

**Idaho State University
AGN-201M Reactor Facility
License R-110, Docket No. 50-284
Annual Operating Report for 2020 Calendar Year**

1. Narrative Summary

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

The reactor console was changed from the old vacuum circuits to more modern solid state circuits. Performance characteristics stayed the same between consoles by design to allow for an easier transition for reactor operators, and operating procedures were updated to reflect the new console.

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 11/30/2020.
- 2) Power level (06/19/2020) and period check (06/19/2020) experiments were performed with satisfactory results.
- 3) The shield water tank was inspected (11/23/2020) and no leaks or excessive corrosion were observed. The water level interlock tested satisfactorily (11/23/2020).
- 4) The Seismic Displacement & temperature interlocks were tested and found satisfactory on 11/23/2020.
- 5) Inspections
 - a) Control element capsules (cladding) were inspected (06/17/2020) and found to be in good condition with no evidence of deterioration since the previous inspection.
 - b) The control rod drive mechanisms were inspected (06/17/2020) and tested with satisfactory results.
 - c) Ejection times were measured (06/18/2020) for all SCRAM-able rods, SR-1, SR-2, and the CCR and were found to be 0.15, 0.15, and 0.2 seconds respectively. The requirement that ejection times be less than 1 second is satisfied.
 - d) The reactivity worth of the Fine Control Rod was measured on 3/4/2020, and of Safety Rods 1 and 2 and the Course Control Rod on 8/14/2020. The time to drive each rod fully into the core was measured on 6/18/2020 as part of performing Maintenance Procedure 1. The largest reactivity insertion rate is 0.0275 (% $\Delta k/k$)/s, which is less than the tech spec limit of 0.065 (% $\Delta k/k$)/s.
 - e) On 8/14/2020 the shutdown margin (SDM) with the most reactive SCRAM-able rod and the fine control rod fully inserted was determined to be 1.69 % $\Delta k/k$ (at

maximum allowable k excess 0.65 % $\Delta k/k$). This value meets the tech spec requirement that the SDM be greater than 1% $\Delta k/k$.

- f) All Surveillances were within the appropriate Technical Specification requirements.

C. NRC Inspections

The annual inspection was conducted June 29 - July 3. One finding of significance was found. The rod worth calculation was not completed within the time period for CY 2019. This was immediately corrected, and rod worth calculations have been incorporated into the annual surveillance procedures. No violations were found during the inspection.

2. Operating History and Energy Output

The reactor was operated at power levels up to 4.8 Watts for a total of 45.1456 Watt-hours of thermal energy during this reporting period. A summary of monthly operations for 2020 is given in Table I.

Table I. Summary of Monthly Reactor Operations
 (1 January 2020 through 31 December 2020)

Year Totals		
January	5.8667	Watt-hr
February	0.0390	Watt-hr
March	0.4849	Watt-hr
April	0.0000	Watt-hr
May	0.0000	Watt-hr
June	9.9038	Watt-hr
July	8.0280	Watt-hr
August	7.6842	Watt-hr
September	0.0000	Watt-hr
October	13.1247	Watt-hr
November	0.0143	Watt-hr
December	0.0000	Watt-hr
Total	45.1456	Watt-hr
	0.0451	kWatt-hr

The 0.0451 kWatt-hr consumed 1.98 μ grams of U-235 using Equation (1)

$$g_{U235} = (Whr) \left(\frac{3600 J}{1 Whr} \right) \left(\frac{6.242 \times 10^{12} MeV}{1 J} \right) \left(\frac{1 Fission}{200 MeV} \right) \left(\frac{1 atom U235}{1 Fission} \right) \left(\frac{1 mol U235}{6.022 \times 10^{23} atoms U235} \right) \left(\frac{235 g U235}{1 mol U235} \right) \quad (1)$$

During the calendar year, several students went through reactor operator training. During the calendar year, no students took NRC licensing exams and no Reactor Operator (RO) or Senior Reactor Operator (SRO) licenses were awarded. The lack of exams was due to COVID-19 travel restrictions and the Channel 2 detector problems we experienced in the

latter half of the year. All students who were planning to take the 2020 NRC Licensing Exams will be able to take the 2021 NRC Licensing Exams if they are still interested and on campus.

