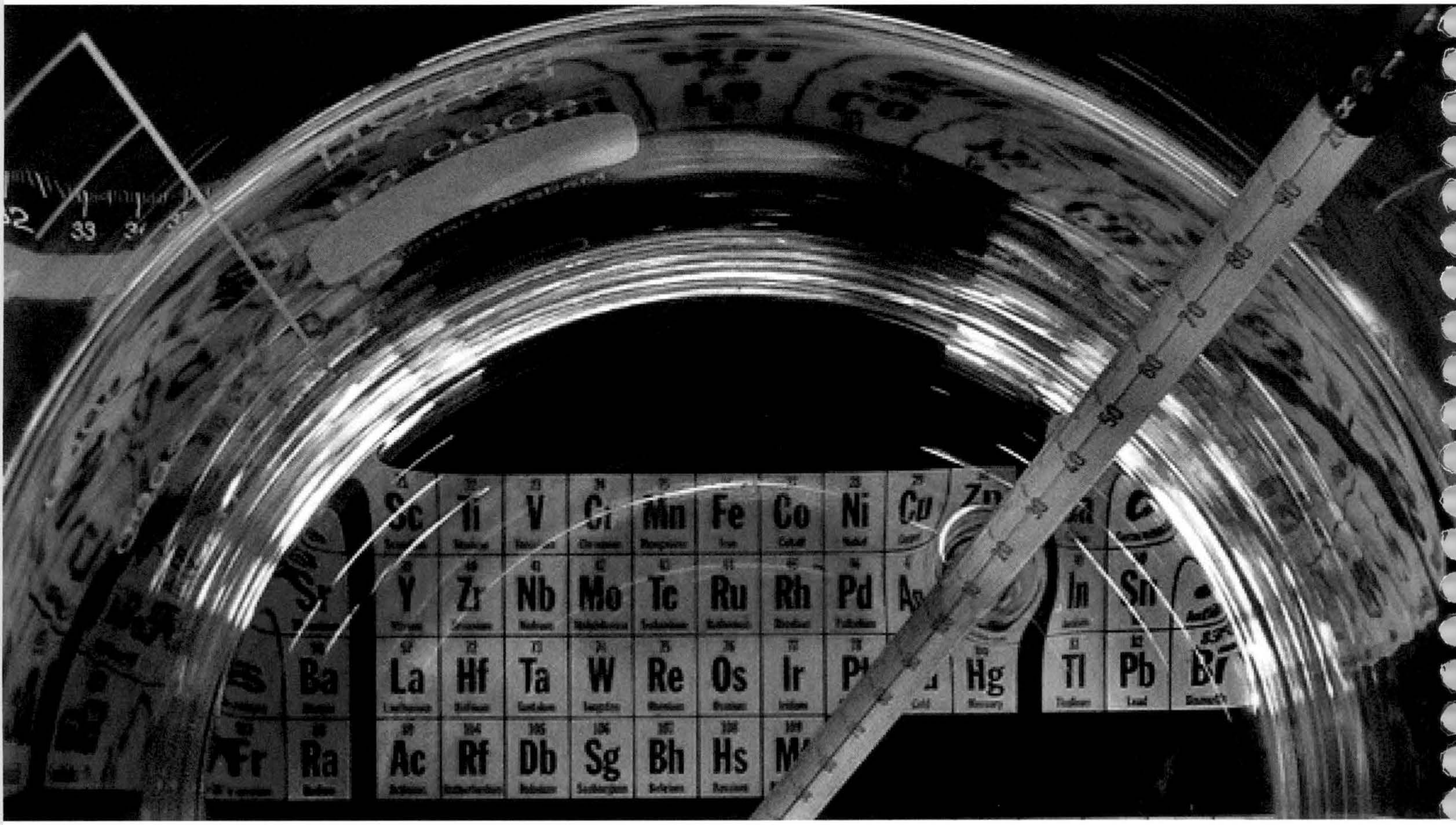


Table V.4

Monthly TRIGA Reactor Gaseous Waste Discharges and Analysis

Month	Total Estimated Activity Released (Curies)	Total Estimated Quantity of Argon-41 Released(1) (Curies)	Estimated Atmospheric Diluted Concentration of Argon-41 at Point of Release (μCi/cc)	Fraction of the Technical Specification Annual Average Argon-41 Concentration Limit (%)
July	1.33	1.33	1.06×10^{-7}	2.65
August	1.76	1.76	1.41×10^{-7}	3.51
September	1.01	1.01	8.34×10^{-8}	2.09
October	1.96	1.96	1.57×10^{-7}	3.93
November	1.80	1.80	1.49×10^{-7}	3.71
December	1.84	1.84	1.47×10^{-7}	3.68
January	2.84	2.84	2.27×10^{-7}	5.68
February	2.85	2.85	2.52×10^{-7}	6.30
March	2.76	2.76	2.20×10^{-7}	5.51
April	3.25	3.25	2.69×10^{-7}	6.71
May	1.97	1.97	1.57×10^{-7}	3.93
June	1.65	1.65	1.32×10^{-7}	3.29
TOTAL ('20-'21)	**25.02**	**25.02**	1.70×10^{-7}(2)	**4.25**

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

(2) Annual Average.

Table V.5

Annual Summary of Solid Waste Generated and Transferred

Origin of Solid Waste	Volume of Solid Waste Packaged(1) (Cubic Feet)	Detectable Radionuclides in the Waste	Total Quantity of Radioactivity in Solid Waste (Curies)	Dates of Waste Pickup for Transfer to the OSU Waste Processing Facility
TRIGA Reactor Facility	26	C-14, Co-58, Co-60, Sc-46, Cr-51, Mn-54, Se-75, Sb-124, Fe-59, Zn-65	5.99×10^{-4}	9/23/2020 1/15/2021 2/25/2021
Radiation Center Laboratories	20	Fe-55, Cd-109, Eu-152, Cf-248, Cf-249, Cf-252, U-238, Pu-240, Pu-242, Np-237, Pu-239, Am-241, Th-232	5.01×10^{-5}	1/15/2021 2/25/2021
TOTAL	46	See Above	6.49×10^{-4}	

(1) OSTR and Radiation Center lab waste is picked up by OSU Radiation Safety for transfer to its waste processing facility for final packaging.

Table V.6

Annual Summary of Personnel Radiation Doses Received

	Average Annual Dose(1)		Greatest Individual Dose(1)		Total Person-mrem for the Group(1)	
Personnel Group	**Whole Body (mrem)**	**Extremities (mrem)**	**Whole Body (mrem)**	**Extremities (mrem)**	**Whole Body (mrem)**	**Extremities (mrem)**
Facility Operating Personnel	114	234	265	1,132	914	1,872
Key Facility Research Personnel	1	2	15	21	26	21
Facilities Services Maintenance Personnel	0	N/A	0	N/A	0	N/A
Laboratory Class and Students	8	37	174	899	564	1,199
Campus Police and Security Personnel	<1	N/A	16	N/A	16	N/A
Visitors	<1	N/A	4.7	N/A	62	N/A
Onsite-Contractors	64	187	64	187	64	187

(1) "N/A" indicates that there was no extremity monitoring conducted or required for the group.

Table V.7

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

Monitor I.D.	TRIGA Reactor Facility Location (See Figure V.1)	Total Recorded	Dose Equivalent(1)(2)
		Xß(γ) (mrem)	Neutron (mrem)
MRCTNE	D104: North Badge East Wall	167	ND
MRCTSE	D104: South Badge East Wall	140	ND
MRCTSW	D104: South Badge West Wall	363	ND
MRCTNW	D104: North Badge West Wall	143	ND
MRCTWN	D104: West Badge North Wall	399	ND
MRCTEN	D104: East Badge North Wall	272	ND
MRCTES	D104: East Badge South Wall	1,084	ND
MRCTWS	D104: West Badge South Wall	522	ND
MRCTTOP	D104: Reactor Top Badge	949	ND
MRCTHXS	D104A: South Badge HX Room	577	ND
MRCTHXW	D104A: West Badge HX Room	296	ND
MRCD-302	D302: Reactor Control Room	407	ND
MRCD-302A	D302A: Reactor Supervisor's Office	96	ND
MRCBP1	D104: Beam Port Number 1	366	ND
MRCBP2	D104: Beam Port Number 2	165	ND
MRCBP3	D104: Beam Port Number 3	763	ND
MRCBP4	D104: Beam Port Number 4	1,192	ND

(1) The total recorded dose equivalent values do not include natural background contribution and reflect the summation of the results of four quarterly beta-gamma dosimeters or four quarterly fast neutron dosimeters for each location. A total dose equivalent of "ND" indicates that each of the dosimeters during the reporting period was less than the vendor's gamma dose reporting threshold of 10 mrem or that each of the fast neutron dosimeters was less than the vendor's threshold of 10 mrem. "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.

