WASHINGTON STATE UNIVERSITY | Nuclear Science Center

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

The Annual Report for the WSU facility, License R-76, Docket 50-27, prepared by C. Corey Hines, Associate Director and Reactor Supervisor of the WSU Facility, is hereby submitted. The report covers the operating period July 1, 2017 through June 30, 2018.

Respectfully Submitted,

Donald Wall

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Director

Enclosure

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2018

ANNUAL OPERATIONS REPORT

WASHINGTON STATE UNIVERSITY TRIGA REACTOR

FACILITY LICENSE R-76 FOR THE REPORTING PERIOD JULY 1, 2017 TO JUNE 30, 2018

NUCLEAR SCIENCE CENTER | Washington State University, Pullman, WA

TABLE OF CONTENTS

1. Narrative Summary of Operation for Fiscal Year 2018

A. Operating Experience

Core 35A has accumulated 9,486 MWH from beginning of life (BOL) through June 30, 2018. During the reporting period of July 1, 2017 to June 30, 2018, a total of 1,186 samples were irradiated, for 12,386 user-hours. Additionally, 18 pulses greater than $1.00 of reactivity addition were performed during the reporting period. The quarterly operations summaries are shown in Table I.

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

No changes in design, performance characteristics, or operating procedures have occurred 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 the 1967 TRIGA fuel core was put in to service is 1,673 megawatt days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated 443 MWD.

Table I
Fiscal Year 2017 Summary of Reactor Operation[1]

	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Totals
Hours of Operation	354	364	380	328	1,426
Megawatt Hours	305	307	300	238	1,149
No. of Sample Irradiations	109	65	51	75	300
No. of Samples	382	227	202	375	1,186
No. of Commercial Irradiations	36	31	34	34	135
User Hours	3,149	3,070	3,481	2,685	12,386
No. of Pulses > $1.00	7	8	4	1	18

3. Emergency Shutdowns and Inadvertent Scrams

There were no emergency shutdowns or unplanned shutdown periods that occurred during the reporting period. The dates and causes of the eight inadvertent scrams are listed in Table II. No scrams were due to exceeding the limiting safety system setting or safety limit.

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

Table II
Inadvertent Scrams

Date	Description of Scram
8/14/2017	Indicated Pulse High Power Scram during a pulse due to an electronic malfunction on the NPP-1000. Malfunction determined, on 3/14/2018, to be a bad solder point.
10/31/2017	WSU Facility Operations was inspecting the building compressed air supply and turned an air compressor off. They did not turn it back on which resulted in a low pulse air pressure alarm while operating at 1 MW. The reactor was manually air scrammed for this reason. WSU Facility Operations returned to the facility and turned the air compressor back on. Pressure was restored to the building compressed air system and the pulse rod system.
11/21/2017	Trainee switched to pulse mode during steady state operation at 1.0 MW.
12/6/2017	Indicated Pulse High Power Scram during a pulse due to an electronic malfunction on the NPP-1000. Malfunction was determined, on 3/14/2018, to be a bad solder point.
3/14/2018	Indicated Pulse High Power Scram during a pulse due to an electronic malfunction on the NPP-1000. Malfunction determined, on 3/14/2018, to be a bad solder point.
3/14/2018	Indicated Pulse High Power Scram during a pulse due to an electronic malfunction on the NPP-1000. Malfunction determined, on 3/14/2018, to be a bad solder point.
3/14/2018	Indicated Pulse High Power Scram during a pulse due to an electronic malfunction on the NPP-1000. Malfunction determined, on 3/14/2018, to be a bad solder point.
5/11/2018	The cause of a C.I.C. High Voltage Scram could not be determined. C.I.C. high voltage output was checked and verified to be 650 V as specified. The high voltage failure was most likely due to overheating. High voltage will continue to be monitored.

4. Major Maintenance

Although they are not part of routine preventative maintenance, the below listed items were performed.