3. **Unscheduled Events and Inadvertent SCRAMS**

A. **Unscheduled Shutdowns and Corrective Actions Taken – None**

B. **Inadvertent SCRAMS and Actions Taken**

There were 3 inadvertent scrams during this reporting period. Table II summarizes the inadvertent scrams, known or suspected cause, actions taken and resolution.

Table II. Summary of Inadvertent Scrams
 (1 January 2020 through 31 December 2020)

Inadvertent scrams					
Date	Time	Scram Type	Cause	Resolution	Action
2/7/20	11:00	Electrical Failure	Console Power Turned Off	Ensured console was securely plugged into wall outlet	Restart
3/4/20	18:57	Channel 3 Low	Possible Electrical Noise		Shutdown & Investigate
8/21/20	16:09	Manual	Course Control Rod Stuck	Removed Course Control Rod and Inspected	Shutdown & Investigate

ISU is in the process of updating our procedures to modernize the logging process to ensure we have all necessary details for each SCRAM in the future.

4. Safety Related Corrective Maintenance

Table III. Summary of Safety Related Maintenance
 (1 January 2020 through 31 December 2020)

Safety related Corrective Maintenance	
Date Performed	Description
3/12/20	Safety Rod 1 (SR1) removed from reactor due to slow insertion times during tests with the new console. Insertion times were 8-10 seconds slower than in 2019 but consistent with SR2.
8/25/20	Course Control Rod (CCR) removed from reactor due to binding at top of travel and below 7cm insertion. Adjustment to CCR drive was made and tested until acceptable results achieved.
9/4/20	Channel 2 detector removed from water shield tank for inspection due to reading off scale low during operations on 08/28/2020. Detector can was disassembled under fume hood in counting lab and inspected for corrosion and BF3 gas leaks.
9/18/20	Channel 2 detector was returned to water tank in a temporary waterproof container to compare with Channel 3 detector readings. No difference in Channel 2 reading was noticed. Channel 2 detector was removed.
10/2/20	Channel 2 cables were cleaned and inspected by Craig Shull and then tested with the Channel 2 detector. The signal returned to levels similar to those measured on 08/28/20 before the original problem.
10/2/20	Channel 2 detector returned to reactor vessel in new detector can made of PVC instead of the original aluminum can per 50.59 Screen <i>ISU-50.59-2020-1</i> . The original aluminum can was pitted and prone to leaking. The outside of the can was previously coated in FlexSeal to ensure a watertight seal, but it should not be used for a permanent solution.
10/23/20	Channel 2 low level trip setpoint was changed from 2E-13 amps to 3E-13 amps to ensure compliance with Technical Specifications.
10/23/20	A 35 μ F capacitor was added to Channel 2 to eliminate low level noise scram issues due to a short Time Constant. This capacitor increases the Time Constant of the circuit closer to the vacuum tube circuit.

Table IV. Summary of New Console Work
 (1 January 2020 through 31 December 2020)

New Console Work	
Date Performed	Description
3/13/20	Console validated for control rod installation process.
3/19/20	Channel 2 noise was investigated. A temporary fix of using the Cf-252 source was implemented to prevent low level trip.
3/24/20	New console powered through isolation transformer to test if noise is a grounding issue.
3/25/20	New console testing of control rod manipulation on test stand.
5/30/20	Work on new console relay chassis
6/6/20	Continued work on new console relay chassis
6/12/20	Continued work on new console
6/19/20	New Console Initial Startup

5. Modifications

- A. Changes in Facility Design – Reactor console was changed from vacuum tube circuitry to solid state circuitry and went critical on June 19th, 2020 following the *Preparation Procedure for Restart Testing of Idaho State University’s AGN-201 Solid-State Control System*.
- B. Changes to Procedures – Operating Procedure #1 was updated to reflect the new console.
- C. Changes to Experiments – None
- D. Reactor Safety Committee

