WASHINGTON STATE UNIVERSITY
Nuclear Radiation Center

August 24, 2012

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

Re: Docket No. 50-27; Facility License R-76

In accordance with Technical Specifications for Facility License R-76 the attached Annual Report prepared by C. Corey Hines, Reactor Supervisor of the WSU Facility, is hereby submitted. The report covers the operating period July 1, 2011 through June 30, 2012.

Respectfully Submitted,

Donald Wall

Donald Wall, Ph.D.
Director

Enclosure

cc: C.C. Hines

P.O. Box641300, Pullman, WA 99164-1300
509-335-8641 • Fax: 509-335-4433 • www.wsu.edu/nrc

ADZD
NRR

ANNUAL REPORT

WASHINGTON STATE UNIVERSITY

NUCLEAR RADIATION CENTER

TRIGA REACTOR

Facility License R-76 for the Reporting Period of July 1, 2011 to June 30, 2012

Nuclear Radiation Center
Washington State University
Pullman, WA 99164-1300

TABLE OF CONTENTS

ANNUAL REPORT ON THE OPERATION OF THE WASHINGTON STATE UNIVERSITY NUCLEAR RADIATION CENTER TRIGA REACTOR

Facility License R-76 for the Reporting Period of
July 1, 2011 to June 30, 2012

1. Narrative Summary of the Year's Operation

A. Operating Experience

Core 35A has accumulated 3,614 MWH from beginning of life (BOL) through June 30, 2012. A total of 831 samples were irradiated, for a total of 9,320 user-hours. In addition, 23 pulses greater than $1.00 of reactivity addition were performed during this reporting period. The quarterly operations summaries are shown in Table I located in Section 2.

B. Changes In Facility Design, Performance Characteristics, and Operating Procedures Related to Reactor Safety.

No changes were performed during the reporting period.

C. Results of Surveillance Tests and Requirements

All surveillance tests and requirements were performed and completed within the prescribed time period.

2. Energy and Cumulative Output

The quarterly operations summaries are given in Table I. The cumulative energy output since criticality of the TRIGA core (1967) is 1380.5 Megawatt Days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated a total of 150.6 MWD.

Table I
Fiscal Year 2012 Summary of Reactor Operation

	Q3 2011	Q4 2011	Q1 2012	Q2 2012	TOTALS
Hours of Operation	305	238	397	335	1,275
Megawatt Hours	262	213	348	312	1,135
No of Sample Irradiations[1]	25	33	50	36	144
No. of Samples	114	147	370	90	721
No. of Iridium Cans Irradiated	35	19	29	27	110
User Hours[2]	2,741	1,515	2,847	2,217	9,320
No. of Pulses > $1.00	9	7	1	6	23

[1] Number of samples and sample irradiations do not include iridium data.
[2] User hours denotes the total user hours, including iridium.

3. Emergency Shutdowns and Inadvertent Scrams

There were no emergency shutdowns that occurred during the reporting period. The dates and causes of the 17 inadvertent scrams are listed in Table II. No scrams were due to exceeding the Limiting Safety Systems Setting.

Table II
Inadvertent SCRAMS

Date	SCRAM
8/25/2011	Low Pulse Air alarm tripped while at power. Pulse rod was Air SCRAMed and reactor rundown. System was inspected. No cause determined. System will be monitored in the future. Restart okay.
9/1/2011	Trainee inadvertently switched mode switch into test when attempting to rundown. Restart okay.
9/15/2011	Linear channel scaled down for unknown reasons causing a "High Power" SCRAM. Restart okay.
9/15/2011	Reactor was manually SCRAMed due to a visitor fainting during a tour. Restart okay.
10/27/2011	Log N High Voltage loss SCRAM. Restart okay. Fan installed to keep channel cool.
11/7/2011	Log N High Voltage failure, unknown cause. Restart okay.
2/3/2012	Log N High Voltage failure SCRAM. Restart okay.
2/22/2012	Power flicker due to weather. Restart okay.
3/9/2012	Log N High Voltage failure SCRAM. Restart okay.
3/20/2012	Log N High Voltage failure SCRAM. Restart okay.
3/21/2012	Log N High Voltage failure SCRAM. Restart okay.
3/23/2012	Log N High Voltage failure SCRAM. Restart okay.
4/16/2012	A DC power switch was hit causing a "high radiation" SCRAM. Restart okay.
4/17/2012	Trainee turned mode switch into test when attempting to rundown. Restart okay.
5/10/2012	Log N High Voltage failure SCRAM unknown cause.
6/25/2012	Short period alarm received while the reactor was supercritical with no blade movement. RO decided to manually SCRAM. Okay to start up.
6/29/2012	Abating system wiring and caused a SCRAM. Restart okay.