7/18/2017: *Selector Switch: Pulse Mode*
During a checkout it was found that switching the mode selector switch caused a continuous clicking sound from a relay in the console. The relay was the 5K8 relay, which controls the pulse rod firing system. The contacts on the relay were cleaned which resolved the problem.

3/14/2018: *NPP-1000: Pulse Power Channel*
High power scram on the NPP-1000 when firing a pulse. The NPP-1000 was verified to be operating correctly, however a wire for the mode switch for pulse mode was loose. The wire was re-soldered and the issue was corrected.

3/15/2018: *ARMs*
The readouts for the area radiation monitors were difficult to see when operating the reactor. After a 50.59 screening it was determined a 50.59 change was not required

to relocate the ARM readouts. The ARM readouts were relocated to an instrument panel above the console.

6/18/2018: *Hold Up Tanks*
During a pre-startup check out the RO determined that the holdup waste tanks system was not energized. The RO checked the indicator lights on the console to confirm the lights were working. The control system in Room 2 was checked and it was found that there was a fuse that had failed. The fuse was replaced and power was restored to the hold up tanks.

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

There were no changes to the facility made under 10 CFR50.59 criteria during the 2017-2018 reporting year.

6. Radioactive Effluent Discharges

A. Radioactive Liquid Effluent Releases

The liquid effluent releases for the facility during the reporting period are provided in Table III.

Table III
Monthly Liquid Effluent Releases

Month	Volume (gallons)
July 2017	0
August	0
September	0
October	0
November	0
December	0
January 2018	0
February	0
March	0
April	0
May	0
June	0

No liquid effluents were released from the storage tank during the reporting period.

B. Radioactive Gaseous Effluent Release

During the reporting period, no emission of a measurable quantity of gaseous or particulate material with a half-life greater than eight days was

detected. The argon-41 release did not exceed 20% of the effluent release limit. A total of 2.9 Ci of argon-41 was released, with an average argon-41 concentration of 1.47×10^{-10} µCi/mL of air, after environmental dilution. The argon-41 release and the pool water analysis is used in the 2018 Annual Report for Radioactive Air Emission License (RAEL-004), stack number 7. Per COMPLY v1.7, the reactor facility (stack 7) is in compliance at level 4 with an effective dose equivalent of 8.3×10^{-3} mrem/yr. The monthly releases from Ar-41 are summarized in Table IV.

Table IV
Monthly Argon-41 Releases[2]

Month	Quantity (Ci)	Conc. After Dilution, (µCi/mL)	% of DAC Limit
July 2017	2.0×10^{-1}	1.2×10^{-10}	3.9×10^{-3}
August	2.0×10^{-1}	1.2×10^{-10}	4.0×10^{-3}
September	2.8×10^{-1}	1.8×10^{-10}	5.9×10^{-3}
October	2.5×10^{-1}	1.5×10^{-10}	5.0×10^{-3}
November	3.0×10^{-1}	1.8×10^{-10}	6.1×10^{-3}
December	2.0×10^{-1}	1.2×10^{-10}	3.9×10^{-3}
January 2018	1.9×10^{-1}	1.1×10^{-10}	3.8×10^{-3}
February	2.5×10^{-1}	1.7×10^{-10}	5.5×10^{-3}
March	4.5×10^{-1}	2.7×10^{-10}	8.9×10^{-3}
April	1.3×10^{-1}	9.1×10^{-11}	3.0×10^{-3}
May	2.1×10^{-1}	1.3×10^{-10}	4.3×10^{-3}
June	2.2×10^{-1}	1.4×10^{-10}	4.6×10^{-3}

C. Radioactive Solid Waste Disposal

During the reporting period, 0.88 mCi in 56.7 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 Science Center reactor staff and experimenters are given in Table V. The maximum quarterly dose to a reactor staff member was 153 mrem, whole body.