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

Kermit Bunde – Chair (DOE-ID)
 Mary Lou Dunzik-Gougar, PhD – Reactor Administrator (Assoc. Dean, ISU)
 George Imel, PhD – Assistant Reactor Administrator (Prof., ISU)
 Jonathan Scott – Reactor Supervisor
 John Longley – Radiation Safety Officer
 Robert Boston, PE, CHP (DOE-ID Manager)
 Jay F. Kunze, PhD, PE, CHP (Emeritus Prof., ISU)
 Benjamin Baker, PhD (INL)
 Mark Cox (INL)
 Jason Andrus, PE (INL)

6. Summary of Changes Subject to 10 CFR 50.59 Analyses – Modified the detector can from the original aluminum can design to a PVC design. *ISU-50.59-2020-1* screening was completed and determined that no evaluation was needed.

7. Radioactive Effluents

A. Liquid Waste – Total Activity Released – None

B. Gaseous Waste – Total Estimated Activity Released

The AGN-201 Reactor was operated for 45.1456 Watt-hours at power levels up to approximately 4.8 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 0.9372 μCi using Equation (2). 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.

Table IV. Summary of Monthly Gaseous Radioactive Effluent Releases
 (1 January 2020 through 31 December 2020)

Year Totals Ar-41		
January	0.1218	μCi
February	0.0008	μCi
March	0.0101	μCi
April	0.0000	μCi
May	0.0000	μCi
June	0.2056	μCi
July	0.1667	μCi
August	0.1595	μCi
September	0.0000	μCi
October	0.2725	μCi
November	0.0003	μCi
December	0.0000	μCi
Total	0.9372	μCi

$$A_{\text{Ar-41}} (\text{Ci}) = \frac{\sigma_{\text{Ar-40}} * Y_{\text{Ar-40}} * m_{\text{Ar-40}} * (0.961) * P(\text{Whr}) * M_{\text{U-235}} * \left(\frac{3600}{\text{Whr}} \right) * \lambda_{\text{Ar-41}}}{M_{\text{Ar-40}} * E_{\text{R}} * m_{\text{U-235}} * \sigma_{\text{U-235}} * (3.7 \times 10^{10} \frac{\text{Bq}}{\text{Ci}})} \quad (2)$$

C. Solid Waste – Total Activity – None

8. Environmental Radiation survey

A environmental radiation survey was not completed in 2020 due to COVID-19 and the reactor being inoperable. Reactor personnel are working with the Radiation Safety Office to schedule an environmental radiation survey once the reactor is operational again.

9. Radiation Exposure

The Radiation Safety Officer reviews personnel Radiation exposure quarterly. Annual reports of ionizing radiation doses are provided by the Radiation Safety Officer to all monitored personnel as specified in Section 15.4 of the ISU Radiation Safety Manual. Personnel are issued dosimeters by the Radiation Safety Department if they meet the criteria of Section 15.1 of the ISU Radiation Safety Manual. All monitored personnel were below dose limits for calendar year 2020.

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 2020 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).

Table VI. Summary of Whole-Body Exposures to the Public
 (1 January 2020 through 31 December 2020)

Estimated Whole-Body Exposure Range (mrem):	Number of Individuals in Each Range:
No Observable Dose	188
1.0 mrem*	8
1.0 mrem < Dose < 5.0 mrem	0
5.0 mrem < Dose < 10.0 mrem	0
10.0 mrem < Dose < 15.0 mrem	0
Dropped Dosimeter**	0
Total Number of Individuals Reported:	196
*Below 1.0 mrem is considered un-measurable **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 196 visitors to the facility during 2020 received a measurable dose that would exceed the annual 0.1 rem dose limit of 10 CFR 20.1301 for members of the public. Therefore, the average and maximum doses received by the personnel and the public are within NRC guidelines.

Report Prepared by:

Jonathan Scott
AGN-201m Reactor Supervisor
Completed: February 5, 2021

Reviewed and Approved by:

Jonathan Scott
AGN-201m Reactor Supervisor
Completed: February 10, 2021

Dr. Mary Lou Dunzik-Gougar
AGN-201m Reactor Administrator
Completed: