Idaho State University
AGN-201M Reactor Facility
License R-110, Docket No. 50-284
Annual Operating Report for 2016 Calendar Year

1. Narrative Summary

A. Changes in Facility Design, Performance Characteristics, and Operating Procedures:

There were no changes in facility design, performance characteristics, and operating procedures relating to reactor safety during the reporting period.

B. Results of Major Surveillance Tests and Inspections:

(1) The period, count rate, and power level measuring channels were calibrated and set points were verified. Channels 1, 2, & 3 were tested on 05/03/2016, 05/03/2016 & 05/08/2016 respectively.

(2) Power level (02/23/2016) and period check (05/08/2016) experiments were performed with satisfactory results.

(3) The shield water tank was inspected (05/08/2016) and no leaks or excessive corrosion were observed. The water level interlock tested satisfactorily (05/08/2016).

(4) The seismic displacement & temperature interlocks were tested and found satisfactory on 05/08/2016 and 05/08/2016 respectively.

(5) (a) Control element capsules (cladding) were inspected (06/03/2016) and found to be in good condition with no evidence of deterioration since the previous inspection.

(b) The control rod drive mechanisms were inspected (06/03/2016) and tested with satisfactory results.

(c) Ejection times were measured (06/03/2016) for all SCRAM-able rods, SR-1, SR-2 and CCR and were found to be 0.104, 0.107 and 0.092 seconds respectively. The requirement that the ejection times be less than 1 second is satisfied.

(d) The reactivity worth of all safety and control rods were measured (06/16/2016), as well as the time required to drive each rod to its fully inserted position (06/01/2016). The largest reactivity insertion rate was 0.021089 $\%\Delta k/k\ s^{-1}$ ($0.0285 s^{-1}), which is less than the prescribed limit of $0.065\%\Delta k/k\ s^{-1}$.

(e) On 06/16/2016 the shutdown margin with both the most reactive SCRAM-able rod and the fine control rod remaining fully inserted was determined to be 1.507%Δk/k ($2.036) (at the maximum allowable k excess of 0.65 %Δk/k) and satisfies the requirement that it be greater than 1%Δk/k.

(f) All surveillances were within the appropriate Technical Specification requirements.

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C. NRC Inspection

The annual inspection was conducted on July 25-27, 2016. No findings of significance were identified. No violations were found during the inspection.

2. Operating History and Energy Output.

The reactor was operated at power levels up to 3.7 Watts for a total of 93.06 Watt-hours of thermal energy during this reporting period. A summary of monthly operations for 2016 is given in Table I.

Table I. Summary of Monthly Reactor Operations
(1 January 2016 through 31 December 2016)

Year Totals		
January	0	
February	3.51	
March	11.32167	
April	4.881	
May	4.472414	
June	3.6345	
July	0	
August	0	
September	26.73966	
October	12.03633	
November	1.660833	
December	24.80317	
Total	93.05957	Watt-hr
	0.09306	**kWatt-hr**

The 0.09306 kWh consumed 4.76 micrograms of U-235.

During the calendar year, a number of students went through reactor operator training. During the calendar year, six students took NRC licensing exams and three were awarded Reactor Operator (RO) licenses, one was awarded a Senior Reactor Operator instant (SRO-Instant) license, one was awarded a Senior Reactor Operator Upgrade (SRO-Upgrade) license, and one did not pass section A of the Written Examination.

3. A. Unscheduled Shutdowns and Corrective Actions Taken.

None.

B. Inadvertent Scrams and Action Taken.

There were 44 inadvertent scrams during this reporting period. Table II summarizes the inadvertent scrams, known or suspected cause, and action taken.

Table II. Summary of Inadvertent Scrams
(1 January 2016 through 31 December 2016)

Date	Time	Scram Type	Cause	Action
02/29/2016	1519	CH#3 Low	Electrical transient	Restart
03/02/2016	1504	Period	Electrical transient	Restart
03/05/2016	1118	CH#3 Low	Operator missed range change	Restart
03/14/2016	1313	CH#2 High	CH#2 scram set point set to low	Restart
03/15/2016	1414	CH#3 High	Operator missed range change	Restart
03/22/2016	1453	Period	Electrical transient	Restart
04/04/2016	1350	CH#3 High	Electrical transient	Restart
04/04/2016	1402	Period	Electrical transient	Restart
04/04/2016	1410	Period	Electrical transient	Shutdown & Investigate
04/21/2016	1359	Period	Electrical transient	Restart
04/23/2016	1516	CH#3 High	Operator missed range change	Restart
04/23/2016	1526	Period	Electrical transient	Restart
05/07/2016	1104	Period	Electrical transient	Restart
05/07/2016	2007	CH#3 High	Electrical transient	Restart
05/10/2016	1434	Period	Electrical transient	Restart
05/27/2016	1042	CH#3 Low	Electrical noise	Restart
05/27/2016	1155	CH#3 High	Operator missed range change	Restart
05/27/2016	1512	CH#3 High	Electrical transient	Restart
06/02/2016	1652	CH#2 Low	Electrical transient	Restart
06/29/2016	1008	Period	Electrical transient	Restart
06/30/2016	1211	Period	Electrical transient	Restart
09/12/2016	1439	CH#3 High	Operator missed range change	Restart
09/23/2016	1557	Period	Electrical transient	Restart
09/26/2016	1305	CH#3 High	Operator missed range change	Restart
09/27/2016	1612	Period	Electrical transient	Restart
09/27/2016	1624	Period	Electrical transient	Restart
09/28/2016	1517	CH#2 Low	Fast Neutron drop due to BP#3 graphite removed	Restart
09/28/2016	1751	Period	Electrical transient	Restart
09/30/2016	1150	Period	Electrical transient	Restart
09/30/2016	1342	Period	Electrical transient	Restart
10/03/2016	1318	Period	Electrical transient	Restart