A total of 789 individual persons visited the Nuclear Science Center during the reporting period, of which 198 entered a controlled access area (CAA).[3] A total of 64 group tours, consisting of 488 individuals, visited the center during the reporting

[2] Quantity released based on 4500 CFM effluent of ventilation system in AUTO mode of operation. Concentration after dilution is based on 10 CFR 20 effluent release limit of 1.0×10^{-8} µCi/mL for Ar-41 (Table 2, Col.1), and a dilution factor of 3.4×10^{-3} (WSU Technical Specifications 3.5.2). DAC limits are based on 10 CFR 20 derived air concentration limit of 3.0×10^{-6} µCi/mL for Ar-41 (Table 1, Col. 3) and a dilution factor of 3.4×10^{-3}.

[3] A controlled access area is an area in the building where radioactive materials are used or stored and is a part of the licensed reactor facility.

period, also entering a CAA. All doses were less than or equal to 0.2 mrem as determined by digital pocket dosimeters.

Table V
Quarterly Reactor and Experimenter Staff Dose[4] (in mrem)

Badge No.	Q3 2017	Q4 2017	Q1 2018	Q2 2018
10921	43	83	42	79
11516	18	3	M	M
11205	M	M	--	--
11761	--	2	2	4
11239	7	4	2	5
08141	9	3	M	105
11762	--	M	4	2
10910	29	6	53	7
10916	65	13	9	153
10450	3	3	M	M
11763	--	3	M	M
10392	7	--	--	--
11255	3	2	1	--
10451	1	--	--	--
11764	--	13	2	M
10641	16	50	1	--
11694	6	5	1	--
11765	--	1	1	--
11222	1	--	--	--
08594	6	3	M	M
07748	1	2	M	M
10643	4	3	1	--

8. Reactor Facility Radiation and Contamination Levels

The limit of quantification (LOQ) for building removable contamination determination survey samples as measured by liquid scintillation assay is 8.89×10^{-8} $\mu Ci/cm^2$; the survey sample data that was collected for removable contamination determination were averaged over one year. Routine building surveys showed average levels of removable activity to be less than the LOQ for all non-CAAs. Routine building surveys showed average levels of removable activity to be less than the LOQ for all CAAs except the 201 Experimenters Platform and the Room 2 Cave Floor West.

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

Table VI
Average Removable Contamination for
Weekly Monitoring in CAAs and Non-CAAs[5]

Location	Measured Activity Above LOQ (μCi/cm²)
201B	M
201A	M
201 Reactor Bridge Steps	M
201 Sample Drop Tube	M
201 Reactor Bridge South	M
201 Reactor Bridge North	M
201 Experimenter Platform	3.4E-07
201 Laboratory Benches	M
201 Floor South	M
201-C Heat Exchanger Floor	M
201 Floor North	M
106 Ion Exchanger Pit	M
101-A Purification Pump Pit	M
101 Doorway	M
101 Sample Preparation Bench	M
101 Sample Drop Hood #2	M
101 Shipment Bench	M
101 Hood #1	M
101 Hood #18	M
101 Hood #4	M
B21 Panoramic Irradiator	M
B21 Floor	M
2 South Floor	M
2 Thermal Column	M
2 Thermal Column Floor	M
2 North Floor	M
2 Cave Floor West	3.2E-07
2 Cave Floor East	M

The results for the routine area radiation surveys of the building in CAAs and non-CAAs are given in Table VII. The highest average dose rate for a single location in a CAA was 31.9 mrem/hr, which occurred in Room 2 East Cave. This value is less than the limit for CAAs. The lowest average dose rate in a CAA was 0.04 mrem/hr (a level

[5] Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of 8.8×10^{-8} μCi/cm².

considered background), which occurred in Room 2 Thermal Column. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 0.52 mrem/hr. The East and West cave are secured storage areas and are designed to house radioactive sources and provide shielding. The space is posted as a high radiation area. Personnel do not typically work in this area and it is locked when not in use.