4. Major Maintenance

All routine planned maintenance items were completed within the reporting period. The below listed items were performed, although they are not part of routine preventative maintenance.

8/8/2011: Ventilation System: Fan 2 Tripped
During a reactor checkout, fan 2 (beam room fan) was found to be inoperable. The cause was found to be a tripped breaker in the penthouse mechanical room. The breaker was reset, the fan is working normally.

8/8/2011: ARIES System: Repair
The "C" battery in the ARIES system will no longer hold a charge. It was replaced with an equivalent deep cycle marine battery.

10/6/2011: Co-60 Source: Recalibration Report
The cobalt-60 gamma irradiator was recalibrated following the installation of security enhancements. The new dose rate at 4 inches from the bottom of the irradiation basket is 445 rads/min.

11/29/2011: EGM Pump Control Failure
The 24 VAC relay in the control box in the EGM cave suffered a failure resulting in a blown fuse in the console bin containing the EGM pump controls. The entire bin containing the EGM pump, CAM pump, and pulse air pressure controls was without power until the fuse was replaced. The EGM pump was still not functional until the relay was replaced with an equivalent model. The system is now functioning normally.

1/25/2012: Pulse Rod Air Pressure Malfunction
The pulse rod air pressure meter in the console was indicating high pulse rod air pressure (~120 psi) during checkouts when first fired. The building air pressure gauge in the pool room was indicating normal pressures (~75 psi) at these times. It was determined that it was an issue with the pressure transducer. A new pressure transducer, air pressure meter, and pressure snubber were purchased. The new meter and transducer were wired into the console and operated correctly. A new wiring schematic of the pulse rod air pressure meter was drawn up to replace the older version. Written out instructions for the setup and wiring of the meter and transducer were also created.

6/18/2012: Co-60 Source: Recalibration Report
The colbalt-60 gamma irradiator was recalibrated following the replacement of the crank system and a solid platform was added to the irradiation basket for more stable sample loading. The new dose rate at 4 inches from the bottom of the irradiation basket is 454 rads/min.

5. Changes, Tests, and Experiments Performed Under 10 CFR 50.59 Criteria

No changes under 10 CFR 50.59 were performed during the reporting period.

6. Radioactive Effluent Discharges

A. Radioactive Liquid Releases

The liquid effluent releases for the facility during the reporting period can be found in Table III.

Table III
Monthly Liquid Waste Releases

Month	Volume (gallons)
July 2011	0
August	0
September	0
October	4,862
November	0
December	0
January 2012	0
February	0
March	0
April	0
May	0
June	0

Approximately 4862 gallons of liquid waste was released; however, after analysis with gamma spectroscopy, no radioactivity above the limit of detection was found.

B. Radioactive Gaseous Release

During the reporting period, no measurable quantity of gaseous or particulate material with a half-life greater that eight days was released. At no time did the argon-41 release exceed 20% of the effluent release limit. A total of 0.496 curies of argon-41 was released, with an average argon-41 concentration of 7.39×10^{-9} µCi/mL of air, before dilution. The release of 0.496 curies of argon-41 as stated in the 2012 Annual Report for Air Operating Permit 06-602, per COMPLY v1.6, the facility is in compliance at level 4 with an effective dose equivalent of 4.4×10^{-4} mrem/yr. The monthly releases are summarized in Table IV.

