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To whom it may concern:

Transmitted herewith is Operations Report No. 76 for the NBSR. The report covers the period January 1, 2023 to December 31, 2023. This re-submission corrects the report number, the signing and submission year, and adds the analyzed annual dose information in section 6.7.1(7).

Sincerely,

James M. Adams
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Enclosure

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**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY REACTOR
(NBSR)**

Docket #50-184

Facility License No. TR-5

Operations Report

-- #76--

January 1, 2023 - December 31, 2023

This report contains a summary of activities connected with the operations of the NBSR. This report fulfills the requirements of section 6.7.1 of the NBSR Technical Specifications for the period from January 1, 2023 to December 31, 2023.

The section numbers in the report (such as 6.7.1(1)) correspond to the sections in the Technical Specifications.

April 24, 2024,

James M. Adams
Director, NIST Center for Neutron Research

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6.7.1(1) Summary of plant operations including the energy produced by the reactor and the hours the reactor was critical

During the period January 1, 2023, through December 31, 2023, the reactor was critical for 125.4 hours with a thermal energy output of 78.4 MWH (0.16 equivalent full power days). Major activities during this period included:

- Continued efforts directly involved to recover the reactor.
 - Operated the reactor to determine the operational impacts.
 - Operated the reactor at a maximum of 1 MW nominal thermal power.
 - Observed elevated Fission Products in the helium sweep gas
 - Observed elevated Fission Products in the B-1 area of the confinement building. Controls were established for entry into B-1 during and after operations.
 - Started plans to locate Fission Product causing debris, analyze fission product impacts, and mitigating the impacts of fission product causing debris.
- Training
 - Expanded the requalification training to include 3 training topics. These trainings were scheduled for 3 to 4 hours in length and included the entire shift. Below are the training topics
 - Emergency Plan and Emergency Instructions
 - Administrative Rules and applicable Title 10 Code of Federal Regulations sections
 - Reactor Theory
- Fuel Transfers
 - On 1/13/23 moved the remaining 3 elements out of the vessel to the spent storage pool.
 - On 3/10/23 moved elements within the vessel
 - On 3/14/23 moved inserted 13 new elements
- Shipments
 - On 2/21/23 received 2 fresh fuel elements
 - On 2/27/23 received 2 fresh fuel elements
 - On 3/10/23 received 1 fresh fuel element

6.7.1(2) Unscheduled shutdowns, including reasons therefore

On 8/9/23 a loss of power caused a loss of main coolant pumps and loss of ventilation. The reactor scrammed on a loss of flow. Shortly after the scram the loss of ventilation allowed fission product gasses to trip the irradiated air monitor for a major scram at the reduced 5,000 counts setpoint. SF-19 was started to turn the air over for the detector allowing the restart of ventilation and placing the reactor facility in a normal configuration.

6.7.1(3) Tabulation of major preventative and corrective maintenance operations having safety significance

Note: Some of these items may be also listed as Engineering Change Notices (ECN) in section 6.7.1(4).

The following list is significant I &C maintenance tasks:

31 regularly scheduled calibrations

- 01/25/23 BTUR
- 01/30/23 RM 4-6
- 02/16/23 FIA-10
- 02/22/23 LIA-40
- 03/07/23 RD 3-5
- 03/09/23 NC-4
- 03/10/23 NC-7
- 04/17/23 NC-2
- 04/17/23 RD 3-1
- 04/17/23 RD 3-3
- 05/08/23 TIA-40A
- 05/17/23 RM 4-5
- 06/15/23 NC-3
- 06/28/23 RM 1-15
- 07/07/23 PC-3
- 07/11/23 NC-1
- 07/26/23 FRC-3
- 07/26/23 FRC-4
- 08/14/23 RD 3-4
- 08/15/23 NC-5
- 08/17/23 PC-150
- 08/17/23 PS-150

- 09/12/23 LRC-1
- 10/02/23 RD 4-1
- 10/11/23 PT-27
- 10/11/23 PS-151
- 10/17/23 TIA-40B
- 10/25/23 RD 1-1 to RD 1-10
- 11/06/23 LCA-19
- 11/07/23 RD 4-2
- 11/08/23 RD 3-2

The following maintenance occurred during the unscheduled/scheduled shutdowns.