Table V.8

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

Monitor I.D.	Radiation Center Facility Location (See Figure V.1)	Total Recorded Dose Equivalent[1]	
		Xß(γ) (mrem)	Neutron (mrem)
MRCA100	A100: Receptionist's Office	0	ND
MRCBRF	A102H: Front Personnel Dosimetry Storage Rack	0	ND
MRCA120	A120: Stock Room	30	ND
MRCA120A	A120A: NAA Temporary Storage	119	ND
MRCA126	A126: Radioisotope Research Laboratory	160	ND
MRCCO-60	A128: ^{60}Co Irradiator Room	764	ND
MRCA130	A130: Shielded Exposure Room	0	ND
MRCA132	A132: TLD Equipment Room	0	ND
MRCA138	A138: Health Physics Laboratory	0	ND
MRCB100	B100: Gamma Analyzer Room (Storage Cave)	167	ND
MRCB114	B114: Lab (^{226}Ra Storage Facility)	24	ND
MRCB119-1	B119: Source Storage Room	15	ND
MRCB119-2	B119: Source Storage Room	243	ND
MRCB119A	B119A: Sealed Source Storage Room	2,149	22
MRCB120	B120: Instrument Calibration Facility	16	ND
MRCB122-2	B122: Radioisotope Hood	50	ND
MRCB122-3	B122: Radioisotope Research Laboratory	16	ND
MRCB124-1	B124: Radioisotope Research Laboratory (Hood)	178	ND
MRCB124-2	B124: Radioisotope Research Laboratory	0	ND
MRCB124-6	B124: Radioisotope Research Laboratory	14	ND
MRCB128	B128: Instrument Repair Shop	0	ND
MRCB136	B136 Gamma Analyzer Room	0	ND
MRCC100	C100: Radiation Center Director's Office	0	ND

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

Table V.8 (continued)

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

Monitor I.D.	Radiation Center Facility Location (See Figure V.1)	Total Recorded Dose Equivalent[(1)]	
		Xß(γ) (mrem)	Neutron (mrem)
MRCC106A	C106A: Office	0	ND
MRCC106B	C106B: Custodian Supply Storage	0	ND
MRCC106-H	C106H: East Loading Dock	11	ND
MRCC118	C118: Radiochemistry Laboratory	0	ND
MRCC120	C120: Student Counting Laboratory	0	ND
MRCF100	F100: APEX Facility	0	ND
MRCF102	F102: APEX Control Room	0	ND
MRCB125N	B125: Gamma Analyzer Room (Storage Cave)	0	ND
MRCN125S	B125: Gamma Analyzer Room	0	ND
MRCC124	C124: Classroom	11	ND
MRCC130	C130: Radioisotope Laboratory (Hood)	0	ND
MRCD100	D100: Reactor Support Laboratory	12	ND
MRCD102	D102: Pneumatic Transfer Terminal Laboratory	182	ND
MRCD102-H	D102H: 1st Floor Corridor at D102	49	ND
MRCD106-H	D106H: 1st Floor Corridor at D106	366	ND
MRCD200	D200: Reactor Administrator's Office	136	ND
MRCD202	D202: Senior Health Physicist's Office	232	ND
MRCBRR	D200H: Rear Personnel Dosimetry Storage Rack	12	ND
MRCD204	D204: Health Physicist Office	259	ND
MRCATHRL	F104: ATHRL	0	ND
MRCD300	D300: 3rd Floor Conference Room	138	ND
MRCA144	A144: Radioisotope Research Laboratory	33	ND

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

Table V.9

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

Accessible Location (See Figure V.1)	Whole Body Radiation Levels (mrem/hr)		Contamination Levels(1) (dpm/cm^2)	
	Average	Maximum	Average	Maximum
TRIGA Reactor Facility:				
Reactor Top (D104)	3.49	110	<500	1,667
Reactor 2nd Deck Area (D104)	6.57	90	<500	<500
Reactor Bay SW (D104)	<1	23	<500	<500
Reactor Bay NW (D104)	<1	8	<500	10,625
Reactor Bay NE (D104)	<1	40	<500	<500
Reactor Bay SE (D104)	<1	30	<500	<500
Class Experiments (D104, D302)	<1	2.7	<500	<500
Demineralizer Tank & Make Up Water System (D104A)	<1	8	<500	<500
Particulate Filter--Outside Shielding (D104A)	<1	2	<500	<500
Radiation Center:				
NAA Counting Rooms (A146, B100)	<1	1.1	<500	<500
Health Physics Laboratory (A138)	<1	<1	<500	<500
^{60}Co Irradiator Room and Calibration Rooms (A128, B120, A130)	<1	3.5	<500	<500
Radiation Research Labs (A126, A136) (B108, B114, B122, B124, C126, C130, A144)	<1	2.8	<500	<500
Radioactive Source Storage (B119, B119A, A120A, A132A)	<1	6	<500	<500
Student Chemistry Laboratory (C118)	<1	<1	<500	<500
Student Counting Laboratory (C120)	<1	<1	<500	<500
Operations Counting Room (B136, B125)	<1	<1	<500	<500
Pneumatic Transfer Laboratory (D102)	<1	<1	<500	<500
RX support Room (D100)	<1	<1	<500	<500

(1) <500 dpm/100 cm2 = Less than the lower limit of detection for the portable survey instrument used.

Table V.10

Total Dose Equivalent at the TRIGA Reactor Facility Fence

Fence Environmental Monitoring Station (See Figure V.1)	Total Recorded Dose Equivalent (Including Background) Based on Mirion TLDs(1, 2) (mrem)
MRCFE-1	82 ± 7
MRCFE-2	76 ± 8
MRCFE-3	76 ± 7
MRCFE-4	80 ± 7
MRCFE-5	85 ± 8
MRCFE-6	82 ± 7
MRCFE-7	83 ± 8
MRCFE-8	81 ± 6
MRCFE-9	79 ± 7

(1) Average Corvallis area natural background using Mirion TLDs totals 77 ± 14 mrem for the same period.

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

Table V.11

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

Off-Site Radiation Monitoring Station (See Figure V.1)	Total Recorded Dose Equivalent (Including Background) Based on Mirion TLDs(1, 2) (mrem)
MRCTE-2	83 ± 6
MRCTE-3	78 ± 8
MRCTE-4	74 ± 5
MRCTE-5	88 ± 7
MRCTE-6	82 ± 4
MRCTE-7	97 ± 12
MRCTE-8	95 ± 6
MRCTE-9	85 ± 5
MRCTE-10	70 ± 10
MRCTE-12	94 ± 5
MRCTE-13	82 ± 5
MRCTE-14	81 ± 6
MRCTE-15	62 ± 6
MRCTE-16	83 ± 4
MRCTE-17	76 ± 6
MRCTE-18	80 ± 3
MRCTE-19	69 ± 5
MRCTE-20	76 ± 7
MRCTE-21	71 ± 3
MRCTE-22	73 ± 8

(1) Average Corvallis area natural background using Mirion TLDs totals 77 ± 14 mrem for the same period.

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

Table V.12

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

Sample Location (See Fig. V.1)	Sample Type	Annual Average Concentration Of the Total Net Beta (Minus ^{3}H) Radioactivity(1)	LLD	Reporting Units
1-W	Water	no sample	no sample	μCi ml^{-1}
4-W	Water	no sample	no sample	μCi ml^{-1}
11-W	Water	$7.33x10^{-8}$(2)	$7.33x10^{-8}$	μCi ml^{-1}
19-RW	Water	no sample	no sample	μCi ml^{-1}
3-S	Soil	$2.03x10^{-5}$(2)	$2.03x10^{-5}$	μCi g^{-1} of dry soil
5-S	Soil	$1.45x10^{-5}$(2)	$1.45x10^{-5}$	μCi g^{-1} of dry soil
20-S	Soil	$2.08x10^{-5}$(2)	$2.08x10^{-5}$	μCi g^{-1} of dry soil
21-S	Soil	$1.36x10^{-5}$(2)	$1.36x10^{-5}$	μCi g^{-1} of dry soil
2-G	Grass	$1.73x10^{-4} \pm 3.45x10^{-5}$	$6.84x10^{-5}$	μCi g^{-1} of dry ash
6-G	Grass	$2.08x10^{-4} \pm 3.95x10^{-5}$	$6.84x10^{-5}$	μCi g^{-1} of dry ash
7-G	Grass	$3.58x10^{-5}$(2)	$3.58x10^{-5}$	μCi g^{-1} of dry ash
8-G	Grass	$2.41x10^{-4} \pm 2.16x10^{-5}$	$3.37x10^{-5}$	μCi g^{-1} of dry ash
9-G	Grass	$2.68x10^{-4} \pm 3.59x10^{-5}$	$6.46x10^{-5}$	μCi g^{-1} of dry ash
10-G	Grass	$3.22x10^{-4} \pm 2.76x10^{-5}$	$4.23x10^{-5}$	μCi g^{-1} of dry ash
12-G	Grass	$3.01x10^{-4} \pm 2.29x10^{-5}$	$3.32x10^{-5}$	μCi g^{-1} of dry ash
13-G	Grass	$2.93x10^{-4} \pm 2.29x10^{-5}$	$3.37x10^{-5}$	μCi g^{-1} of dry ash
14-G	Grass	$1.57x10^{-4} \pm 1.62x10^{-5}$	$2.67x10^{-5}$	μCi g^{-1} of dry ash
15-G	Grass	$1.46x10^{-4} \pm 2.61x10^{-5}$	$5.05x10^{-5}$	μCi g^{-1} of dry ash
16-G	Grass	$1.77x10^{-4} \pm 2.54x10^{-5}$	$4.65x10^{-5}$	μCi g^{-1} of dry ash
17-G	Grass	$1.73x10^{-4} \pm 2.79x10^{-5}$	$5.28x10^{-5}$	μCi g^{-1} of dry ash
18-G	Grass	$1.55x10^{-4} \pm 2.55x10^{-5}$	$4.84x10^{-5}$	μCi g^{-1} of dry ash
22-G	Grass	$1.71x10^{-4} \pm 2.18x10^{-5}$	$3.87x10^{-5}$	μCi g^{-1} of dry ash

(1) ± values represent the standard deviation of the value at the 95% confidence level.
(2) Less than lower limit of detection value shown.

