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RESEARCH REACTOR CENTER

February 27, 2014

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-37
Washington, DC 20555-0001

REFERENCE: Docket 50-186
University of Missouri-Columbia Research Reactor
Amended Facility License R-103

SUBJECT: University of Missouri Research Reactor
2013 Reactor Operations Annual Report

Enclosed is a copy of the Reactor Operations Annual Report for the University of Missouri Research Reactor. The reporting period covers January 1, 2013 through December 31, 2013.

This document is submitted to the U.S. Nuclear Regulatory Commission in accordance with the University of Missouri Research Reactor Technical Specification 6.1.h(4).

If you have any questions regarding the contents of this report, please contact John Fruits at (573) 882-5319 or FruitsJ@missouri.edu.

Sincerely,

John L. Fruits
Reactor Manager

ENDORSEMENT:
Reviewed and Approved

Ralph A. Butler, P.E.
Director

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UNIVERSITY OF MISSOURI RESEARCH REACTOR

REACTOR OPERATIONS ANNUAL REPORT

January 1, 2013 – December 31, 2013

UNIVERSITY OF MISSOURI
RESEARCH REACTOR FACILITY

REACTOR OPERATIONS
ANNUAL REPORT

January 1, 2013 through December 31, 2013

Compiled by the Research Reactor Staff of MURR

Submitted by: _____

John L. Fruits
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Director

UNIVERSITY OF MISSOURI – COLUMBIA
RESEARCH REACTOR

REACTOR OPERATIONS ANNUAL REPORT

January 1, 2013 through December 31, 2013

INTRODUCTION

The University of Missouri Research Reactor (MURR) is a multi-disciplinary research and education facility providing a broad range of analytical, materials science and irradiation services to the research community and the commercial sector. Scientific programs include research in archaeometry, epidemiology, health physics, human and animal nutrition, nuclear medicine, radiation effects, radioisotope studies, radiotherapy, boron neutron capture therapy and nuclear engineering; and research techniques including neutron activation analysis, neutron and gamma-ray scattering and neutron interferometry. The heart of this facility is a pressurized, reflected, open pool-type, light water moderated and cooled, heterogeneous reactor designed for operation at a maximum steady-state power level of 10 Megawatts thermal – the highest powered university-operated research reactor in the United States.

The Reactor Operations Annual Report presents a summary of reactor operating experience for calendar year 2013. Included within this report are changes to MURR reactor operations and health physics procedures, revisions to the Hazards Summary Report, facility modifications, new tests and experiments, reactor physics activities and environmental and health physics data.

This report is being submitted to the U.S. Nuclear Regulatory Commission (NRC) to meet the administrative requirements of MURR Technical Specification 6.1.h (4).

ACKNOWLEDGMENTS

The success of MURR and these scientific programs is due to the dedication and hard work of many individuals and organizations. Included within this group are: the University administration; the governing officials of the State of Missouri; the Missouri State Highway Patrol; the City of Columbia Police Department; the Missouri University Police Department (MUPD); the Federal Bureau of Investigation (FBI); our regulators; those who have provided funding including the Department of Energy (DOE), the National Nuclear Security Administration (NNSA) and the Department of Homeland Security (DHS); Argonne National Laboratory (ANL); Idaho National Laboratory (INL); Sandia National Laboratories (SNL); the researchers; the students; the Columbia Fire Department; the Campus Facilities organization; members of the National Organization of Test, Research and Training Reactors (TRTR); and many others who have made, and will continue to make, key contributions to our overall success. To these individuals and organizations, the staff of MURR wishes to extend its fondest appreciation.

Some of the major facility projects that were supported by Reactor Operations during this calendar year included (1) implementing Amendment No. 36 to Amended Facility License No. R-103, which revised the Safety Limit Curves based on newer, more accurate power peaking factors developed using a 3-dimensional diffusion code, (2) replacement of the 30-degree graphite reflector elements 'GH' and 'IJ' with a single 60-degree graphite reflector element 'GHIJ,' and (3) irradiating and processing a 5-gram natural uranium target to determine the feasibility of producing molybdenum-99 using a selective gaseous extraction process. Additionally, in August 2006 MURR submitted a request to the NRC to renew

Amended Facility License No. R-103. Significant efforts have already been placed in responding to the Requests for Additional Information and these efforts continued in this past year.

The facility continues to actively collaborate with the Reduced Enrichment for Research and Test Reactors (RERTR) Program and four other U.S. high-performance research reactor facilities that use highly-enriched uranium (HEU) fuel to find a suitable low-enriched uranium (LEU) fuel replacement. Although each one of the five high-performance research reactors is responsible for its own feasibility and safety studies, regulatory interactions, fuel procurement and conversion, there are common interests and activities among all five reactors that will benefit from a coordinated, working-group effort. This past year, resources were focused on completing Phase 1 accident analyses for the LEU conversion core.

MURR also hosted the 2013 Annual Test, Research and Training Reactors Conference. The TRTR organization represents research reactor facilities across the nation from government, major universities, national laboratories and industry. TRTR's primary mission is education, fundamental and applied research, application of technology in areas of national concern and improving U.S. technological competitiveness around the world. TRTR membership includes managers and directors of research reactors, educators, administrators, regulators and research scientists and engineers.

