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Subject: 2019 Annual Report for the WSU Nuclear Science Center

The annual report for the WSU reactor facility is hereby submitted. The report covers the operating period from July 1, 2018 through June 30, 2019.

Respectfully Submitted,

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Enclosure

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2019

ANNUAL OPERATIONS REPORT

WASHINGTON STATE UNIVERSITY TRIGA REACTOR

FACILITY LICENSE R-76 FOR THE REPORTING PERIOD
JULY 1, 2018 TO JUNE 30, 2019

NUCLEAR SCIENCE CENTER | Washington State University, Pullman, WA

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1. Narrative Summary of Operation for Fiscal Year 2019

A. Operating Experience

Core 35A has accumulated 11,536 MWH from beginning of life (BOL) through June 30, 2019. During the reporting period of July 1, 2018 to June 30, 2019, a total of 838 samples were irradiated, for 9,682 user-hours. Additionally, 12 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.

The Standard Operating Procedures (SOP) were revised and approved by the Reactor Safeguards Committee on 8/23/2018.

C. Results of Surveillance Tests and Requirements

During a self-audit of operation documents, paperwork for week 16 of weekly swipes and surveys could not be found. The annual average radiation dose rates for weekly monitoring in CAAs and Non-CAAs does not include week 16 as the maintenance item is to be considered incomplete for that week. Weekly swipes were recovered from the liquid scintillation counter's associated computer. No unusual levels of radiation were found in the following week. The facility remains in compliance with Technical Specification 6.5 (1), the Radiation Protection Program and 10 CFR 20.1501 as the frequency for the maintenance item is determined by the facility. All other 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 1,711 megawatt days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated 481 MWD.

Table I. Fiscal Year 2019 Summary of Reactor Operation[1]

	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Totals
Hours of Operation	317	56	520	260	1,153
Megawatt Hours	274	49	424	153	900
Sample Irradiations	52	9	72	74	207
Samples	198	28	236	376	838
External Irradiations	32	16	37	34	119
User Hours	2,833	503	4,708	1,638	9,682
Pulses > $1.00	2	0	2	8	12

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

3. Emergency Shutdowns and Inadvertent Scrams

During the reporting period, there were no emergency shutdowns. During a period of unplanned shutdown, seven inadvertent scrams were caused by the equipment malfunction of the NLW-1000 channel and fission chamber as recorded in Table II.

The dates and causes of the eleven inadvertent scrams are listed in Table II. No scrams were due to exceeding the limiting safety system setting or safety limit.

Table II. Inadvertent Scrams

Date	Description
11/2/2018	High voltage failure scram on the NLW-1000 while attempting a start up for testing.
11/5/2018	High voltage failure scram on the NLW-1000 while attempting a start up after replacing the isolation amplifier in the NLW-1000.
11/8/2018	High voltage failure scram on the NLW-1000 while attempting a start up for testing.
12/3/2018	High voltage failure scram on the NLW-1000 while attempting a start up for testing.
12/5/2018	High voltage failure scram on the NLW-1000 while attempting a start up for testing.
12/7/2018	High voltage failure scram on the NLW-1000 while attempting a start up for testing.
12/17/2018	High voltage failure scram on the Log-N channel after 3 hours of operation. The scram is suspected to have been caused by overheating of the Log-N channel.
2/13/2019	Loss of power to the building caused a scram. There was no damage to the reactor or corresponding equipment. Loss of power was due to a campus-wide outage.
4/1/2019	A failure in the building compressed air supply system caused the air pressure to the pulse rod to drop significantly. The operator air scrammed the pulse rod and ran down all other control elements.
5/10/2019	Trainee placed the mode selector switch into test instead of rundown while operating at 1.0 MW.
5/21/2019	Building power flickered causing a loss of power to the console and a subsequent scram.

4. Major Maintenance

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

7/16/2018: *Pool Temperature Readout*
The temperature probe and its pipe housing were removed from the pool and the pipe was repaired to be watertight. The probe was rewired and placed back into service.

8/21/2018: *Log-N Channel*
Four of the wires in the J6 (Pre-Amp Power) cable had come loose from the connector. The wires were soldered to their appropriate pins.

9/26/2018: *Transient Rod Fire Switch*
The transient rod fire button and switch in the reactor control console was replaced.

10/9/2018 - 12/21/2018: *Fission Chamber*
A fission chamber assembly was prepared and placed in core to replace a failed detector.