Table V.13

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

		Number of Shipments				
Shipped To	Total Activity (TBq)	Exempt	Limited Quantity	Yellow II	Yellow III	Total
Arizona State University Tucson, AZ USA	1.07x10^{-6}	1	1	0	0	2
Berkeley Geochronology Center Berkeley, CA USA	6.18x10^{-7}	2	1	0	0	3
Columbia University Palisades, NY USA	1.68x10^{-6}	5	2	0	0	7
Lawrence Livermore National Lab Livermore, CA USA	4.57x10^{-8}	1	1	0	0	2
Materion Corporation Elmore, OH USA	3.85x10^{-2}	0	0	0	4	4
Materion Natural Resources Delta, UT USA	1.08x10^{-1}	0	0	0	21	21
Montana State University Bozeman, MT USA	2.61x10^{-8}	1	0	0	0	1
New Mexico Geochronology Research Lab Socorro, NM USA	6.07x10^{-6}	2	1	1	0	4
Occidental College Los Angeles, CA USA	9.25x10^{-9}	1	0	0	0	1
Oregon State University Corvallis, OR USA	4.52x10^{-7}	5	1	0	0	6
Rutgers Piscataway, NJ USA	4.10x10^{-6}	1	0	1	0	2
University of Arizona Tucson, AZ USA	1.77x10^{-6}	4	1	0	0	5
University of California at Santa Barbara Santa Barbara, CA USA	5.96x10^{-7}	0	1	0	0	1
University of Minnesota Minneapolis, MN USA	1.84x10^{-7}	1	0	0	0	1
University of Nevada, Las Vegas Las Vegas, NV USA	4.15x10^{-6}	0	1	2	0	3
University of Vermont Burlington, VT USA	3.82x10^{-9}	1	0	0	0	1
University of Wisconsin-Madison Madison, WI USA	9.12x10^{-6}	1	3	1	0	5
US Army 102CST Salem, OR USA	1.30x10^{-4}	0	0	1	0	1
USGS CA Menlo Park, CA USA	5.95x10^{-8}	1	0	0	0	1
USGS CO Denver, CO USA	1.97x10^{-7}	0	1	0	0	1
Totals	1.46x10^{-1}	27	14	6	25	72

Table V.14

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

Shipped To	Total Activity (TBq)	Number of Shipments				
		Exempt	Limited Quantity	White I	Yellow II	Total
Argonne National Lab Argonne, IL USA	9.08×10^{-9}	1	0	0	0	1
Lawrence Liveremore National Lab Liveremore, CA USA	1.56×10^{-8}	5	0	0	0	5
Los Alamos National Lab Los Alamos, NM USA	1.43×10^{-6}	2	5	0	0	7
Totals	1.46×10^{-6}	8	5	0	0	13

Table V.15

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

Shipped To	Total Activity (TBq)	Number of Shipments			
		Exempt	Limited Quantity	Yellow II	Total
Beijing Research Institute of Uranium Geology Beijing, CHINA	1.21×10^{-7}	0	1	0	1
China Earthquake Administration Beijing, CHINA	6.75×10^{-8}	2	0	0	2
Curtin University of Technology Bently Western Australia AUSTRALIA	3.99×10^{-6}	0	0	1	1
Dalhousie University Halifax, Nova Scotia CANADA	1.42×10^{-8}	1	0	0	1
Geological Survey of Japan Ibaraki, JAPAN	7.26×10^{-8}	1	0	0	1
Glasgow University Glasgow, SCOTLAND	4.72×10^{-9}	1	0	0	1
Hewbrew University of Jerusalem Jerusalem, ISRAEL	4.00×10^{-9}	1	0	0	1
Institute of Tibetan Plateau Research Beijing, CHINA	6.48×10^{-7}	1	0	0	1
ISTO Orleans, FRANCE	1.28×10^{-6}	2	2	0	4
Korean Baskic Science Institute Cheongju-si, Chungcheongbuk-do KOREA	9.51×10^{-8}	5	0	0	5
Lanzhou Center of Oil and Gas Resources Lanzhou, CHINA	3.76×10^{-8}	1	0	0	1

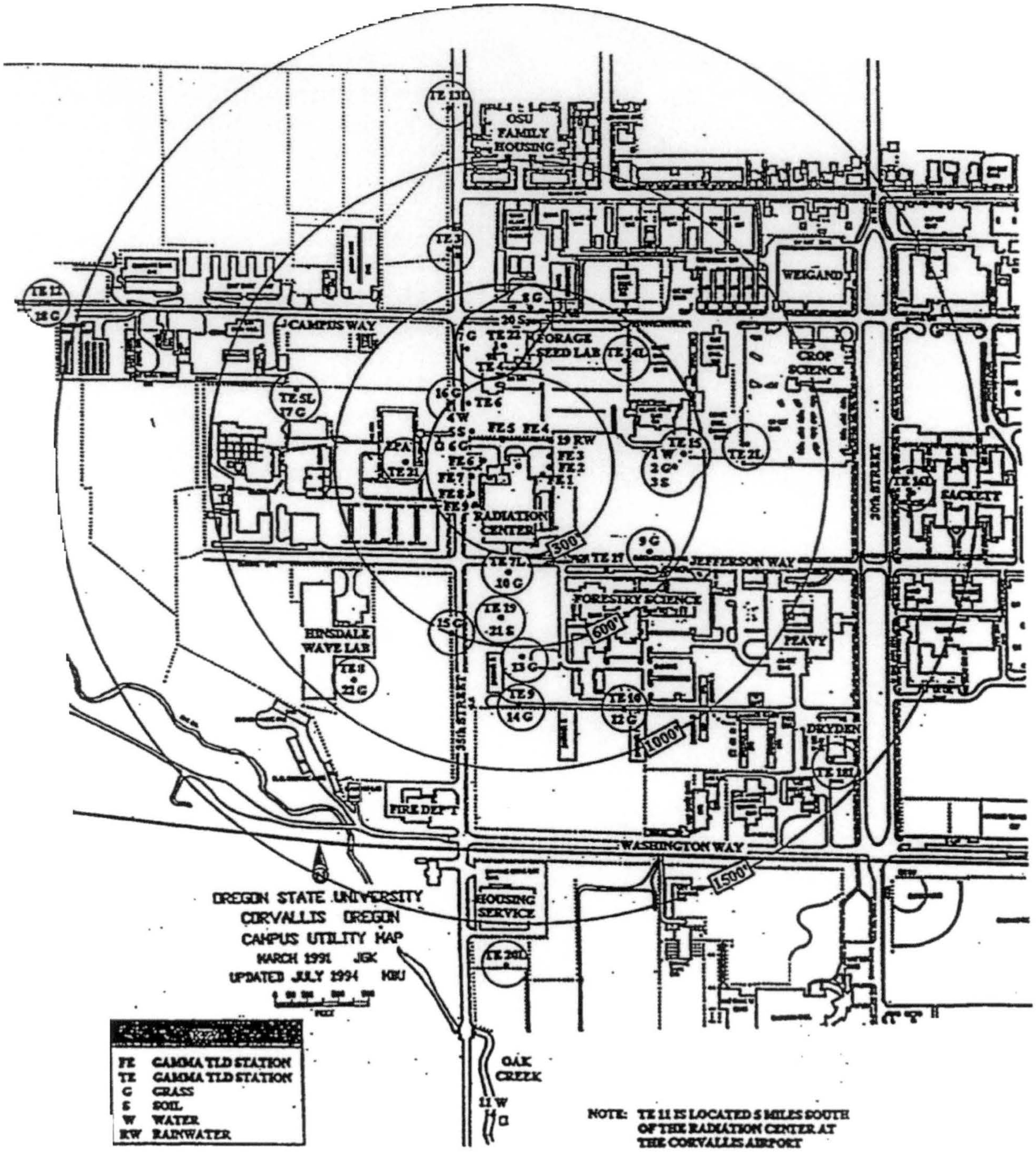
Table V.15 (continued)

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

		Number of Shipments			
Shipped To	Total Activity (TBq)	Exempt	Limited Quantity	Yellow II	Total
Lanzhou University Lanzhou, Gansu CHINA	1.80×10^{-7}	4	0	0	4
LSCE-CNRS Gif-Sur-Yvette, FRANCE	1.80×10^{-7}	4	0	0	4
Northwest University XiAn, CHINA	7.67×10^{-9}	1	0	0	1
Polish Academy of Sciences Krakow, POLAND	1.28×10^{-8}	2	0	0	2
QUAD-Lab, Natural Histoyr Museum of Denmark Copenhagen, DEMARK	1.07×10^{-7}	2	0	0	2
Scottish Universities Research & Reactor Centre East Kilbride, SCOTLAND	1.12×10^{-6}	4	1	0	5
Universidade de Sao Paulo San Paulo, BRAZIL	6.24×10^{-8}	1	0	0	1
Univeritat Potsdam Postdam, GERMANY	3.69×10^{-8}	2	0	0	2
University Grenoble Alps Grenoble, FRANCE	1.78×10^{-9}	1	0	0	1
University of Geneva Geneva, SWITZERLAND	4.64×10^{-6}	2	3	0	5
University of Innsbruck Innsbruck, AUSTRIA	3.50×10^{-8}	2	0	0	2
University of Manchester Manchester, UK	5.20×10^{-6}	0	2	0	2
University of Manitoba Winnipeg, CANADA	1.16×10^{-5}	0	4	0	4
University of Melbourne Parkville, Victoria AUSTRALIA	3.91×10^{-6}	1	2	1	4
University of Padova Padova, ITALY	7.83×10^{-9}	2	0	0	2
University of Zurich Zurich, SWITZERLAND	8.21×10^{-10}	1	0	0	1
Victoria University of Wellington Wellington, NEW ZEALAND	3.06×10^{-8}	1	0	0	1
Vrijc Universiteit Amsterdam, THE NETHERLANDS	2.88×10^{-6}	1	2	0	3
Wadia Institute of Himalayan Geology Dehradun, Uttarakhand INDIA	1.24×10^{-8}	1	0	0	1
Zhejiang University Hangzhou, CHINA	2.41×10^{-8}	1	0	0	1
Totals	3.64×10^{-5}	48	17	2	67

Figure V.1

Monitoring Stations for the OSU TRIGA Reactor



Work

Summary

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

Teaching

An important responsibility of the Radiation Center and the reactor is to support OSU's academic programs. Implementation of this support occurs through direct involvement of the Center's staff and facilities in the teaching programs of various departments and through participation in University research programs. Table III.2 plus the "Training and Instuction" section (see next page) provide detailed information on the use of the Radiation Center and reactor for instruction and training.

Research and Service

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

Table VI.1 provides a summary of institutions 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.