10/03/2016	1425	CH#1 Low	Electrical transient	Shutdown & Investigate
10/05/2016	1525	Period	Electrical transient	Restart
10/10/2016	1317	Period	Electrical transient	Restart
10/17/2016	1358	CH#3 Low	Electrical transient	Shutdown & Investigate
10/21/2016	1143	CH#3 Low	Electrical transient	Restart
11/02/2016	1717	CH#3 High	Operator missed range change	Restart
11/10/2016	1913	Period	Electrical transient	Restart
11/30/2016	1837	Ch#3 Low	Operator missed range change	Restart
12/03/2016	1406	Period	Electrical transient	Restart
12/05/2016	1303	Period	Electrical transient	Restart
12/07/2016	1529	Period	Electrical transient	Shutdown & Investigate
12/07/2016	1726	Period	Electrical transient	Restart
12/08/2016	1725	CH#3 High	Operator missed range change	Restart

4. Safety-Related Corrective Maintenance:

03/23/2016: Replaced V13, and V14 vacuum tubes.

04/27/2016: Replaced CH#2 6Y6 vacuum tube and re-soldered vacuum tube socket.

09/28/2016: The diodes SR2 were replaced with equivalent diodes. The s886 vacuum tube located near the channel #2 signal input had all of its legs re-soldered to the board. The transistor (Q101 2N365) was wired in backwards so it was changed and re-soldered. Connections to S1 and S2 were re-soldered on the front panel. Capacitor B1 was changed form 1.34volts to 1.5 volts to account for this change in capacitor the resistor equivalent value was changed to 1.5 KΩ. This helped greatly with the 10^{-7} issue. All vacuum tube sockets were cleaned with electronic cleaner and the vacuum tubes were verified to work well with the sockets.

09/20-22/2016: The channel # 3 ion chamber was replaced with the spare ion chamber of the same type. Re-tightened reactor console grounding for better results.

09/25/2016: Removal of brass position indicator for the CCR was removed for a smooth synchro range of the CCR positon.

09/29/2016: Channel #2 6CB6 vacuum tube was replaced.

10/26/2016: The "SET 10^{-11}" and the "AMPLIFIER BALNANCE" potentiometer were replaced with both 200 Ω @ 5% uncertainty potentiometers that meet the

specifications needed.

11/15/2016: CCR rod and drive was taken out, calibrated, tested, and re-greased.

12/08/2016: CCR rod and drive was taken out, calibrated, tested, and re-greased

5. Modifications.

   A. Changes in Facility Design.

      None.

   B. Changes to Procedures.

      None.

   C. Changes to Experiments.

      None.

   D. Reactor Safety Committee.

      As of the end of the reporting period, membership of the Reactor Safety Committee (RSC) consisted of the following individuals:

      Frank H. Just – Chair (retired from INL)
      Mary Lou Dunzik-Gougar - Reactor Administrator
      George Imel – Assistant Reactor Administrator
      Maxwell J. Daniels - Reactor Supervisor
      Richard R. Brey – ISU Radiation Safety Officer
      Robert Boston, PE, CHP (DOE-ID)
      Kermit Bunde (DOE-ID)
      Richard E. McCracken (retired from INL)
      Benjamin Baker (INL)
      Jay F. Kunze – Former Reactor Administrator

6. Summary of Changes Subject to 10 CFR 50.59 Analyses.

   None.

7. Radioactive Effluents.

   A. Liquid Waste - Total Activity Released: None.

   B. Gaseous Waste - Total Estimated Activity Released: 1.93186 μCi of Ar-41.

The AGN-201 Reactor was operated for 93.06 watt-hours at power levels up to approximately 3.7 watts. At this power level Ar-41 production is negligible and substantially below the effluent concentration limit given in 10 CFR 20 Appendix B, Table 2. The total activity of Ar-41 released to the environment was conservatively estimated at 1.93186 μCi. This activity corresponds to the total activity of all gaseous radioactive effluent from the facility. A monthly summary of calculated gaseous releases is given in Table IV and the equation used is shown in Equation (1).