- 01/05/2023 Performed smoke test and leak checks around SF-1 and SF-11 supply as well as the south end of B1 with both building vacuum and pressure.
- 01/06/2023 Commenced replacement of ACV-28, ACV-29, ACV-30, and ACV-31.
- 01/12/2023 Completed testing of ACV-28, ACV-29, ACV-30, and ACV-31.
- 01/25/2023 Repaired high-capacity bleed line upstream of CAV-43.
- 01/26/2023 Commenced disassembly of telescopic cylinder.
- 01/31/2023 Replaced Cold Source Diaphragm Pump "B".
- 02/02/2023 Replaced leaking air hose for North Vestibule door seal.
- 02/21/2023 Epoxy was injected into cement cracks around the air intake louvre for SF-11 and SF-2.
- 02/23/2023 Continued work on the refueling cannon telescopic cylinder. Cleaned the cannon raising piston components and successfully test-fit the newly made bearing for the piston.
- 03/02/2023 Replaced the B2 air dryer for the compressed air system.
- 03/07/2023 Contractors finished refurbishment of Helium bulk tanks.
- 03/09/2023 Configured and replaced the signal conditioner for log output (AT4-1) for NC-4.
- 03/09/2023 Contractors repaired leaks on the stub pipe for #6 pressure relief and another valve.
- 03/09/2023 The rate meter for RM 3-5 was documented as replaced.
- 03/09/2023 Installed re-built motor for North Vestibule Confinement door.
- 03/21/2023 Repaired two leaks on helium bulk tanks.
- 04/10/2023 Plant sealed EF-3 ducting.
- 04/11/2023 Plant worked on EF-3 ducting. Put new foam on EF-3 cover to linkage.
- 04/12/2023 Plant worked on sealing EF-3 ducting.
- 04/17/2023 Conducted smoke test of ductwork.
- 04/17/2023 TK250 and HV modules replaced with spares in shop. Calibrated

NC2.

- 04/18/2023 Removed B1 panel to seal EF-3 duct leaks by damper.
- 04/19/2023 Checked EF-3 leakage with smoke test.
- 04/28/2023 Sealed more ducting and checked EF-4 ducting for leaks.
- 04/28/2023 Completed replacement of the four cannon hoses.
- 05/01/2023 Tested EF-3 ducting for leaks and resealed leaks that were found.
- 05/01/2023 TVSS for MCC-B6 was replaced in the month of May.
- 05/02/2023 Leak tested EF-23 ducting and resealed leaks.
- 05/03/2023 Smoke tested EF-3 ducting.
- 05/10/2023 Replaced diesel day tank overflow pump and control panel lights.
- 05/12/2023 Replaced gasket on HEV-2 flange.
- 06/12/2023 Performed MP 5.51.0, for ECN 1169 Conduit Seal Leakage Test, for helium recovery project.
- 06/14/2023 Contractor sealed ducting per ECN-1296 Repair Sealing of Ductwork, on B1 from 06/14/2023-06/16/2023.
- 06/15/2023 Completed MP 5.68.04 for ECN 1260 Automatically Securing Carbon Dioxide Following a Major Scram.
- 06/16/2023 Replaced diaphragms for HEV-40 and HEV-41. In addition, replaced diaphragm for HEV-41 operator.
- 06/20/2023 Cleaned and tested alarm relay contacts for RM 3-4.
- 07/07/2023 Assembled and installed the new gear boxes for the shim arms. Tested each shim to 12 degrees and scrambled.
- 07/21/2023 Replaced UPS for Refueling Test Panel.
- 07/23/2023 Replaced diodes for NC-1.
- 07/28/2023 Replaced process loop voltage regulator for cooling tower basin temperature.
- 08/01/2023 Replaced failed alarm module for BT-9 H2 Pressure C alarm.
- 08/10/2023 Performed external leak check of IRV-5 and 6.
- 08/18/2023 Worked on ECN-1305 Shim Arm Drive Gear-Clutch Shaft Redesign for all four shims.
- 08/21/2023 ECN-1290 Add Forced Ventilation to B1 space was commenced.
- 09/05/2023 Replaced diaphragm for HEV-77.
- 09/08/2023 Replaced PIA-32, HE-2 Primary/Secondary ΔP meter.
- 09/08/2023 Completed alignment of four main D2O pumps after shaft seal replacement.
- 09/12/2023 Differential pressure transmitter was replaced and calibrated for FI-17 for auxiliary secondary flow.
- 09/18/2023 Repaired DWV-100A fuse clip.
- 10/10/2023 Replaced N-16's system per ECN-1271 N16 Monitoring System Replacement.
- 10/12/2023 Replaced section of secondary shutdown pump outlet piping that had