The major table in this section is Table VI.2. 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 the following text.

Neutron Activation Analysis

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

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

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

Irradiations

As described throughout this report, a major capability of the Radiation Center involves the irradiation of a large variety of substances with gamma rays and neutrons. Detailed data on these irradiations and their use are included in Part III as well as in the "Research & Service" text of this section.

Radiological Emergency Response Services

The Radiation Center has an emergency response team capable of responding to all types of radiological accidents. This team directly supports the City of Corvallis and Benton County emergency response organizations and medical facilities. The team can also provide assistance at the scene of any radiological incident anywhere in the state of Oregon on behalf of the Oregon Radiation Protection Services and the Oregon Department of Energy.

The Radiation Center maintains dedicated stocks of radiological emergency response equipment and instrumentation. These items are located at the Radiation Center and at the Good Samaritan Hospital in 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 actual incidents.

Training and Instruction

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

Special training programs generally fall into one of several categories: visiting faculty and research scientists; International Atomic Energy Agency fellows; special short-term courses; or individual reactor operator or health physics training programs. During this reporting period there were a large number of such people as shown in the People Section.

As has been the practice since 1985, Radiation Center personnel annually present a HAZMAT Response Team Radiological Course. This year the course was held at Oregon State University.

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 OSU Radiation Safety 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 Part VI), radioactive waste disposal, radioactive material hood flow surveys, and radiation safety analysis and audits.

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

Radiological Instrument Repair and Calibration

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

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

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

Table VI.3 is a summary of the instruments which were calibrated in support of the Radiation Center's instructional and research programs and the OSTR Emergency Plan, while Table VI.4 shows instruments calibrated for other OSU departments and non-OSU agencies.

Consultation

Radiation Center staff are available to provide consultation services in any of the areas discussed in this Annual Report, but in particular on the subjects of research reactor operations and use, radiation protection, neutron activation analysis, radiation shielding, radiological emergency response, and radiotracer methods.

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

Table VI.1

Institutions, Agencies and Groups Which Utilized the Radiation Center

Intuitions, Agencies and Groups	Number of Projects	Number of Times of Faculty Involvement	Number of Uses of Center Facilities
Akhezion Biomedical Hudson, NC USA	2	0	2
*Arizona State Univeristy Tempe, AZ USA	1	0	3
*Beijing Research Institute of Uranium Geology Beijing CHINA	1	0	1
*Berkeley Geochronology Center Berkeley, CA USA	1	0	3
Branch Engineering Springfield, OR USA	1	0	1
Colorado Gem and Mineral Company Tempe, AZ USA	1	0	3
*Columbia University Palisades, NY USA	1	0	8
*Dalhousie University Halifax, Novia Scotia CANADA	1	2	1
*Dept of Geological Sciences, University of Florida Gainesville, FL USA	1	0	1
*Department of Geosciences Tucson, AZ USA	1	0	1
Dept of Plant Science and Landscape Architecture College Park, MD USA	1	1	2
*Environmental and Molecular Toxicology Corvallis, OR USA	1	4	1
*ETH Zuirch Zurich, SWITZERLAND	1	1	1
*Fusion Energy Solutions Tempe, AZ USA	1	0	3

Table VI.1 (continued)
Institutions, Agencies and Groups Which Utilized the Radiation Center

Intuitions, Agencies and Groups	Number of Projects	Number of Times of Faculty Involvement	Number of Uses of Center Facilities
Genis, Inc. Reykjavik, ICELAND	1	0	2
*Geological Survey of Japan/AIST Tsukuba, Ibaraki, JAPAN	1	0	1
*Hi-Tech Precious Metals Refinery Dallas, TX USA	1	0	2
*Howe Industries Scottsdale, AZ USA	1	0	5
*Institute of Geology, China Earthquake Administration Beijing, CHINA	1	0	2
*Institute of Tibetan Plateau Research, Chinese Acad of Sci Beijing, CHINA	1	0	1
*INSU-CNRS - Universite d'Orleans Orleans, FRANCE	1	1	3
*Korea Basic Science Institute Cheongwon-gun, Chungcheongbuk-do SOUTH KOREA	1	1	4
*Lanzhou Center of Oil and Gas Resources, CAS Lanzhou, CHINA	1	1	3
*Lanzhou University Lanzhou City, Gansu Province CHINA	2	0	3
*Lanzhou University Lanzhou, CHINA	2	0	3
*Lawrence Livermore National Laboratory Livermore, CA USA	1	1	2
*LSCE-CNRS Gif-Sur-Yvette Cedex, FRANCE	1	0	5
*Materion Brush, Inc. Elmore, OH USA	1	0	5
* Materion Natural Resources Delta, UT USA	1	0	14
*Montana State Univeresity Bozeman, MT USA	1	0	1
New Mexico Institute of Mining & Technology Socorro, NM USA	1	0	5
*Northwest University Xi'An, CHINA	1	0	1
*Nray Services, Inc. Dundas, Ontario CANADA	1	1	5
*Occidental College Los Angeles, CA USA	1	1	1
*Oregon State University(1) Corvallis, OR USA	16	43	32(2)

Table VI.1 (continued)
Institutions, Agencies and Groups Which Utilized the Radiation Center

Intuitions, Agencies and Groups	Number of Projects	Number of Times of Faculty Involvement	Number of Uses of Center Facilities
*Oregon State University - Educational Tours Corvallis, OR USA	1	0	4
*Oregon State University MIME Corvallis, OR USA	1	3	1
*Oregon State University Radiation Center Corvallis, OR USA	1	1	14
OSU CBEE Corvallis, OR USA	1	1	1
Pacific Northwest National Laboratory Richland, WA USA	1	0	1
*Polish Academy of Sciences Krakow, POLAND	1	0	2
*Quaternary Dating Laboratory Roskilde, DENMARK	1	0	4
Rutgers Piscataway, NJ USA	1	0	2
*School of Nuclear Science and Engineering Corvallis, OR USA	1	2	1
*Scottish Universities Environmental Research Centre East Kilbride UK	1	0	6
Silcon Designs Inc. Kirkland, WA USA	1	0	6
* Solidia Technologies Piscatawsy, NJ USA	1	2	1
Terra Nova Nurseries, Inc. Camby, OR USa	1	0	3
* U.S. Geological Survey Denver, CO USA	2	0	3
*U.S. Geological Survey Menlo Park, CA USA	2	0	3
*Universita' Degli Studi di Padova Padova ITALIA	1	2	2
*Universitat Potsdam Potsdam, GERMANY	1	0	1
*Universite Grenoble Alpes Grenoble, Isere FRANCE	1	1	1
University of Alaska, Anchorage Anchorage, AK USA	1	1	11
*University of Arizona Tucson, AZ USA	2	3	4
University of California at Santa Barbara Santa Barbara, CA USA	1	1	1

Table VI.1 (continued)
Institutions, Agencies and Groups Which Utilized the Radiation Center

Intuitions, Agencies and Groups	Number of Projects	Number of Times of Faculty Involvement	Number of Uses of Center Facilities
*University of Geneva Geneva SWITZERLAND	1	1	6
*University of Innsbruck Innsbruck, AUSTRIA	1	1	2
*University of Manchester Manchester, UK	1	0	1
*University of Manitoba Winnipeg, Manitoba CANADA	1	1	6
*University of Melbourne Melbourne, Victoria AUSTRALIA	1	1	4
*University of Minnesota Minneapolis, MN USA	1	0	1
*University of Nevada, Las Vegas Las Vegas, NV USA	1	1	5
*University of Oregon Eugene, OR USA	1	0	6
University of Potsdam Potsdam, GERMANY	1	0	1
*University of Sao Paulo Sao Paulo BRAZIL	1	0	1
*University of Vermont Burlington, VT USA	1	1	1
*University of Wisconsin Madison, WI USA	1	1	5
US National Parks Service Crater Lake, OR USA	1	0	3
* Victoria Univeristy of Wellington Wellington, NEW ZEALAND	1	0	2
*Vrije Universiteit Amsterdam THE NETHERLANDS	1	1	2
*Wadia Institute of Himalayan Geology Dehradum, Uttarakhand INDIA	1	0	2
*Western Australian Argon Isotope Facility Perth, Western Australia AUSTRALIA	1	0	6
*Zhejiang University Hangzhou, CHINA	1	0	1
Totals	**95**	**82**	**258**

Table VI.2

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

Project	Users	Organization Name	Project Title	Description	Funding
444	Duncan	Oregon State University	Ar-40/Ar-39 Dating of Oceanographic Samples	Production of Ar-39 from K-39 to measure radiometric ages on basaltic rocks from ocean basins.	OSU Oceanography Department
815	Morrell	Oregon State University	Sterilization of Wood Samples	Sterilization of wood samples to 2.5 Mrads in Co-60 irradiator for fungal evaluations.	OSU Forest Products
920	Becker	Berkeley Geochronology Center	Ar-39/Ar-40 Age Dating	Production of Ar-39 from K-39 to determine ages in various anthropologic and geologic materials.	Berkeley Geochronology Center
1074	Wijbrans	Vrije Universiteit	Ar/Ar Dating of Rocks and Minerals	Ar/Ar dating of rocks and minerals.	Vrije Universiteit, Amsterdam
1191	Vasconcelos	University of Queensland	Ar-39/Ar-40 Age Dating	Production of Ar-39 from K-39 to determine ages in various anthropologic and geologic materials.	Earth Sciences, University of Queensland
1465	Singer	University of Wisconsin	Ar-40/Ar-39 Dating of Young Geologic Materials	Irradiation of geological materials such as volcanic rocks from sea floor, etc. for Ar-40/Ar-39 dating.	University of Wisconsin
1504	Teaching and Tours	Oregon State University - Educational Tours	OSU Nuclear Engineering & Radiation Health Physics Department	OSTR tour and reactor lab.	NA
1514	Sobel	Universitat Potsdam	Apatite Fission Track Analysis	Age determination of apatites by fission track analysis.	Universitat Potsdam
1523	Zattin	Universita' Degli Studi di Padova	Fission track analysis of Apatites	Fission track dating method on apatites by fission track analysis.	NA
1555	Fitzgerald	Syracuse University	Fission track thermochronology	Irradiation to induce U-235 fission for fission track thermal history dating, especially for hydrocarbon exploration. The main thrust is towards tectonics, in particular the uplift and formation of mountain ranges.	Syracuse University
1568	Zanetti	University of Nevada Las Vegas	Ar/Ar dating of rocks and minerals	Irradiation of rocks and minerals for Ar/Ar dating to determine eruption ages, emplacement histories, and provenances studies.	Univerity of Nevada Las Vegas
1617	Spikings	University of Geneva	Ar-Ar geochronology and Fission Track dating	Argon dating of Chilean granites.	University of Geneva
1623	Blythe	Occidental College	Fission Track Analysis	Fission track Thermochronology of geological samples	Occidental College
1660	Reactor Operations Staff	Oregon State University	Operations support of the reactor and facilities testing	Operations use of the reactor in support of reactor and facilities testing.	NA
1745	Girdner	US National Parks Service	C14 Measurements	LSC analysis of samples for C14 measurements.	US National Parks Service