Table VII
Average Radiation Dose Rates for
Weekly Monitoring in CAAs and Non-CAAs[6]

Location	Average Dose Rate (mrem/hr)
Room 201 B	0.06
Room 201 A	0.04
Room 201 Bridge	1.48
Room 201 Benches	0.19
Room 201 South	0.24
Room 201 East	0.63
Room 201 C Heat Exchanger	0.05
Room 201 North	0.99
Room 106 Ion Exchanger Pit	2.18
Room 101 A Purification Pit	8.96
Sample Storage	0.34
Room 101 Doorway	0.05
Room 101 Sample Prep Bench	0.05
Room 101 Sample Drop Hood 2	0.52
Room 101 Shipping Bench	0.04
Room 101 Hood 1	0.06
Room 101 Hood 2	0.07
Room 101 Hood 4	0.08
Room B21 Panoramic Irradiator	0.04
Room 2 South	0.37
Room 2 Thermal Column	0.04
Room 2 North	0.18
Room 2 West Cave	1.87
Room 2 East Cave	31.9

9. Environmental Monitoring Program

The environmental monitoring program is used to determine the offsite background radiation levels; thermoluminescent dosimeters (TLD's) are used to make the

[6] Bolded text indicates a non-CAA. Regular text indicates a CAA.

measurements. The offsite radiation monitoring program is required by the Technical Specifications. The TLDs that are used for offsite monitoring are designated as TLD numbers 3, 7, 9, 15 through 35, and 39 through 44. The average background radiation level is then compared to the nearest occupied dwelling. TLD 4, 5, 6, 8, 9, and 10 show abnormally high readings for Q3 2017, Q4 2017, Q1 2018, and Q2 2018 due to irradiated graphite reflector elements stored nearby in the radioactive waste shed on the north side of the facility. The Radiation Safety Office has shielded the reflector barrels such that no public dose rate limits are exceeded. TLD 9 has been removed from background radiation calculations.

Average quarterly dose rates for offsite locations are listed in Table VIII and are used to calculate the Technical Specification threshold of 20% above the background radiation level and compared to the limiting values which are listed in Table XI. The average environmental radiation levels for the closest offsite point of extended occupancy is listed in Table X. Table IX shows the quarterly environmental radiation levels for those TLD's located at onsite locations. The onsite locations are not required to be compared to background radiation levels.

The closest offsite points of extended occupancy are compared in Figure 1 to both the background radiation levels and the 20% above background radiation levels. The ALARA effluent release limits in Technical Specification 3.5.2(3) specify that annual radiation exposure due to reactor operation, at the closest offsite extended occupancy, shall not, on an annual basis, exceed the average offsite background radiation by more than 20%. For the reporting period, the average background radiation dose rate for off-site locations was 0.51 mrem/day, while the average radiation dose rate at the closest extended occupancy area 600 meters away was 0.34 mrem/day. This result indicates that no exposure level above normal background radiation were found, and that no dose levels exceeded Technical Specifications requirements for an offsite area of extended occupancy.

Table VIII
Environmental Radiation Levels at Offsite Locations of the Nuclear Science Center[7]
(dose rate in mrem/day)