Reactor Operations Management also wishes to commend the five individuals who received their Reactor Operator certifications and the four individuals who received their Senior Reactor Operator certifications from the NRC. These individuals participated in a rigorous training program of classroom seminars, self-study and on-the-job training. The results of this training are confident, well-versed, decisive individuals capable of performing the duties of a licensed operator during normal and abnormal situations.

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SECTION I

REACTOR OPERATIONS SUMMARY

January 1, 2013 through December 31, 2013

The following table and discussion summarizes reactor operations during the period from January 1, 2013 through December 31, 2013.

Month	Full Power Hours	Megawatt Days	Full Power % of Total Time	Full Power % of Scheduled[1]
January	679.75	283.43	91.4	102.3
February	589.33	245.87	87.7	98.2
March	664.72	277.30	89.3	100.0
April	619.93	258.61	86.1	96.6
May	649.35	270.93	87.3	97.7
June	633.77	264.35	88.0	98.7
July	653.10	272.39	87.8	98.3
August	653.01	272.41	87.8	98.3
September	631.41	263.39	87.7	98.4
October	672.05	280.20	90.3	101.1
November	656.37	273.77	91.2	102.2
December	666.32	277.85	89.6	100.3
Total for the Year	**7769.11**	**3240.50**	**88.68 %**	**99.34 %**

Note 1: MURR is scheduled to average at least 150 hours of full power operation per week. Total time is the number of hours in the month listed or the year.

January 2013

The reactor operated continuously in January with the following exceptions: four shutdowns for scheduled maintenance and/or refueling and one shutdown for physics measurements. There were no unscheduled/unplanned power reductions this month.

Major maintenance items for the month included: replacing Reactor Pool Reflector Region Differential Pressure Transmitter PT-917; and performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B)."

February 2013

The reactor operated continuously in February with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, two shutdowns for physics measurements and two unscheduled/unplanned power reductions.

On February 23, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not In Contact With Magnet" rod run-in was automatically initiated when the reactor safety system yellow leg Trip Actuator Amplifier

(TAA) de-energized, causing control blades 'A' and 'B' anvils to separate from their electromagnets and drop. A manual scram was then initiated and all immediate and subsequent actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Investigation of all relays and wiring associated with this portion of the reactor safety system revealed that a normally closed contact in the manual scram switch, 1S10, was intermittently making a poor connection. The contact blocks in the manual scram switch were burnished and the yellow leg TAA was replaced. The system was retested satisfactorily and permission to restart the reactor was obtained from the Reactor Manager. The reactor was refueled and subsequently restarted to 10 MW operation.

On February 23, with the reactor operating at 10 MW in the automatic control mode, a reactor scram was automatically initiated when an interruption in electrical supply power from the University Power Plant to the facility occurred. All immediate and subsequent actions of reactor emergency procedure REP-11, "Momentary Loss of Normal Electrical Power," were performed. Permission to restart the reactor was obtained from the Lead Senior Reactor Operator after confirmation from the power plant that the cause of the interruption in electrical power was corrected. A "hot reactor startup" was performed to return the reactor to 10 MW operation.

Major maintenance items for the month included: replacing the 30-degree graphite reflector elements 'GH' and 'IJ' with a single 60-degree graphite reflector element 'GHIJ;' and replacing the pool coolant demineralizer system inlet filters.

March 2013

The reactor operated continuously in March with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, two shutdowns for physics measurements and four unscheduled/unplanned power reductions. U.S. Nuclear Regulatory Commission inspector arrived at the facility for a routine inspection of the Radiation Protection Program and Shipping.

On March 4, while reviewing a list of the completed maintenance items and compliance procedures performed that day, the Surveillance Programs System Specialist discovered that compliance procedure CP-27, "Power Level Interlock Static Scram," was not completed within the prescribed Technical Specification (TS) periodicity. Failure to perform the surveillance within the required time interval resulted in a deviation from TS 5.4. Licensee Event Report No. 13-01 was submitted to the U.S. Nuclear Regulatory Commission on April 2, 2013. The compliance procedure was performed on March 11, the next scheduled maintenance day after discovery of the error.

On March 5, with the reactor operating at 10 MW in the automatic control mode, an unannounced (no audible or visual alarm occurred) rod run-in was automatically initiated. The control room operator immediately noted all four shim control blades moving in the inward direction. After a brief investigation was unable to determine the cause of the rod run-in, the rod run-in was not manually reset and the reactor was shut down. Subsequent investigation of all power supplies, relays, switches and wiring connections associated with the rod run-in system revealed no abnormalities. Additional troubleshooting and investigation were unable to reproduce this system response. Operational checks of the rod run-in system were performed satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On March 5 (5 hours and 55 minutes after the previous power reduction), with the reactor operating at 10 MW in the automatic control mode, an unannounced (no audible or visual alarm occurred) rod run-in was automatically initiated. The control room operator immediately noted all four shim control blades moving in the inward direction. After a brief investigation was unable to determine the cause of the rod run-in, the reactor was manually scrammed. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Subsequent

investigation did not identify a failed component; however, the most likely cause was a failure of either the rod run-in system Trip Actuator Amplifier (TAA) or Non-Coincidence Logic Unit (NCLU). The rod run-in system TAA and NCLUs were replaced and operational checks of the rod run-in system were performed satisfactorily. Permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On March 13, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'D' anvil separated from its electromagnet during a routine sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The operators involved were counseled on the importance of proper sample handling techniques near the offset mechanisms. Visual verification of the pull rod to housing alignment was performed. The reactor was refueled and permission to restart the reactor was obtained from the Lead Senior Reactor Operator. The reactor was subsequently restarted to 10 MW operation.