Table IV
Monthly Argon-41 Releases

Month	Conc. Before Dilution, μCi/mL[1]	% of Release Limit Before Dilution	% of DAC Limit Before Dilution[2]	Quantity μCi[3]
July 2011	4.42×10^{-9}	0.18	5.9×10^{-4}	2.51×10^{4}
August	5.90×10^{-9}	0.24	7.9×10^{-4}	3.36×10^{4}
September	7.04×10^{-9}	0.28	9.4×10^{-4}	3.88×10^{4}
October	6.11×10^{-9}	0.24	8.1×10^{-4}	3.47×10^{4}
November	6.27×10^{-9}	0.25	8.4×10^{-4}	3.45×10^{4}
December	3.29×10^{-9}	0.13	4.4×10^{-4}	1.87×10^{4}
January 2012	5.32×10^{-9}	0.26	7.1×10^{-4}	3.03×10^{4}
February	6.62×10^{-9}	0.26	8.8×10^{-4}	3.52×10^{4}
March	7.57×10^{-9}	0.30	1.01×10^{-3}	4.31×10^{4}
April	8.66×10^{-9}	0.35	1.15×10^{-3}	4.77×10^{4}
May	1.78×10^{-8}	0.71	2.37×10^{-3}	1.01×10^{5}
June	9.70×10^{-9}	0.39	1.29×10^{-3}	5.34×10^{4}

[1] Based on 10 CFR 20 effluent release limit of 1.0×10^{-8} uCi/mL for Ar-41 (Table 2, Col.1), and a dilution factor of 4.0×10^{-3} (S.A.R. 6.4.2) giving a before dilution limit of 2.5×10^{-6} uCi/mL. (20% of this limit is 5.0×10^{-7} uCi/mL).

[2] Based on 10 CFR 20 DAC limit of 3.0×10^{-6} uCi/mL for Ar-41 (Table 1, Col. 3) and a dilution factor of 4.0×10^{-3} giving a before dilution DAC limit of 7.5×10^{-4} uCi/mL.

[3] Based on 4500 CFM effluent of ventilation system in AUTO mode of operation.

C. Radioactive Solid Waste Disposal

During the reporting period, 4.56 mCi in 35.32 cubic feet of non-compacted solid waste was transferred to the WSU Radiation Safety Office for packaging and disposal.

7. Personnel and Visitor Radiation Doses

The quarterly doses of the WSU Nuclear Radiation Center reactor staff and experimenters who routinely utilize the WSU Reactor are given in Table V. The maximum quarterly dose of a reactor staff member was 30 mrem, whole body.

A total of 1227 individual persons visited the Nuclear Radiation Center during the reporting period, of which 565 entered a controlled access area (CAA).[1] All doses as determined by digital pocket dosimeter were less than or equal to 0.3 mrem. A total of 61 group tours, consisting of 493 individuals, visited the center during the reporting period. As determined by digital pocket dosimeter, all doses were less than or equal to 0.1 mrem.

[1] A non-controlled access area is an area in the building where radioactive materials are used or stored but which is not a part of the licensed reactor facility.

Table V
Quarterly Reactor and Experimenter Staff Dose (in mrem)[1,2]

Badge No.	Q3 2011	Q4 2011	Q1 2012	Q2 2012
10012	M	M	30	M
07528	M	M	2	M
08025	M	M	4	2
07463	8	3	11	3
08141	M	8	1	2
07588	8	5	18	4
07805	M	--	--	--
08152	6	6	4	3
07748	M	2	M	17
10042	M	M	6	5
10224	7	--	--	--
10232	2	2	1	2
10225	8	--	--	--
10231	2	5	4	3
10296	--	M	1	2
10301	--	2	3	6
10400	--	--	--	1
10283	--	11	M	2

[1] The "--" denotes data not available either due to departure from the facility or new personnel starting at the facility.
[2] An 'M' denotes that the dosimeter reading was less than or equal to the background radiation level for that quarter.

8. Reactor Facility Radiation and Contamination Levels

The method detection limit (MDL) for building survey samples collected for removable contamination determination by liquid scintillation assay is 6×10^{-8} $\mu Ci/cm^2$. Routine building surveys showed average removable contamination levels less than the MDL for most CAAs and all non-CAAs. The only removable contamination level above the MDL was located on Room 201 Experimenter Platform (CAA, 8.80×10^{-8} $\mu Ci/cm^2$); which falls well under contamination thresholds for a CAA. Other areas in the facility where contamination is more likely, the sample drop tube in Room 201, Laboratory 120, and the radiochemistry hoods for example, all showed averaged removable contamination levels below that of the MDL.

The routine area radiation surveys of the building in CAAs and non-CAAs are given in Table VI. The highest average dose rate level in a CAA was 4.57 mrem/hr, which occurred in Room 2 in the Thermal Column. This value is well below the limit for CAAs. The lowest average dose rate in a CAA was 0.05 mrem/hr, which occurred in Rooms 201 A and B, on the benches in Room 201, and in the Heat Exchanger Room 201C. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 1.72 mrem/hr. The highest onsite dose rate was 55 mrem/hr, which occurred in the Room 101 Sample Drop Hood; however, the survey was performed while there were

experiments located in the Sample Drop Hood and therefore is not indicative of typical readings in this area as the samples do not remain in the Sample Drop Hood for extended periods of time.