Location	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Average
Fence E of NSC	0.35	0.32	0.39	0.33	0.35
Fence, N of Rad Waste Shed	0.57	0.50	0.57	0.52	0.54
Fence directly N Rad Waste Shed	5.90	6.32	5.63	5.74	5.90
S NSC, on parking lot fence	0.32	0.34	0.37	0.32	0.34
Fence S Roundtop Dr, 10th pole W of pole C14	0.36	0.35	0.43	0.37	0.38
Telephone pole C12	0.37	0.32	0.42	0.36	0.37
Telephone pole near golf course gate	0.38	0.33	0.42	0.33	0.37
E across fairway on pine tree	0.34	0.34	0.40	0.33	0.35
Maple tree #54 along driving range	0.32	0.29	0.40	0.32	0.33
NW to fence uphill from driving range	0.45	0.42	0.48	0.34	0.42
Follow fence E to fence corner	0.38	0.36	0.42	0.44	0.40
S to lone spruce tree near water hazard	0.38	0.34	0.39	0.31	0.36
Roundtop hill park, NW fence corner	0.34	0.32	0.39	0.32	0.34
Deciduous tree edge of 18th green	0.36	0.36	0.42	0.40	0.39
6ft pine tree, 3rd W down cart path from clubhouse	0.35	0.37	0.41	0.33	0.37
3rd to last tree after gap in same line of trees	0.30	0.36	0.39	0.31	0.34
SW to fence along path near 2nd to last tee box at bottom hill	0.39	0.35	0.41	0.40	0.39
Follow fence partway up hill after fence turns S	0.36	0.33	0.39	0.34	0.36
Follow fence, 15th pole E after fence turns W	0.37	0.34	0.41	0.34	0.37
Follow fence about halfway between last TLD and corner	0.35	0.36	0.41	0.34	0.37
Largest bush S of NSC	0.36	0.33	0.40	0.36	0.36
2nd fence S NSC, W end at gate	0.37	0.32	0.37	0.36	0.36
S Fairway Rd, 1st light post on right	0.38	0.33	0.40	0.36	0.37
S Fairway Rd, 2nd light post on right	--	0.33	0.39	0.33	0.35
Ellis Way and Hog Lane sign	0.29	0.35	0.36	0.33	0.34
Bottom of radio antenna hill, fence next to shrub left of gate	0.36	0.34	0.39	0.34	0.36
3rd fence S of NSC, SE corner, cow pasture	0.35	0.35	0.39	0.34	0.36
Airport fence W end runway at gate	0.30	0.34	0.42	0.32	0.35
Fence/entry bar E of Jewett Observatory	0.34	0.36	0.37	0.33	0.35
Granite rock Terrell Mall, hole in back	0.27	--	0.42	--	0.35

[7] Offsite defined by the Technical Specification 1.0 and 5.1.1 as any location which is outside the site boundary. The "--" indicates a TLD which was missing.

Table IX
Environmental Radiation Levels at Onsite Locations of the Nuclear Science Center[8]
(dose rate in mrem/day)

Location	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Average
E lower loading dock	0.33	0.33	0.40	0.31	0.34
Pool room truck door fence S end	0.83	0.74	0.66	0.70	0.73
Pool room truck door fence N end	1.77	1.21	1.21	1.22	1.35
E wall rad waste shed	0.72	0.71	0.76	0.63	0.70
N wall rad waste shed	1.00	0.78	0.76	0.63	0.79
Cooling tower fence, NE corner	14.37	18.05	16.58	17.92	16.73
Room 101 window	0.44	0.39	0.46	0.40	0.42
Railing next to upper liquid waste tank	0.39	0.34	0.47	0.39	0.40
Room 2 truck door fence	0.35	0.35	0.41	0.34	0.36
Transformer vault vent louvers	0.40	0.35	0.46	0.39	0.40
NSC main entrance, light fixture	0.39	0.41	0.49	0.47	0.44
NSC roof, pool room vent stack	0.33	0.33	0.37	0.34	0.34
NSC roof, guide wire E end of building	0.37	0.39	0.40	0.36	0.38
NSC roof, E pool room vent support leg	0.55	0.58	0.79	0.77	0.67
NSC roof, air conditioning support leg	0.34	0.33	0.40	0.41	0.37
NSC roof, W pool room vent support leg	0.70	0.74	0.85	0.60	0.72

Table X
Environmental Radiation Levels for the Closest Offsite Point of Extended Occupancy
(dose rate in mrem/day)

Location	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Average
Apt complex C, gas meter	0.35	0.36	0.37	0.33	0.35
Apt complex B, gas meter	0.36	0.35	0.39	0.32	0.36
1st fence S apt complex A	0.29	0.31	0.35	0.32	0.31

Table XI
Background Environmental Radiation Levels
(dose rate in mrem/day)

Description	Q3 2017	Q4 2017	Q1 2018	Q2 2018	Average
Background radiation levels	0.55	0.35	0.41	0.36	0.42
20% above background radiation levels	0.66	0.42	0.49	0.43	0.50

[8] Onsite defined by the Technical Specification 1.0 and 5.1.1 as any location within the site boundary.

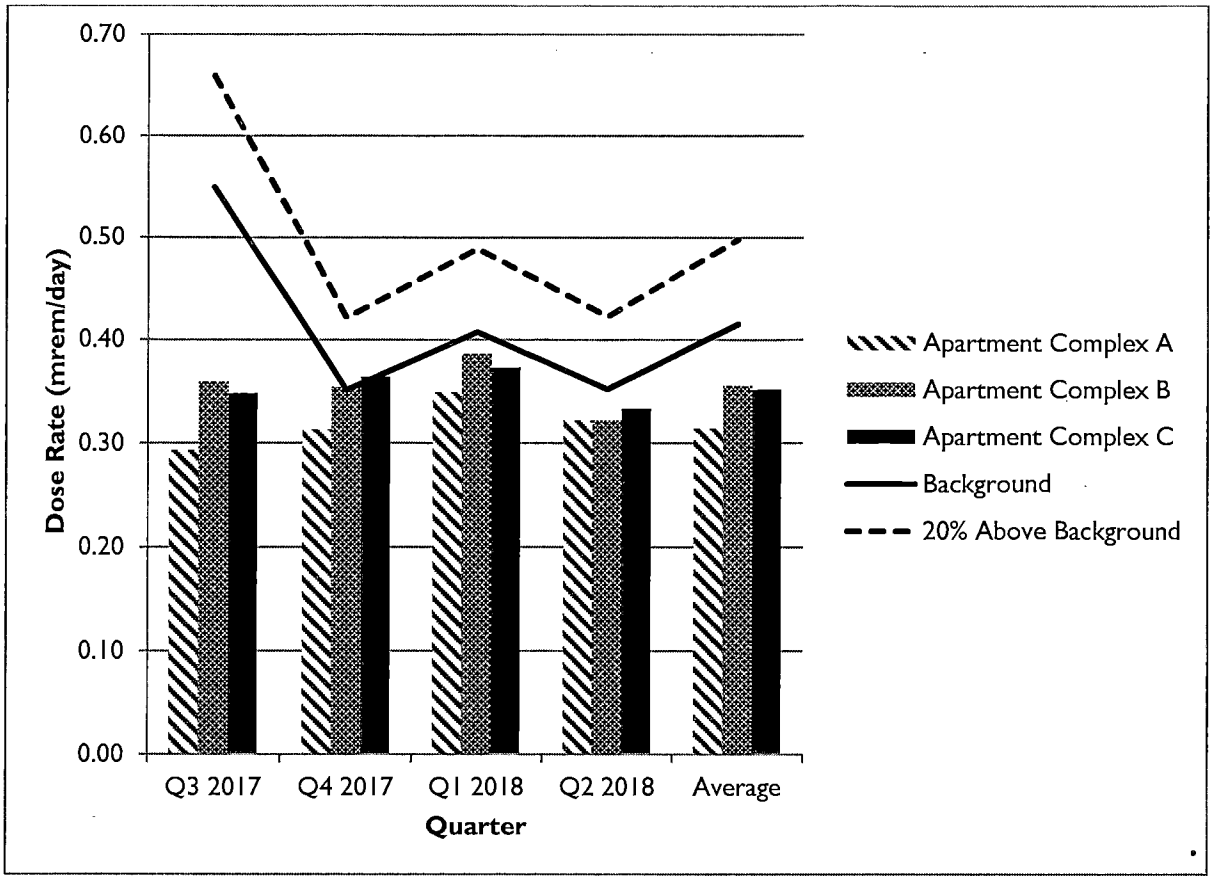

Figure 1: Environmental radiation levels for the closest off-site point of extended occupancy as compared to background radiation levels and 20% above background radiation levels.