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
1767	Korlipara	Terra Nova Nurseries, Inc.	Genera Modifications using gamma irradiation	Use of gamma and fast neutron irradiations for genetic studies in genera.	Terra Nova Nurseries, Inc.
1768	Bringman	Brush-Wellman	Antimony Source Production	Production of Sb-124 sources.	Brush-Wellman
1777	Storey	Quaternary Dating Laboratory	Quaternary Dating	Production of Ar-39 from K-39 to determine radiometric ages of geological materials.	Quaternary Dating Laboratory
1778	Gislason	Genis, Inc	Gamma exposure of Chitosan polymer	This project subjects chitosan polymer in 40 and 70% DDA formulations to 9 and 18 Kgy, boundary doses for commerical sterilization for the purpose of determine changes in the molecular weight and product formulation properites.	Genis, Inc.
1785	Minc	Oregon State Univesity	INAA of Maya ceramics	Trace-element analysis of ancient Maya ceramics from Pultrouser Swamp, Belize.	
1818	Sabey	Brush Wellman	Antimony source production (Utah)		Brush-Wellman
1831	Thomson	University of Arizona	Fission Track	Fission track thermochronometry of the Patagonian Andes and the Northern Apennines, Italy.	Yale University
1855	Anczkiewicz	Polish Academy of Sciences	Fission Track Services	Verification of AFT data for illite-mechte data.	Polish Academy of Sciences
1860	Minc	Oregon State University	INAA of Archaeological Ceramics	Trace-element analysis of archaeological ceramics.	N/A
1864	Gans	University of California at Santa Barbara	Ar-40/Ar-39 Sample Dating	Production of Ar-39 from K-40 to determine radiometric ages of geologic samples.	University of California at Santa Barbara
1865	Carrapa	University of Wyoming	Fission Track Irradiations	Apatite fission track to reveal the exhumation history of rocks from the ID-WY-UY postion of the Sevier fold and thrust belt, Nepal, and Argentina.	University of Wyoming
1878	Roden-Tice	Plattsburgh State University	Fission-track research	Use of fission tracks to detrmine location of 235U, 232Th in natural rocks and minerals.	Plattsburgh State University
1882	Bray	Wayne State Univerity	INAA of Archaeological Ceramics from South America	Trace-element analysis of Inca-period ceramics for provenance determination.	Wayne State University
1884	Contreras	Oregon State University	Mutation breeding of woody plants	The current project is designed to identify the LD50 rate of gamma irradiation so that large seed lots may be irradiated in order to develop novel phenotypes that exhibit reduced fertility or sterility.	OSU Horticulture
1886	Coutand	Dalhousie University	Fission Track Irradiation	Fission track irradiations of apatite samples.	Dahousie University
1887	Farsoni	Oregon State University	Xenon Gas Production	Production of xenon gas.	OSU NERHP

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
1889	Paulenova	Oregon State University	Hydrolysis and Radiolysis of synergistic extractants	The goal of this project is to determine the effects of hydrolysis and radiolysis on the extraction ability of a diamide and chlorinated cobalt dicarbollide (CCD). CCD and the diamide are synergistic extractants and will be together in solution for hydrolysis and radiolysis experiments. Effects will be measured with IR spectroscopy and extraction distribution ratios.	Oregon State Univeristy NSE
1898	Fayon	University of Minnesota	Fission Track Services	Use of fission tracks to determine location of 235U, 232Th in natural rocks and minerals.	
1905	Fellin	ETH Zurich	Fission Track Analysis	Use of fission tracks to determine location of 235U, 232Th in natural rocks and minerals.	Geologisches Institut, ETH Zurich
1913	Reese	Oregon State University	Fission Yield Determination Using Gamma Spectroscopy	Use of neutron activation to determine fission yields for various fissile and fertile materials using gamma spectroscopy.	N/A
1914	Barfod	Scottish Universities Environmental Research Centre	Ar/Ar Age Dating	Ar/Ar age dating.	Scottish Universities Research and Reactor Centre
1927	Seward	Victoria University of Wellington	Fission Track Dating	Fission track dating of apatite samples.	Vitoria University of Wellington
1939	Wang	Lanzhou University	Lanzhou University Fission Track	Fission Track dating.	Lanzhou University
1955	Higley	Oregon State University	Uptake of redionuclides in plants	Deremine concentration ratios in plants.	OSU NERHP
1957	Phillips	University of Melbourne	Radiometric age dating of geologic samples	Ar/Ar age dating.	University of Melbourne
1965	Webb	University of Vermont	Ar/Ar age dating	Irradiation with fast neutrons to produce Ar-39 from K-39 for Ar/Ar geochronology.	University of Vermont
1975	McDonald	University of Glasgow	Samuel Jaanne	Use of fissin tracks to determine last heating event of apatites.	School of Geographical and Earth Science
1979	Paulenova	Oregon State University	Mixed Matrix Extraction Testing	Multi-element, transition metal salt production for mixed matrix extraction testing.	
1980	Carpenter	Radiation Protection Services	Sample counting	Sample counting.	State of Oregon RPS
1995	Camacho	University of Manitoba	Ar/Ar dating	Production of Ar-39 from K-39 to determine radiometric ages of geological materials.	University of Manitoba
2001	Derrick	Branch Engineering	Densitometer Leak Test	Wipe counts for leak test of densitometer sources.	Branch Engineering
2004	Sudo	University of Postdam	Ar/Ar Geochronological Studies	Ar/Ar dating of natural rocks and minerals for geological studies.	
2007	Wartho	Arizona State University	Argon-Argon Geochronology	Fast neutron irradiation of mineral and rock samples for 40 Ar/39Ar dating purposes.	Arizona State University

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2010	Helena Hollanda	University of Sao Paulo	Ar/Ar Geological Dating	Ar/Ar geologic dating of materials.	University of Sao Paulo
2017	Jourdan	Wester Australian Argon Isotope Facility	Age dating of geological material	Ar/Af geochronology.	Curtin University
2023	Cassata	Lawrence Livermore National Laboratory	Ar/Ar dating	Production of neutron induced 39Ar from 39K for Ar/Ar dating.	Lawrence Livermore National Laboratory
2028	Minc	Oregon State University	INAA of ceramics from the Ancient Near East	Provenance determination of ceramics from the Ancient Near East via trace-element analysis.	OSU Anthropology
2029	Kim	Korea Basic Science Institute	Ar/Ar geochronology	Ar/Ar analysis for age dating of geological samples.	Korea Basic Science Institute
2033	Chang	China University of Petroleum - Beijing	Fission Track	Fission track dating of rock samples.	China University of Petroleum - Beijing
2034	Morrell	Oregon State University	Sterilization of Wood Products	Sterilization of wood to 2.0 Mrad for fungal experiments.	OSU Forest Products
2035	Wang	Lanzhou Center of Oil and Gas Resources, CAS	Fission Track	Fission track dating of rock samples.	Lanzhou Center of Oil and Gas Resources, CAS
2036	Loveland	Oregon State University	Measurement of fission product TKE	Measurement of fission product kinetic energy for various fissile elements.	
2039	Gombart	Oregon State University	Prevention of Infections Associated with Combat-related Injuries by Local Sustained Co-Delivery	Prevention of Infections Associated with Combat-related Injuries by Local Sustained Co-Delivery of Vitamin D3 and Other Immune-Boosting Compounds Award Mechanism. We are preparing nanofiber wound dressings that contain compounds that will be released over time to induce the immune response in wounds to help prevent infection and speed wound healing. The nanofibers must be irradiated so that they are sterile. These experiments will be performed in cell culture and in animal models.	
2048	Christensen	Oregon State University	INAA of IV Fluids	INAA to determine trace metals in TPN and additives.	OSU College of Pharmacy
2060	Ishizuka	Geological Survey of Japan/AIST	Ar/Ar Geochronology	Ar/Ar geochronology of volcanic and igneous rocks associated with subduction initiation of oceanic island arc.	Geological Survey of Japan
2061	Weiss	Oregon State University	Neutron Radiography Imaging of Concrete	Investigation into the applicablity of neutron radiography for evaluating concrete curing processes.	
2062	Reese	Oregon State University	Temporal Spectroscopy of Fissile Mateerials	Use of PGNAA facility to perform temporal spectroscopy for the purpose of determining fissile material content.	OSU Radiation Center, DNDO Grant