Table VI
Average Radiation Dose Rates (in mrem/hr) for
Weekly Monitoring in CAAs and Non-CAAs[1,2]

Location	Average dose rate (mrem/hr)
Room 201B	0.05
Room 201A	0.05
Room 201 Bridge	1.47
Room 201 Benches	0.05
Room 201 South	0.23
Room 201 East	1.79
Room 201C Heat Exchanger	0.05
Room 201 Floor North	1.70
Room 106 Ion Exchanger Pit	2.72
Room 101A Purification Pit	1.48
Sample Storage	**1.01**
Rom 101 Door Way	**0.04**
Room 101 Shipment Bench	**0.09**
Room 101 Sample Drop Hood	**2.56**
Room 101 Hood 1	**0.88**
Room 116	**0.04**
Room 120	**0.04**
Room B21 Panoramic Irradiator	**0.04**
Room 2 South	0.10
Room 2 Thermal Column	4.57
Room 2 North	0.37
Room 2 West Cave	0.60
Room 2 East Cave	1.34

[1] Bolded text indicates a non-CAA.
[2] Regular text indicates a CAA.

9. Environmental Monitoring Program

The environmental monitoring program uses thermoluminescent dosimeters (TLD's) placed at locations both on-site and off-site. The environmental monitoring program is used to determine the average background radiation levels through the use of off-site TLD locations. The off-site TLD locations are defined by Technical Specifications 1.0 and 5.1.1, and are TLDs 3, 7, 9, 15 through 35, and 39 through 44. Since these TLD's are used in calculating the background they are not compared to the

background and therefore do not have to meet the less than 20 % above background requirement. This average background radiation level is then compared to the nearest occupied dwelling to ensure it does not, on an annual basis, exceed the average off-site background radiation by more than 20 %. On-site TLD's are also compared to the average background radiation level to determine if they are more than 20 % above background levels or not. Table VII shows the quarterly dose rates for those TLD's located at off-site locations.

Table VII
Environmental Radiation Levels at Off-Site Locations to the Nuclear Radiation Center[1]
(Dose rate in mrem/day)

Location	Q3 2011	Q4 2011	Q1 2012	Q2 2012	Average
Fence E of NRC	0.327	0.333	0.373	0.366	0.350
Fence, N of Rad Waste Shed	0.357	0.385	0.398	0.613	0.438
Fence directly N Rad Waste Shed	0.408	0.417	0.422	0.570	0.454
S NRC, on parking lot fence	0.327	0.344	0.410	0.398	0.369
Fence S Roundtop Dr, 10th pole W of pole C14	0.418	0.375	0.458	0.419	0.418
Telephone pole C12	0.429	0.375	0.446	--[2]	0.417
Telephone pole near golf course gate	0.357	0.344	0.386	0.624	0.428
E across fairway on pine tree	0.304	0.391	0.398	0.473	0.391
Maple tree #54 along driving range	0.314	0.370	0.373	0.376	0.358
NW to fence uphill from driving range	0.392	0.435	0.422	0.441	0.422
Follow fence E to fence corner	0.363	0.424	0.410	0.430	0.407
S to lone spruce tree near water hazard	0.333	0.348	0.373	0.473	0.382
Roundtop hill park, NW fence corner	0.314	0.370	0.361	0.634	0.420
Deciduous tree edge of 18th green	0.333	0.413	0.386	0.355	0.372
6ft pine tree, 3rd W down cartpath from clubhouse	0.402	0.424	0.434	0.430	0.422
3rd to last tree after gap in same line of trees	0.324	0.359	0.361	0.505	0.387
SW to fence along path near 2nd to last tee box at bottom hill	0.363	0.435	0.398	1.269	0.616
Follow fence partway up hill after fence turns S	0.353	0.402	0.386	0.505	0.412
Follow fence, 15th pole E after fence turns W	0.363	0.413	0.361	0.419	0.389
Follow fence about halfway between last TLD and corner	0.392	0.413	0.422	0.462	0.422
Largest bush S of NRC	0.373	0.402	0.398	0.441	0.403
2nd fence S NRC, W end at gate	0.343	0.402	0.361	0.495	0.400
S Fairway Rd, 1st lightpost on right	0.388	0.423	0.463	0.538	0.453
S Fairway Rd, 2nd lightpost on right	0.439	0.330	0.415	0.387	0.393
Ellis Way and Hog Lane sign	0.347	0.330	0.390	0.473	0.385
Bottom of radio antenna hill, fence next to shrub left of gate	0.337	0.371	0.390	0.441	0.385
3rd fence S of NRC, SE corner, cow pasture	0.378	0.567	0.171	0.409	0.381
Airport fence W end runway at gate	0.347	0.330	0.415	0.419	0.378
Fence/entry bar E Jewett Observatory	0.378	0.340	0.427	0.462	0.402
Granite rock Terrall Mall, hole in back	0.949	--[2]	0.915	1.011	0.958