2/7/2019: *Diffuser Pump*
A braided stainless steel waterline was used in place of the tubing from the pump to the pressure gauge. The diffuser and the pressure gauge are operating normally.

5/7/2019*: Low Pool Level Alarm- Float Switch*
The float switch system was removed from the pool and the bottom switch was replaced with an identical part.

6/17/2019: *Log-N Channel*
The scale on the dial had come partially unglued. The tab at the top of the meter face cover was also broken off and was not holding the cover in place. The scaling plate was re-glued down and affixed the tab onto the cover.

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

There were no changes to the facility made under 10 CFR 50.59 criteria during the 2018-2019 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 2018	0
August	0
September	0
October	0
November	0
December	0
January 2019	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 1.82 Ci of argon-41 was released, with an average argon-41 concentration of 9.30×10^{-11} 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 1.7×10^{-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 2018	1.1E-01	6.6E-11	2.1E-03
August	1.9E-01	1.2E-10	3.9E-03
September	1.8E-01	1.1E-10	3.6E-03
October	2.8E-02	1.7E-11	5.6E-04
November	1.7E-01	1.1E-10	3.6E-03
December	1.3E-01	8.0E-11	2.7E-03
January 2019	2.6E-01	1.5E-10	5.1E-03
February	2.1E-01	1.4E-10	4.7E-03
March	1.7E-01	1.0E-10	3.3E-03
April	1.5E-01	9.5E-11	3.2E-03
May	1.5E-01	9.2E-11	3.1E-03
June	6.6E-02	4.1E-11	1.4E-03

C. Radioactive Solid Waste Disposal

During the reporting period, 1.13 mCi in 41.4 cubic feet of non-compacted solid waste was transferred to the WSU Radiation Safety Office for packaging and disposal.

[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}.

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 82 mrem, whole body. A total of 749 individual persons visited the Nuclear Science Center during the reporting period, of which 190 entered a controlled access area (CAA).[3] A total of 51 group tours, consisting of 279 individuals, visited the center during the reporting 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] (mrem)

Badge No.	Q3 2018	Q4 2018	Q1 2019	Q2 2019
10921	54	19	9	25
11974	--	M	--	--
12034	--	--	--	M
11975	--	M	2	3
11976	--	M	1	1
11516	3	M	M	M
11761	7	M	M	--
11239	M	M	2	2
12033	--	--	--	M
11937	1	4	33	79
08141	6	M	M	1
11977	M	M	4	11
12305	--	--	--	M
11986	1	3	M	4
11762	M	M	M	1
10916	8	--	--	--
10450	M	M	--	--
11978	M	M	M	--
12302	--	--	--	M
1209	--	--	--	M
12028	--	--	--	M
12031	--	--	--	M
11979	M	M	6	1
12030	--	--	--	M
08594	M	M	M	M
11965	10	5	82	27
11980	--	M	M	M
07748	M	M	M	M
11973	--	1	4	--
11972	M	M	--	--

[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.

[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.

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 8.93×10^{-8} µCi/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.

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

Location	Measured Activity Above LOQ (µCi/cm^2)
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	M
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 Hood #1	M
101 Hood #2	M
101 Hood #3	M
101 Hood #4	M
101 Shipment Bench	M
RAM Storage Safe	M
101 Island	M
101 North lab Bench	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	M
2 Cave Floor East	M

[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/cm^2.

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 3.93 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 considered background), which occurred in Room 2 Thermal Column. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 0.05 mrem/hr. The East and West cave are secured storage areas that 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	0.05
Room 201 Bridge	0.94
Room 201 Benches	0.22
Room 201 South	0.29
Room 201 East	0.56
Room 201 C Heat Exchanger	0.08
Room 201 North	0.31
Room 106 Ion Exchanger Pit	0.79
Room 101 A Purification Pit	2.45
Sample Storage	0.16
Room 101 Doorway	0.04
Room 101 Sample Prep Bench	0.05
Room 101 Sample Drop Hood	0.09
Room 101 Shipping Bench	0.04
Room 101 Hood 1	0.05
Room 101 Hood 2	0.05
Room 101 Hood 3	0.04
Room 101 Hood 4	0.04
Room B21 Panoramic Irradiator	0.04
Room 2 South	0.11
Room 2 Thermal Column	0.04
Room 2 North	0.21
Room 2 West Cave	0.75
Room 2 East Cave	3.93

[6] 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} $\mu Ci/cm^2$.