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2064	Schaefer	CDM Smith	Abiotic Dechlorination of chlorinated solvents in soil matrices.	We will be performing bench scale microcosm studies to measure the abiotic dechlorination in different soil matrices. Gamma irradiation will be used to sterilize the samples.	CDM Smith
2067	Reese	Oregon State University	Neutron Radiography of Long-Term Concrete Curing	Use of neutron radiography and omography imaging in long-term studies of concrete curing used in civil construction.	Oregon State University CCE
2069	Scaillet	INSU-CNRS-Universite d'Orleans	Ar/Ar dating of geologic samples	Ar/Ar analysis for age dating of geologic samples (solid rock chips and minerals)	INSU-CNRS-Universite d'Orleans
2070	Lowell	Colorado Gem and Mineral Co.	Gamma irradiation induced change of color in Tourmaline from a Pegmatite in the Oban Massif, Nigeria	The purpose of this experiment is to determine what color a nearly colorless Tourmaline will turn with dosages of 5, 10 and 20 Mr of Gamma irradiation. Two Pakistan Beryl crystals are also part of this experiment to see the color change as well as 2 pieces of Four Peaks Amethyst that may have been faded by sunlight. For the Tourmaline, color possibilities are brown, yellow, and pink to red. The commercial value of colorless gem Tourmaline is very low, but other colors of gem Tourmaline, especially pink and red results, would stimulate mining of this material in Nigeria. 20 Mr is usually a dosage that will saturate the visible color, and lower dosages may be preferable if the Gamma rays cause a new color other than pink or red which is the desirable result.	Colorado Gema and Mineral Co.
2074	Minc	Oregon State University	Market Exchange in Ancient Oaxaca, Mexico	I NAA of archaeological ceramics from the Valley of Oaxaca, Mexico, to trace the origins of market exchange.	NSF
2083	Nadel	Charlotte Pipe and Foundry Co.	ABS Antimony Testing	Testing for trace antimony in ABS via INAA according to ASTM E3063.	Charlotte Pipe & Foundry Co.
2084	Nadel	Charlotte Pipe and Foundry Co.	ABS Antimony Testing	Testing for trace antimony in ABS via INAA according to ASTM E3063.	Charlotte Pipe & Foundry Co.
2085	He	Lanzhou University	Apatite Fission Track	Use of fission track analysis to determine U content in the sedimentation of Xining Basin.	Lanzhou University
2092	Jianaiqng	Northwest University	Fission Track Dating of Qaidam Basin	Fission track dating of Qaidam Basin, China to determine its age.	

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2097	Boyt	Boyt Veterinary Lab	Donor Bovine Serum Irradiation	Project is designed to irradiate liquid donor bovine serum contained in vinyl bags to a minimum level of 25 kGy to inactivate any adventitious agents that may be present in 0.2 um sterile filtered product.	Boyt Veterinary Lab
2098	Pang	Institute of Geology, China Earthquake Administration	Fission-Track dating	Studying the thermal history of the northeast Tibet Plateau by the fission-track dating method.	China Earthquake Administration
2099	Wesel	Nakhla Dog Meteroites	Gamma Spectroscopy of Hiroshima Watch	Use of gamma spectroscopy to verify authenticity of watch claimed to have been exposed to the Hiroshima bombing.	
2100	Palmer	School of Nuclear Science and Engineering	Soft Robotic Applications for Nuclear Safeguards	This project is a collaboration with OSU Robotics. We are investigating the performance of PDMS materials, which are used to fabricate soft robotics, following radiation exposure. We would like to characterize any changes in hardness, tensile strength, and recovery after exposure to high radiation environments.	Idaho National Laboratory
2101	Yang	Zhejiang University	Fission-track thermochronometry	Fission-track analysis for dating geological material.	Zhejiang University
2102	Shulzhenko	College of Veterinary Medicine	Gut microbiota mediates the interplay between immunity and glucose metabolism	To identify microbial taxa and their genes that affect glucose metabolism and immune response using mouse model of diet-induced diabetes.	OSU Veterinary Medicine
2103	Higgins	Colorado School of Mines	SERDP ER-2720	The project is SERDP ER-2720, Key Fate and Transport Processes Impacting the Mass Discharge, Attenuation, and Treatment of Poly- and Perfluoroalkyl Substances and Comingled Chlorinated Solvents or Aromatic Hydrocarbons. The overall goal of this research is to attain improved insight into the fundamental fate and transport processes that control per- and polyfluoroalkyl substance (PFAS) fate and transport as well as comingled chlorinated solvents and/or fuel hydrocarbons in groundwater at aqueous film forming foam (AFFF)-impacted sites. This research will particularly focus on the release and transformation of polyfluorinated PFASs to the more problematic perfluoroalkyl acids (PFAAs) in source zones.	Colorado School of Mines

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2104	Oest	Department of Orthopedic Surgery	Shape-memory polymers for accelerated repair of complex bone defects	The goal of this project is to explore the use of shape-memory polymer constructs to deliver and retain bioactive agents within complex bone fractures and defect sites. Bioabsorbable shape-memory polymer constructs will be doped with antimicrobial and osteogenic agents, then triggered by a local temperature change to conform to the bone defect site, effectively containing the bioactive agents within the area to be repaired.	SUNY Upstate Medical University
2107	Palmer	School of Nuclear Science and Engineering	Soft Robotic Applications ofr Nuclear Safegaurds	This project is a collaboration with OSU Robotics. We are investigating the performance of PDMS materials, which are used to fabricate soft robotics, following radiation exposure. We would like to characterize any changes in hardness, tensile strength, and recovery after exposure to high radiation environments.	Idaho National Laboratory
2111	Turrin	Rutgers	Ar/Ar Geochronology	Lunar/solar system chronology.	NASA
2112	Carpenter	University of Michigan	INAA of Formative Zapotec Ceramics	INAA to determine provenance of pottery from the Valley of Oaxaca.	
2115	Scao	LSCE-CNRS	Age dating of geologic materials	Ar/Ar analysis for age dating of Geologic materials.	LSCE-CNRS
2116	Nyman	Department of Chemistry	Determine if the oligomerization of uranyl peroxide can be driven by radiation	We would like to determine if the oligomerization of uranyl peroxide can be driven by radiation, in solution. We will prepare solutions of lithium uranyl triperoxide monomers and apply different radiation doses (time of radiation) until change is observed by visual inspection and spectroscopic characterization. We estimate 3 samples, irradiated for one day, and TBD for the other two samples. Irradiation of all will start simultaneously.	Department of Chemistry
2118	Reese	Oregon State University	NRF Beam Purity	Use of beam quality indicators to categorize the NRF beam.	

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2120	Li	Institute of Tibetan Plateau Research, Chinese Academy of Sciences	Alpha-particle induced annealing effects of fission tracks in apatite	Using the in situ TEM ion irradiation facility at Argonne National Laboratory, we already observed He ions (simulating alpha-particles) induced annealing effects on 80 MeV ion tracks (simulating fission tracks) in apatite. For the next step, we are planning to use chemical etching to further confirm the alpha-annealing effects on real fission tracks. Neutron-induced fission tracks are essential to the etching experiments because neutron-induced fission tracks, have no thermal history (or thermal annealing effects).	Chinese Academy of Sciences
2121	Jia	Beijing Research Institue of Uranium Geology	Fission track analysis to determine U content in South China	Fision track dating of areas of South China.	Beijing Research Institue of Uranium Geology
2122	Jia	Beijing Research Institue of Uranium Geology	Ar-Ar analysis for age dating of geologic materials.	Ar-Ar analysis for age dating of geologic materials (solid rock grains and minerals).	
2123	Dick	Sch of Environ & Natural Res	Effect of soil type on bioavailability of aminomethylphosphonic acid to microorganisms	This research will test the effect of three different soil textures and mineralogy on the bioavailability of aminomethylphosphonic acid to soil microorganisms. Different concentrations of AMPA will be applied to soil, and chemical extractions and microbial properties will be measured at different time intervals. Chemical extractions from sterilized and unsterilized soil samples will be compared at each time interval to determine the chemical vs. biological degradation effects.	Sch of Environ & Natural Res
2126	Hunde	Barenburg	Cool Season Grasses Mutatuion Breeding Project	The main objective of the project is to induce random mutations in elite diploid cool season grass varieties. It is anticipated that some of these random mutations could have economic value and could be commercialized. The species used in the project will be Annual Ryegrass, Perennial Ryegrass, Italian Ryegrass and Meadow Fescue.	Barenbrug USA
2130	Perez Rodriguez	University at Albany, SUNY	Geochemical analysis of clays and ceramics from Oaxaca	INAA to determine chemical composition of natural clays and ceramics from the Mixteca Alta, Oaxaca, Mexico.	
2132	Popp	InertialWave Inc.	Hardened Electronics Testing	Developing radiation hardened electronics integrated with inertial sensors (i.e. gyroscopes and accelerometers) in support of NASA interplanetary space missions.	InertialWave Inc.