[1] Off-site defined by the Technical Specification 1.0 and 5.1.1.
[2] "--" indicates a TLD which was unavailable for sampling

From Table VII, the background radiation levels and what 20 % above background radiation levels would be were determined and can be seen in Table VIII.

Table VIII
Background Environmental Radiation Levels (Dose rate in mrem/day)

	Q3 2011	Q4 2011	Q1 2012	Q2 2012	Average
Background Radiation Levels	0.382	0.388	0.411	0.512	0.427
20 % Above Background Radiation Levels	0.458	0.466	0.493	0.614	0.513

Table IX shows the quarterly exposures for those TLD's located at on-site locations.

Table IX
Environmental Radiation Levels at On-Site Locations to the Nuclear Radiation Center[1]
(Dose rate in mrem/day)

Location	Q3 2011	Q4 2011	Q1 2012	Q2 2012	Average
E lower loading dock	0.327	0.375	0.398	0.398	0.374
Pool room truck door fence S end	0.378	0.458	0.482	0.505	0.456
Pool room truck door fence N end	0.337	0.417	0.422	0.495	0.417
E wall rad waste shed	0.327	0.344	0.361	0.581	0.403
N wall rad waste shed	0.367	0.375	0.422	0.624	0.447
Cooling tower fence, NE corner	0.337	0.385	0.410	0.452	0.396
Room 101 window	0.388	0.365	0.470	0.559	0.445
Railing next to upper liquid waste tank	0.347	0.396	0.434	0.462	0.410
Room 2 truck door fence	0.367	0.365	0.386	0.409	0.382
Transformer vault vent louvers	0.378	0.406	0.410	0.538	0.433
NRC main entrance, light fixture	0.388	0.454	0.476	0.505	0.456
NRC roof, pool room vent stack	0.286	0.330	0.390	0.387	0.348
NRC roof, guide wire E end of building	0.337	0.340	0.415	0.398	0.372
NRC roof, E pool room vent support leg	0.582	0.619	0.829	0.914	0.736
NRC roof, air conditioning support leg	0.316	0.340	0.768	0.796	0.555
NRC roof, W pool room vent support leg	0.643	0.691	0.415	0.366	0.528

[1] On-site defined by the Technical Specification 1.0 and 5.1.1

Any TLD's on-site found to exceed the 20 % above background radiation level require an explanation on the quarterly report and review by a Senior Reactor Operator. None of the on-site radiation levels found to exceed the 20 % above background radiation level are located in unrestricted access areas and are therefore not accessible to the general public.

The dose rate for the closest off-site point of extended occupancy can be found in Table X.

Table X
Environmental Radiation Levels for the closet off-site point of extended occupancy
(Dose rate in mrem/day)

Location	Q3 2011	Q4 2011	Q1 2012	Q2 2012	Average
Apt complex C, gas meter	0.378	0.381	0.415	0.419	0.398
Apt complex B, gas meter	0.296	0.309	0.390	0.387	0.346
1st fence S apt complex A	0.327	0.320	0.415	0.591	0.413

Technical Specifications describing ALARA effluent releases in 3.5.2(3) specify annual radiation exposure due to reactor operation, at the closest off-site extended occupancy, shall not, on an annual basis, exceed the average off-site background radiation by more than 20 %. For the reporting period, the average background radiation dose rate for off-site locations was 0.427 mrem/day, while the average radiation dose rate at the closest extended occupancy area 600 meters away was 0.386 mrem/day. This result indicates that no exposure level above normal background radiation was found.