- rusted through.
- 11/01/2023 Worked on #1 and #3 main D20 pumps per MP 2.92, Main D2O Pump Seal Replacement
 - 11/03/2023 Re-performed portions of MP 2.92 Main D2O Pump Seal Replacement for #1 and #3 main D20 pumps.
 - 11/03/2023 The duplicate RM 3-2 channel that was installed on the Yokogawa has been removed, testing complete.
 - 11/06/2023 Helium leak tested main D2O pumps #1 and #3 per MP 2.92 Main D2O Pump Seal Replacement.
 - 11/06/2023 Switched control of AN 2-12, 2-16, 2-17, 4-6, 4-7, and 4-8 to the GX-20 recorder on Radiation Monitoring System.
 - 11/08/2023 Tested FTV-32 per ECN-1315 Cannon 3-Way Solenoid Valve Replacement.
 - 11/17/2023 Commenced MP 5.79 #4 shim arm shaft seal replacement.
 - 11/20/2023 Replaced ACV hoses per MP 2.2.3 Installation of Pneumatic Hoses.
 - 11/30/2023 Continued MP 5.79 to replace mechanical seal on #4 shim shaft. Cleaned the interior mating surface. The new mechanical seal was installed and the shaft completely reinserted into the shim.
 - 11/20/2023 Removed cover and cycled locking mechanism for process room door. Cleaned up parts and retested satisfactory.
 - 11/29/2023 Tightened packing for SCV-20
 - 12/12/2023 Replaced Diesel "A" Primary/Secondary selector switch.
 - 12/13/2023 Tested the ARM's per TSP4.7.1(4) after ECN 1180 NBSR Radiation Monitoring System installation.

6.7.1(4) A brief description, including a summary of the safety evaluations, of changes in the facility or in procedures and of test and experiments carried out pursuant to 10 CFR 50.59

There were 14 Level II Engineering Change Notifications (ECN) for which further evaluation was performed using 10 CFR 50.59.

ECR Number	ECR Title	Created
1330	Shim Arm Shaft Seal Replacement Procedure Corrections MP 5.79	12/7/2023
1327	Shim Arm Drive Shaft Seal Replacement Documentation	11/28/2023
1314	LAR for Tritium Gas Storage at the NCNR	9/18/2023
1305	Shim Arm Drive Gear-Clutch Shaft Redesign	6/30/2023

1304	Additional Gas Sampling for Fission Product Monitor system	6/26/2023
1303	Shim gear-clutch shaft modification to correct setscrew issues	6/23/2023
1294	Updates for the NBSR Alternative Fuel Management Schemes Analysis Procedure	5/5/2023
1291	Active control of Reactor Vessel He pressure	5/2/2023
1282	Harmonizing debris license amendment with TS 3.7.1(2) basis	3/23/2023
1276	HEU Fuel Specification Stray Particles outside Fuel Zone	2/13/2023
1275	Source Range Detector Validation and High Voltage Control Switch Change	2/7/2023
1274	Cycle 655 AFMS Core Loading Analysis	2/2/2023
1272	Replacement of Confinement North Seal Door Motor	1/10/2023
1271	N16 Monitoring System Replacement	1/10/2023

6.7.1(5) Summary of the nature and amount of radioactive effluents released or discharged to the environs and the sewer beyond the effective control of the licensee as measured at or prior to the point of such release or discharge

The table below summarizes 40 discrete releases into the sanitary sewer for which HP did analysis and notifications; there were thirty-seven tank releases from tanks #1 and #2 (~94,522 gallons), and three separate individual Cooling Tower Basin (aka “secondary”) releases (~263,600 gallons). Blowdown releases are not considered here.