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 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 2018, Q4 2018, Q1 2019, and Q2 2019 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 TLDs 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 0.36 mrem/day, while the average radiation dose rate at the closest extended occupancy area 600 meters away was 0.32 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[7,8]

Location	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Average
Fence E of NSC	0.33	0.37	0.33	0.35	0.34
Fence, N of Rad Waste Shed	0.56	0.48	0.49	0.52	0.52
Fence directly N Rad Waste Shed	5.52	5.11	4.72	4.14	4.87
S NSC, on parking lot fence	0.33	0.35	0.33	0.33	0.33
Fence S Roundtop Dr, 10th pole W of pole C14	0.40	0.39	0.35	0.36	0.37
Telephone pole C12	0.37	0.35	0.32	0.36	0.35
Telephone pole near golf course gate	0.34	0.35	0.36	0.32	0.34
E across fairway on pine tree	0.35	0.32	0.32	0.35	0.33
Maple tree #54 along driving range	0.36	0.31	0.37	0.36	0.35
NW to fence uphill from driving range	0.45	0.37	0.37	0.36	0.38
Follow fence E to fence corner	0.36	0.38	0.44	0.38	0.39
S to lone spruce tree near water hazard	0.36	0.31	0.35	0.36	0.35
Roundtop hill park, NW fence corner	0.34	0.32	0.34	0.33	0.33
Deciduous tree edge of 18th green	0.38	0.35	0.42	0.38	0.38
6ft pine tree, 3rd W down cart path from clubhouse	0.37	0.34	0.34	0.35	0.35
3rd to last tree after gap in same line of trees	0.35	0.32	0.38	0.35	0.35
SW to fence along path near 2nd to last tee box at bottom hill	0.39	0.32	0.35	0.36	0.36
Follow fence partway up hill after fence turns S	0.38	0.31	0.42	0.36	0.37
Follow fence, 15th pole E after fence turns W	0.40	0.32	0.39	0.38	0.37
Follow fence about halfway between last TLD and corner	0.37	0.36	0.39	0.38	0.38
Largest bush S of NSC	0.39	0.31	0.39	0.36	0.36
2nd fence S NSC, W end at gate	0.33	0.32	0.38	0.34	0.34
S Fairway Rd, 1st light post on right	0.33	0.35	0.34	0.32	0.34
S Fairway Rd, 2nd light post on right	0.34	0.38	0.37	0.37	0.36
Ellis Way and Hog Lane sign	0.30	0.32	0.37	0.31	0.33
Bottom of radio antenna hill, fence next to shrub left of gate	0.38	0.34	0.39	0.38	0.37
3rd fence S of NSC, SE corner, cow pasture	0.37	0.34	0.41	0.33	0.36
Airport fence W end runway at gate	0.33	0.32	0.38	0.31	0.34
Fence/entry bar E of Jewett Observatory	0.34	0.30	0.35	0.30	0.32
Railing at Terrell Mall / Library	--	0.28	0.38	0.28	0.31

[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.

[8] Dose rate in mrem/day.

Table IX. Environmental Radiation Levels at Onsite Locations[9,10]

Location	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Average
E lower loading dock	0.40	0.35	0.36	0.35	0.36
Pool room truck door fence S end	0.66	0.53	0.57	0.83	0.65
Pool room truck door fence N end	0.95	0.84	1.14	1.05	0.99
E wall rad waste shed	0.71	0.66	0.63	0.64	0.66
N wall rad waste shed	0.65	0.70	0.84	0.88	0.77
Cooling tower fence, NE corner	18.59	15.58	14.07	14.42	15.66
Room 101 window	0.43	0.45	0.42	0.41	0.42
Railing next to upper liquid waste tank	0.39	0.40	0.35	0.41	0.39
Room 2 truck door fence	0.37	0.37	0.36	0.36	0.36
Transformer vault vent louvers	0.36	0.39	0.42	0.39	0.39
NSC main entrance, light fixture	0.43	0.41	0.49	0.41	0.43
NSC roof, pool room vent stack	0.31	0.29	0.44	0.33	0.34
NSC roof, guide wire E end of building	0.31	0.34	0.48	0.31	0.36
NSC roof, E pool room vent support leg	0.62	0.44	0.89	0.52	0.62
NSC roof, air conditioning support leg	0.34	0.31	0.48	0.30	0.36
NSC roof, W pool room vent support leg	0.73	0.42	0.99	0.53	0.66