Table IV. Summary of Monthly Gaseous Radioactive Effluent Releases
(1 January 2016 through 31 December 2016)

Year Totals Ar-41 [μCi]		
January	0	
February	0.07287	
March	0.23503	
April	0.10133	
May	0.09284	
June	0.07545	
July	0	
August	0	
September	0.5551	
October	0.24987	
November	0.03448	
December	0.5149	
Total	1.93186	μCi

$$R = \frac{(\sigma_{Ar-40})(\gamma_{Ar-40})(m_{Ar-40}\text{in Volume})(\phi_{th}\text{ to }\phi_{TOT})(M_{U-235})(3600\,{}^{J}/_{W*hr})(\lambda_{Ar-41})(X)}{(M_{Ar-40})(E_R)(m_{TOT\,(U-235)})(\sigma_{f\,(U-235)})(3.7*10^{10})} \quad (1)$$

Where (R) is the total amount of Ar -41 produced.

C. Solid Waste - Total Activity: None.

8. The latest environmental radiation survey, performed at the facility boundary while the reactor was operating at 72% of full licensed power (3.6 watts), measured a maximum combined neutron and gamma dose equivalent rate of 0.432 mrem hr^{-1} or less at the outside walls of the building proximal to the reactor. The requirement that the total equivalent dose rate be less than 2.0 mrem hr^{-1} was satisfied.

9. Radiation Exposures.

The Radiation Safety Officer reviews personnel radiation exposures quarterly. Annual reports of ionizing radiation doses are provided by the Radiation Safety Officer to all monitored personnel as required under the provisions of 10 CFR 19.

Personnel with duties in the reactor laboratory on either a regular or occasional basis have been issued radiation dosimeters by the Idaho State University Technical Safety Office. The whole body exposures for the 2016 monitoring period of personnel are summarized in Table V:

Table V. Personnel Radiation Monitored for 1/1/2016-12/31/2016

Name	Exposure by Type (mrem)		
	Deep	Lens	Shallow
Byambadorj, Bilguun	M	M	M
Lehmer, Jacob P	M	M	M
Grayson, Brittany J	M	M	M
Beatty, Matthew W	M	M	M
Beveridge, Lucas B	M	M	M
Daniels, Maxwell J	M	M	M
Giegel, Sam H	M	M	M
IMEL, GEORGE	M	M	M
KUNZE, JAY F	M	M	M
LOVELAND, RYAN K	M	M	M
Maas, Andrew M	M	M	M
Mulvaney, John V	M	M	M
Pierson, Paul B	M	M	M
Pizzichemi, Bryan M	7	7	8
Pollock, Theodore	M	M	M
Robison, Seth A	M	M	M
Suresh, Sneha	M	M	M
Thompson, Aaron M	M	M	M
Munson, David C	M	M	M
Alesmail, Azam F	M	M	1
Dabb, Nicholas	M	M	M
Flores, Solymara	4	3	4
MALLICOAT, ADAM	M	M	M

Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M."

The 10 CFR 20.1201 occupational dose limits to adults are: total 5 rem, lens of eye 15 rem, shallow 50 rem, and deep 50 rem. The doses received for all reactor laboratory personnel during 2016 are well below the dose limits of 10 CFR 20.1201, and well below ISU ALARA limits (1 rem per year, 0.3 rem per quarter).
Anytime a member of the public visits the reactor, pen dosimeters are issued for the

Anytime a member of the public visits the reactor, pen dosimeters are issued for the extent of the tour. A minimum of 1 dosimeter to every 4 people is issued for a representative group dose. During the 2016 calendar year there were 507 recorded visitors to the facility. A summary of the public dose exposure is presented in Table VI.

Table VI. Summary Whole-Body Exposures to the Public
(1 January 2016 through 31 December 2016)

Estimated whole-body exposure range (mrem):	Number of individuals in each range:
No Observable Dose	490
1.0 mrem*	10
1.0 mrem < Dose ≤ 5.0 mrem	3
5.0 mrem < Dose < 10.0 mrem	0
10.0 mrem < Dose < 15.0 mrem	0
Dropped Dosimeter**	4
Total number of individuals reported	507

*Below 1.0 mrem is considered un-measureable
**When a dosimeter is dropped, the value indicated is altered from the true value. All individuals who dropped dosimeters are assumed to have no observable dose.

None of the 507 visitors to the facility during 2016 received a measurable dose that would exceed the annual 0.5 rem dose limit of 10 CFR 20.1301. Therefore, the average and maximum doses received by personnel and the public are within NRC guidelines.

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May 15, 2017

Reviewed and approved by:

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May 22, 2017

Mary Lou Dunzik-Gougar,
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May 22, 2017

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