H-3 ⁽¹⁾ (STDEV[2s%]) ⁽⁴⁾	C-14 ⁽¹⁾ (STDEV[2s%]) ⁽⁴⁾	Beta ⁽²⁾ (STDEV[2σ]) ⁽⁴⁾	Gamma ^(2, 3) (STDEV[2σ]) ⁽⁴⁾	Alpha ^(2, 5) (STDEV[2σ]) ⁽⁴⁾
1.138 Ci (0.002 Ci)	0.003 Ci (0.001 Ci)	290 μCi (80 μCi)	5.4 μCi (0.9 μCi)	20 μCi (21 μCi)

1. Via Liquid Scintillation Spectroscopy (TRI-CARB).
2. Gamma column is from a one-hour count on a Mirion HPGe gamma spectrometer. Beta and Alpha columns are from 15-minute counts from Tennelec/Mirion Model 6 type-instruments Beta activity includes contributions from gamma radionuclides. “Negative” disintegration/minute values for Mirion counters are assigned the value of zero (and hence the statistics are skewed upwards).
3. There were ~40 gamma isotope samples, with an average of ~923 g ($\sigma_{(N-1)} = 100$ g) in 1000 ml Marinelli beakers. The 2023 total activities of detected gamma emitters are, in approximate decreasing order of reported values: Co-60, Cs-137, Ce-144/Pr-144, Tc-99m/Mo-99. The identity assignment for the last pair is conservative; the pertinent activity was quite small, the peak location for this pair is near in location to a low-activity background artifact of the detector, and the pair is not common at the NCNR.
4. STDEV refers to the average propagated standard deviation using an Excel® function. For Alpha and Beta activity, 2σ is two times the standard sigma function. For H-3 and C-14, 2s% refers to a Packard/Perkin Elmer industry standard function, where 2s% is the percent uncertainty in a gross count value (with 95% confidence limits), or 2s% = (100 X 2 X σ) / (Total Counts).
5. Alpha has historically been attributed to natural background.

Gaseous releases from the NBSR Reactor Stack for the Calendar year of 2023 included Tritium (H-3), Argon-41 (Ar-41) and gaseous fission products. These releases are summarized in the table below.

The reactor began operating in 2023 for the first time since the February 3, 2021 incident. Most of the reactor startups in 2023 were done for the purpose of low power testing but also to give reactor operator trainees time on the console and for NRC reactor operator certification exams. One megawatt is the highest power level that the reactor achieved during this testing.

2023 total Activity Releases from the Reactor Stack Gaseous Effluents (Ci)

H-3	Ar-41	Kr-85m	Kr-87	Kr-88	Xe-135	Xe-135m	Xe-138
523	0.298	0.924	2.86	2.51	1.90	0.413	5.090

H-3 releases were calculated in the usual manner, a routine (as often as weekly) reactor stack cold trap.

Ar-41 releases are calculated based on the reactor stack monitoring system that employs a GM tube in the stack that reports back to a Ludlum 375. With the addition

of gaseous fission products (attributed to tramp uranium in the reactor vessel because of the February 3 incident) in the effluent not usually seen in past years of reactor operations, a fraction of the counts seen in the stack monitor can be attributed to the fission products and not Ar-41. As a conservative estimate, the full counts were used to determine the Ar- 41 releases w/o any attempt to account for counts from fission products. This method is considered an overestimation of the Ar-41 released and is done to assure compliance with NRC release limits.

In the past, fission product releases were measured using reactor stack charcoal and particulate filter analysis. The analysis of these filters in 2023 showed no detectable isotopes. Stack Marinelli grab sampling was also conducted on various days for the purpose of identifying and quantifying gaseous fission products. These Marinelli samples were taken after the reactor had reached an equilibrium state at maximum power level for the day just prior to reactor shutdown. Marinelli sampling was conducted on multiple days but not on all days that the reactor had restarted. Samples were collected at every novel power level. On days where a sample wasn't collected, a previous day's data was used to estimate fission product release that had been measured at the same power level. Total release activities for fission products were calculated for each day the reactor was operated. As a conservative estimate the maximum concentrations measured are used to estimate the releases based on the time frame where counts in the reactor stack monitoring system were seen above background after reactor startup to the time where they fell back to background levels after the reactor was shut down. This method is considered an overestimation of the fission products released and is done to assure compliance with NRC release limits.

An analysis of this effluent release was performed using the EPA Comply Code software. This analysis showed that the total effective dose to a member of the public would be no greater than 0.1 mrem for the year.