Table X. Environmental Radiation Levels for the Closest Offsite Point of Extended Occupancy[10]

Location	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Average
Apt complex C, gas meter	0.32	0.34	0.35	0.37	0.33
Apt complex B, gas meter	0.28	0.34	0.37	0.30	0.32
1st fence S apt complex A	0.28	0.33	0.34	0.28	0.31

Table XI. Background Environmental Radiation Levels[10]

Description	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Average
Background radiation levels	0.37	0.34	0.37	0.35	0.36
20% above background radiation levels	0.44	0.41	0.45	0.42	0.43

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

[10] Dose rate in mrem/day.

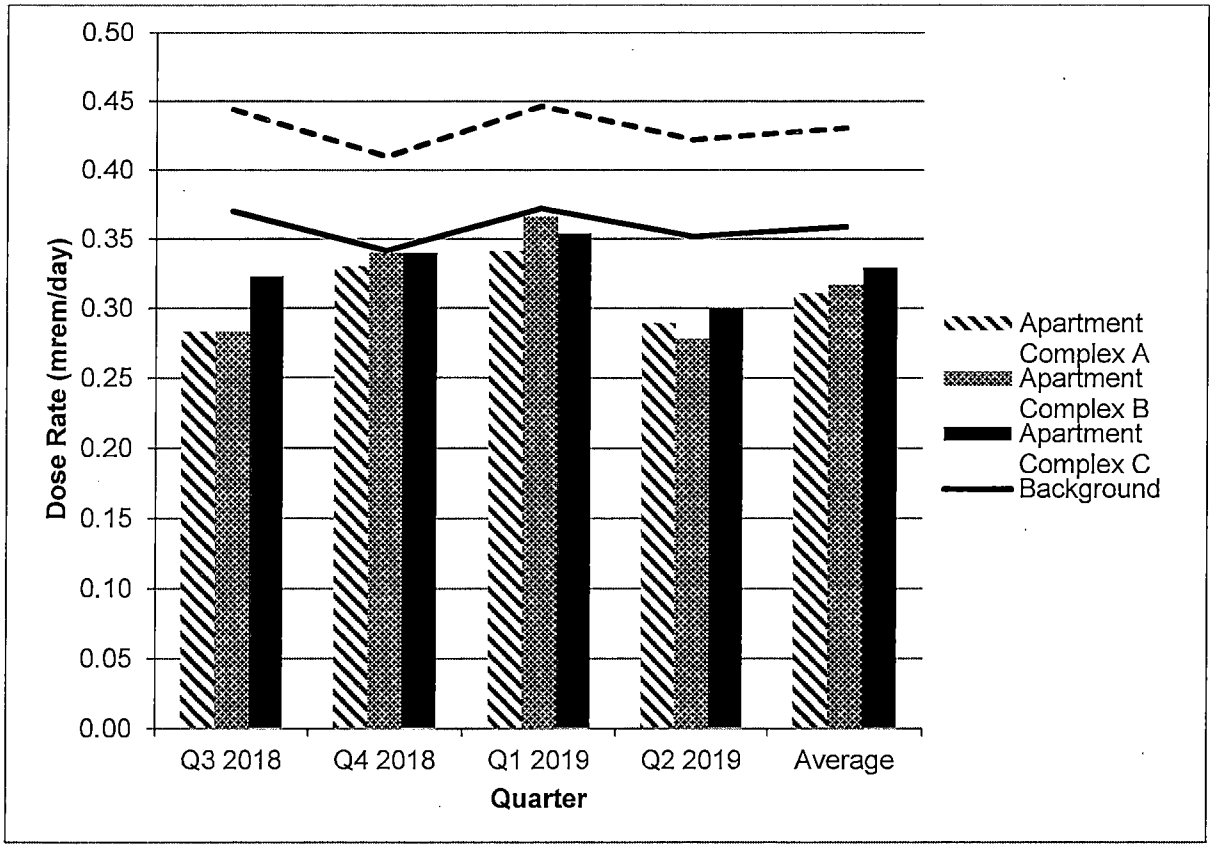

Figure I: Environmental radiation levels for the closest offsite point of extended occupancy radiation levels as compared to background radiation levels and 20% above background radiation levels.