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2133	Briggs	University of Alaska, Anchorage	The Effects of Rotenone on Freshwater Microbes	We are studying the effects of northern climate on the attenuation time of Rotenone as well as the effects Rotenone has on freshwater microbes. Our project plans to determine if there is biotic degradation occurring with Rotenone.	University of Alaska
2134	Twaddell	envirosure Solutions, LLC	Isotopic Determination of Material	Determine isotope and activity of materials from received samples.	
2135	Pomella	University of Innsbruck	Apatite Fission Track	Apatite fission track, standards for zeta calibration.	University of Innsbruck
2136	Higley	Oregon State University	INAA of Mining Site Soils	Soil analysis by INAA for Uranium/Thorium concentration assessment.	
2137	Kelley	New Mexico Bureau of Geology	Basin and Range NSF	Fission-track analysis of apatite from mountain ranges in southwestern New Mexico.	New Mexico Tech
2138	Hames	Auburn University	40Ar/39Ar dating of mineral samples from orogenic belts and mineral deposits	This project will result in new geological age determinations by the 40Ar/39Ar method for potassium-bearing silicate minerals (including hornblende, muscovite, biotite and orthoclase), along with basalt whole rock samples, in the Auburn Noble Isotope Mass Analysis Laboratory (ANIMAL). This project is for scientific investigation of Earth's history, and has applications to mining industries.	Auburn University
2139	Grove	Stanford University	Ar/Ar Thermochronology (IRR 16X)	Ar/Ar Thermochronology of Hawaiian lava samples.	Stanford University
2140	Weiss	Oregon State University	Us of neutron radiography to examine hydrogen content in steal alloys	Neutron radiography will be used to examine coupons of stainless steal alloys that have be exposed to a hydrogen environment on one surface. The content and depth profile of the hydrogen will be determined.	
2141	Akey	Oregon State University	NRF Imaging of Battery	Neutron radiography imaging of NiCd battery to obtain data on its construction.	
2142	Heizler	New Mexico Institue of Mining & Technology	Irradiation of samples for 40Ar/39Ar geochronology for NM Tech	Fast neutron irradiation of geological samples to primarily transmute 39K to 39Ar for the purposes of rock and mineral dating. Samples are for academic geological investigations requiring knowledge of age and/or thermal history.	NM Bureau of Geology
2143	Noller	Oregon State University	INAA of Roman Ceramics	Elemental composition of ceramics from Rome via INAA.	OSU Crop and Soil Science

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2144	Hemming	Columbia University	Ar Geochronology for the Earth Sciences (AGES)	We analyze a variety of geological samples for their 40Ar/39Ar ages, including samples for external collaborators and for internal grant-supported research.	Columbia Univeristy
2145	Morgan	U.S. Geological Survey	40 Ar/39Ar Geochronology	Neutron irradiation requested for 40Ar/39Ar geochronology. Will use 39K (n,p) 39Ar reaction to determine ages on rocks and minerals.	USGS Argon Geochronology
2146	Calvert	U.S. Geological Survey	40 Ar/39Ar Geochronology	Menlo Park Geochronology uses 40Ar/39Ar techniques to date materials for geologic hazards, mapping, tectonic and mineral resource projects. The method requires fast-neutron irradiation of separates from volcanic, plutonic, sedimentary and metamorphic rocks to convert 39K to 39Ar.	Menlo Park Geochronology
2147	Veselovskiy	Shmidt Institute of Physics of the Earth	Thermal history of Siberian platform	The main aim of this project is the complex study of the Siberian Traps Large Igneous Province (LIP), the typical example of LIPs. Investigation of such provinces is of both fundamental scientific and applied importance, due to needs for understanding of reasons of the intraplate magmatic activity, revealing the possible influence of the intense volcanism to the biotic hazards, and explanation of the origin of the unique Pt-Cu-Ni deposits related to the Siberian Traps.	Shmidt Institute of Physics of the Earth
2148	Reese	Oregon State University	PGNAA of Neonatal fluid Crystal	Using PGNAA to determine low Z elements found in crystaline material from filtered neonatal fluid.	
2149	Vanderstelt	Nray Services, Inc.	Titanium Trubine Blade Activation	Examination of neutron activation in titanium turbine blades from neutron radiography.	Nray Services, Inc.
2150	McAleer	U.S. Geological Survey	U.S. Geological Survey-Reston Ar/Ar Geochronology Laboratory	Irradiation of potassium-bearing minerals that will be dated by the Ar/Ar method at the USGS Reston Argon Geochronology Laboratory. The samples are from diverse localities and of diverse age.	U.S. Geological Society
2151	Williams	Oregon State University	"Benzo[a]pyrene Toxicokinetics: Impact of Indoles from Diet or Microbial Tryptophan Metabolism"	To identify the role of dietary and microbrial-derived indoles in mice.	Oregon State University EMT
2152	Burke	Lawrence Livermore National Laboratory	Fission Product Yield Measurement	Measurement of fission product yeild of fissile and fertile materials through fission reactions with gamma spectroscopy.	Lawrence Livermore National Laboratory
2153	Quinn	Solidia Technologies	Neutron Radiography to Image Carbon Dioxide in Concrete	Using neutron radiography to look at pressurized CO2 in concrete that is curing.	Solidia Technologies
2154	Field	Environmental and Molecular Toxicology	Insights into the Long-Term Mass Discharge & Transformation of AFFF in the Unsaturated Zone	Sub-task: Assessing the biotransformation of per and polyfluoroalkyl substances.	Oregon State University EMT

Table VI.2 (continued)

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

Project	Users	Organization Name	Project Title	Description	Funding
2155	Turner	Selmet, Inc.	Sludge Radioisotope Identification	Identification of any and/or quantification of any radioisotopes in sludge material.	Selmet, Inc.
2157	Fawcett	University of Manchester	MN2019a	Neutron irradiation of geologic material for noble gas analysis and dating.	University of Manchester
2158	Balkanska	Sofia University	Thermochronological reconstruction of the tectonic evolution of the Balkanides	Reconstruction of the cooling histories of the surface rocks that comprise the Balkanides mountains in Bulgaria by modeling the observed FT and other thermochronologic data. Placement constraints on mountain building and tectonic processes of the Balkanides region.	Sofia University
2160	Schaen	Department of Geosciences	University of Arizona 40Ar/39Ar geochronology	Irradiation rock & mineral samples for 40Ar/39Ar dating.	University of Arizona
2161	Turina	Museo Egizio	NAA of Clays	NAA of clays to determine radioactivity level for future neutron radiography work. This will determine/estimate how long the samples will need to be held prior to free release.	
2162	Jump	Oregon State University	Role of microbiota in the effects of polyunsaturated fatty acids (PUFA) on liver	To address the role of microbiota in fatty liver disease and in beneficial effect of PUFA on liver.	Oregon State University
2163	Sathuvalli	Dept of Horticulture	Gamma irradiation of potatoes	The main idea is to introduce gamma rays to tissue cultures of 3 potato varieties in a bid to induce mutations to the plants. There are certain qualities / characteristics we hope will be mutated and so, upon inducement with gamma radiation, we will evaluate the plants (if they survive the mutation) for those qualities. The first stage is to ascertain the optimum radiation dosage for the 3 varieties under evaluation. A second stage will come up where the potatoes will be evaluated based on information from the first i.e. the optimum radiation dosage.	Oregon State University Horticulture
2164	Goddard	Rowan University	ATR Irradiation	Irradiation of apatite grains mounted in epoxy for fission track analysis at Rowan University.	Rowan University
2165	Caffrey	NASA Marshall Space Flight Center	Nuclear Propulsion Polymer Tests	A set of 5 polymers (EPDM, PTFE, PCTFE, PFA, PAI) used in common spaceflight applications are to be exposed to the mixed neutron/gamma field of the OSTR in order to evaluate changes in material properties. The current test includes a total of 60 'microdogbone' ASTM D638 Type V tensile specimens.	NASA
2166	Kampfer	Materion Corp.	Trace-element analysis of Be powder.	INAA to determine U content of Be powder.	Materion Corp.

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2167	Reese	Oregon State University	Neutron Radiography of Artifacts	Use of neutron radiography to examine archaeological artifacts.	
2168	Radniecki	Oregon State University CBEE	The Effects of Biofilms in clm testing of sorbents for removal of Cu, Zn and PFAS's from Storwater	We are trying to isolate the effects that biofilm growth and fouling has on sorption kinetics, breakthrough, and desorption in packed columns of two different proprietary adsorbents. By looking at the data for triplicate columns with and without biofilms enriched from the OGSIR facility in Avery park, we hope to isolate the effects that naturally occuring biofilms have on sorption removal of PFASs, zinc and copper in stormwater.	Oregon State University CBEE
2170	Howe	Howe Industries	Thermoelectric Cooler Conductivity Experiment	Testing electrical conductivity changes of materials while monitoring temperatures of device and ambient conditions. Power will be stepped at various levels to determine these parameter changes.	Howe Industries
2171	Tiwari	Department of Plant Science and Landscape Architecture	Gamma induced chromosomal breaks in CS and MOV wheats	We would like to get these seeds irradiated for inducing gamma irradiation-induced chromosomal breaks in CS and MOV-wheats.It will allow us to map targeted candidate genes in low recombination regions and will help in overall wheat improvement.	University of Maryland College Park
2172	Graziano	University of Alaska Anchorage	Control of invasive plants at high latitudes with persistent herbicides	The project is looking at positive and negative consequences of using persistent herbicides for invasive species management at high latitudes. The irradiated soils will be used to develop soil herbicide isotherms for aminopyralid and clopyralid. The soils originate from two field sites (Fairbanks and Palmer) where these herbicides were applied. We will determine if the isotherms help predict the persistence of these herbicides at the field sites.	University of Alaska
2173	Lee	University of Oregon	INAA of Ancient Korean Ceramics	Trace-element analyses of Neolithic and Bronze Age ceramics from Korea.	University of Oregon

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2174	Horvath	Fusion Energy Solutions	Fast neutron detection	The scope of this project is to run tests and calibrate our fast neutron detector through the D(T,n)alpha reactions and calibration by F18 decay from O16+T reactions to be measured on an OSU HPGe detector.	Fusion Energy Solutions, Inc.
2175	Gess	Oregon State University MIME	Neutron Radiography of two Phase Flow	Use of neutron radiography to evaluate two phase flow conditions during TREAT irradiations.	
2176	Phelps	Adhezion Biomedical	Various Ampoule Gamma-Feasibility Run	Adhezion Biomedical is interested in the effect of Gamma on various applicator parts and materials. The purpose of this feasibility run is to provide ampoules from three different product lines to understand the process and ensure your facility can stay within the range of 8-12 kGy. Once we get the samples returned, if all testing on our end result as expected, we will most likely send a second round of samples for further investigation of material compatibility with Gamma-irradiation.	Adhezion Biomedical
2177	Phelps	Adhezion Biomedical	PVDF Ampoule Gamma-Feasibility Run	Adhezion Biomedical is interested in the effect of Gamma on PVDF ampoules and the stability of the product post-irradiation. Analytical testing shall follow on our end after Gamma-irradiation to determine if this is a good sterilization method to move into a larger scale sterilization for our medical device product line.	Adhezion Biomedical
2178	Weiss	Oregon State University	BASF Additive Concrete Curing Investigation	Examination of a BASF addative to concrete mixutures and it's effect upon curing under pressure.	
2179	Weiss	Oregon State University	BASF Additive Concrete Curing Investigation	Examination of a BASF addative to concrete mixutures and it's effect upon curing under pressure.	
2180	Meqbel	Hi-Tech Precious Metal Refinery	INAA of Mine Tailings	INAA to determine precious metal (gold and PGE) content of mine tailings.	
2181	Singh	Wadia Institute of Himalayan Geology	Geo-Thermochronological investigation of Lesser Himalayan Crystialline of Garhwal region,NW-Himalaya	To study the shallow crust exhumation history of the lesser Himalayan crystalline and Meta-sedimentary sequence of Garhwal region.	Wadia Institute of Himalayan Geology

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2182	Reese	Oregon State University	Use of D2O as a contrast enhancement for neutron radiography	Examination of the improvement in contrast gained by using D2O instead of H2O in the analysis of concrete curing.	
2183	Sprain	Department of Geological Sciences, University of Florida	Irradiation for 40Ar/39Ar geochronology	This project is for the irradiation of geological materials with a high flux of fast neutrons to facilitate the 39K(n,p)39Ar reaction. Irradiated geological materials will subsequently be analyzed for 40Ar/39Ar geochronological analysis to determine the age of the geological materials.	Department of Geological Sciences, University of Florida
2184	Bernet	Univeresite Grenoble Alpes	Apatite Fission Track irradiations	The apatite samples are for three different projects for studying the exhumation of the Himalayas, Andes, and European Alps.	Université Grenoble Alpes
2185	Taylor	Univeresity of Minnesota	Pioneer Mountains AFT	Suite of apatite crystals to be irradiated for fission track dating.	University of Minnesota
2186	Cao	Oregon State University	Fluorine Content in PFAS standards	INAA to determine fluorine content in PFAS standards.	Department of Chemistry
2187	Stevens Goddard	Indiana University	Fission Track Analysis	Irradiation of geologic materials (minerals apatite and zircon) for fission track analysis (age dating of thermal events) using the external detector method.	Indiana University
2188	Orme	Montana State University	AFT Irradiation - MSU	Irradiation of apatite grains mounted in epoxy for fission track analysis at Montana State University.	Montana State University
2189	Kasparek	Pacific Northwest National Laboratory	Cerenkov In-Pool Noise Characterization	This project will develop and build a custom UV probe and spectrophotometer to map the UV spectrum in spent fuel ponds and identify and quantify light noise contributions within the pool.	
2190	Loveland	Oregon State University	Seperation characterization of mid and high Z elements.	Seperation characterization of mid and high Z elements.	

Table VI.2 (continued)
Listing of Major Research and Service Projects Preformed or in Progress at the Radiation Center and Their Funding Agencies

Project	Users	Organization Name	Project Title	Description	Funding
2191	Hulbert	Silcon Designs Inc.	Sensor Performance vs Total Ionizing Dose (TID)	The sensor is an industrial grade accelerometer which consists of a silicon sensor and ASIC hermitically sealed in a 0.35" square ceramic package. This project will irradiate several groups of sensors over a range of TID and compare the before and after results of a variety of electrical and dynamic measurements to determine the effect(s) of the radiation.	
2192	Frame	Yale University	INAA of archaeological and geological materials.	Trace-element analysis via INAA of fired clay, brick, and stone.	
2194	Gruendell	Pacific Northwest National Laboratory	Lexan slides for fission track irradiation	Support the 69981 Program (Child Project XYZ – 70039) at Pacific Northwest National Laboratory by providing the ability to perform fission track irradiation on Lexan slide targets in the thermal column facility.	Pacific Northwest National Laboratory

Figure VI.1

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

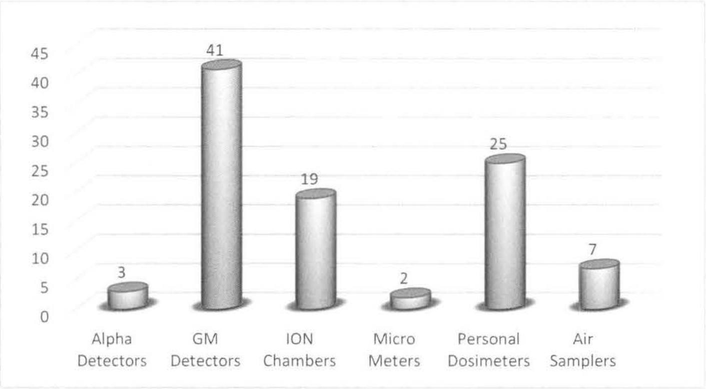


Table VI.3

Summary of Radiological Instrumentation Calibrated to Support OSU Departments

OSUDepartment	Number of Calibrations
Biochem/Biophysics	1
Microbioloby	1
Nutrition & Exercise Science	1
Radiation Safety Office	28
Vet Med	2
Total	**33**

Table VI.4

Summary of Radiological Instrumentation Calibrated to Support Other Agencies

Agency	Number of Calibrations
Columbia Memorial Hospital	2
Columbia Steel Casting	3
Doug Evans, DVM	2
EPA	1
Epic Imaging	2
Fire Marshall/Hazmat	39
Grand Ronde Hospital	5
Health Division	121
Hillsboro Medical Center	6
Hollingsworth & Vose	1
Lake Health District	5
NETL, Albany	4
ODOT	5
Oregon Health and Sciences University	56
Oregon Lottery	1
PSU	14
River Bend Sand & Gravel	2
Salem Hospital	12
Samaritan Health	40
Total	**321**

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Students

Biasi, Joe. PhD, California Institute of Technology. “Paleomagnetism and Geochemistry of Basalts in the North American Cordillera, Davis Strait, and Antarctica.”

Bruck, Ben. PhD, University of Wisconsin-Madison. (Advisor Brad Singer).

Buehlman-Barbeau, Savanna. MA, Applied Anthropology, Oregon State University. (Advisor Leah Minc).

Davidson, Peter. PhD, Oregon State University. “Timescales and Tectonics of Oceanic Plateaus: Insights from Ontong Java Nui and the Rio Grande Rise.”

Genge, Marie Catherine. PhD, University of Padova. “Structural evolution of the Central Patagonia: a source-to-sink approach.” (Advisor Massimiliano Zattin).

Grund, Marc. PhD, Freie Universität Berlin. “The Dinaric-Hellenic junction marked by the Shkoder-Peja Normal Fault in northern Albania and Kosovo.” (Supervisor Mark Handy).

Klotz, Thomas. PhD, University of Innsbruck. “Thermotectonic evolution of the Dolomites indenter.” (Supervisor Hannah Pommella).

Klug, Jake. PhD, University of Wisconsin-Madison. (Advisor Brad Singer).

Lemot, Francois. MS student, University Grenoble Alpes. “Origin and Dating of Karst deposits linked to the Neogene Evolution of Alpine Massifs.” (Advisors Pierre Valla and Peter Van Der Beek).

Li, Youjuan. Post-Doc, University of Wisconsin-Madison. (Brad Singer).

Middtun, Nikolas. Masters student, University of Michigan; visiting student to the University of Arizona Fission Track Laboratory. (Advisor Nathan Niemi).

Moreno Yaeger, Pablo. PhD, University of Wisconsin-Madison. (Advisor Brad Singer).

MS student, ETH Zurich. "Provenance of the Habkern Granite and of the Wilfdflysch (central Switzerland) based on an integrated geo-thermochronologic approach." (Advisors M.G. Fellin and V. Picotti).

Ojo, Oyewande. Masters student, Oklahoma State University; visiting student to the University of Arizona Fission Track Laboratory. (Advisor Daniel Lao Davila).

Rodman, Kelly. MS, Oregon State University. "The Effects of Naturally Occurring Biofilms in Rapid Small Scale Column Testing of Sorbents for the Removal of Copper, Zinc, Nutrients, and Dissolved Organic Carbon from Real Stormwater."

Roger, Mario. PhD student, University Grenoble Alpes. (Advisor Arjan de Leeuw).

Sepp, Mike. PhD, Oregon State University. "What lies beneath? Geochemical and spectral footprints of quartz-alunite-hosted epithermal Au deposits: Insights from Yerington, Nevada and Summitville, Colorado."

Swenton, Vanessa. PhD, Portland State University. "Filling Critical Gaps in the Space-Time Record of High Lava Plains and co-Columbia River Basalt Rhyolite Volcanism."

Wall, Kellie. PhD, Oregon State University. "Evolution and Petrogensis of the Pliocene to Pleistocene Goat Rocks Volcanic Complex.

Wang, Yu. PhD, China University of Geosciences, Wuhan. "Cenozoic uplift and exhumation of SW Fujian linked to preservation of ore deposits, South China Block: Implications from zircon and apatite fission-track thermochronological record." (Co-advisor Massimiliano Zattin).

Warby, Lester. PhD student, Oregon State University, Nuclear Science and Engineering. "High Pressure Bubble Visualization using Neutronic PTV" (working title).

Yang, Chaoqun. PhD, China University of Geosciences, Wuhan. "Provenances of Cenozoic sediments in the Jianghan Basin and implications for the formation of the Three Gorges." (Co-advisor Massimiliano Zattin).

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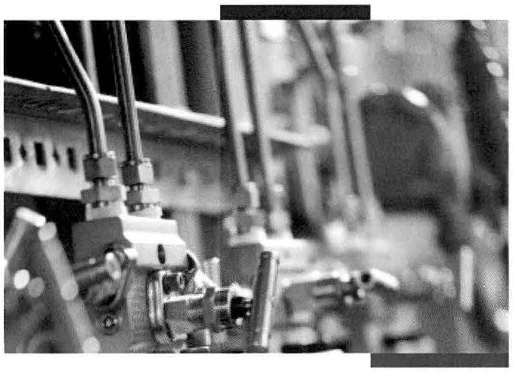

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