On March 20, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'A' anvil separated from its electromagnet during a routine sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The operators involved were counseled on the importance of proper sample handling techniques near the offset mechanisms. Visual verification of the pull rod to housing alignment was performed. The reactor was refueled and permission to restart the reactor was obtained from the Lead Senior Reactor Operator. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: completing Modification Record 13-03, "Replacement of GH and IJ Wedge with a Single 60° Wedge;" completing Modification Record 12-02, "Control Blade Fabrication Alternative Using Laser Welding;" completing Modification Record 01-02, Addendum 9, "Intercommunication and Paging System Changes in Support of MURR Industrial Building (Room 299) Renovations;" performing two reactivity worth measurements in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-203, "Measurement of the Primary Coolant/Moderator Temperature Coefficient of Reactivity, RTP-19," in support of a Nuclear Engineering Department practicum; performing a reactivity worth measurement in accordance with reactor procedure RP-RO-200, "Measurement of Differential Worth of a Shim Blade, RTP-11(D)," in support of a Nuclear Engineering Department practicum; and loading new de-ionization bed 'F' and placing on pool coolant system service.

April 2013

The reactor operated continuously in April with the following exceptions: five shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements and one unscheduled/unplanned power reduction. One additional reactor startup and shutdown were performed in support of NRC operator license examinations. MURR received notification from the U.S. Nuclear Regulatory Commission that two new Reactor Operator and one new Senior Reactor Operator licenses had been issued.

On April 30, with the reactor operating at 10 MW in the automatic control mode, an unannounced (no audible or visual alarm occurred) rod run-in was automatically initiated. The control room operator immediately noted all four shim control blades moving in the inward direction. The reactor was then subsequently shut down. Subsequent investigation did not identify a failed component; however, two resistors in the Trip Actuating Amplifier (TAA) circuit were determined to have resistance values outside their specified tolerances. Both resistors were replaced.

Operational checks of the rod run-in system were performed satisfactorily and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: performing extensive troubleshooting on the rod run-in system wiring; completing Modification Record 11-03, Addendum 1, "Addition of Blow-Down Meter to the Data Acquisition Monitoring System;" completing Modification Record 13-02, "Replacement of Secondary Chemistry Controllers;" replacing primary coolant circulation pump P-501A; performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-200, "Measurement of Differential Worth of a Shim Blade, RTP-11(D);" replacing the actuator for manual scram switch, 1S10; and completing the biennial change-out of Control Blade 'A' Offset Mechanism and associated retesting.

May 2013

The reactor operated continuously in May with the following exceptions: five shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements and three unscheduled/unplanned power reductions.

On May 7, with the reactor operating at 10 MW in the automatic control mode, a manual scram was initiated when an operator discovered the regulating blade would not move in the inward direction. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram" were performed. Subsequent investigation revealed the ball plunger for the overload clutch had loosened and slightly backed out preventing the movement of the servomotor from being transferred to the lead screw assembly, thus preventing the regulating blade from being able to drive in the outward and inward directions. The overload clutch was inspected and the ball plunger was replaced. Operational checks of the regulating blade were performed satisfactorily and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

Failure of the regulating blade to be operable during reactor operation resulted in a deviation from Technical Specification 3.4.c. Licensee Event Report No. 13-02 was submitted to the U.S. Nuclear Regulatory Commission on June 4, 2013.

On May 8, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'D' anvil separated from its electromagnet during a routine sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The operators involved were counseled on the importance of proper sample handling techniques near the offset mechanisms. Visual verification of the pull rod to housing alignment was performed. The reactor was refueled and permission to restart the reactor was obtained from the Lead Senior Reactor Operator. The reactor was subsequently restarted to 10 MW operation.

On May 14, with the reactor operating at 10 MW in the automatic control mode, an unannounced (no audible or visual alarm occurred) reactor scram was automatically initiated. Investigation revealed all monitored parameters were normal and none had trended toward an automatic scram set point or exhibited any abnormalities. Subsequent troubleshooting efforts led to the replacement of Power Level Interlock relay 1K26. Operational checks of the Power Level Interlock circuit were performed satisfactorily and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: replacing Power Level Interlock relay 1K26; replacing the diaphragm and inlet and outlet flange gaskets for pool coolant demineralizer pump P-513B Discharge Valve 515N;

completing compliance procedure CP-26, "Containment Building Compliance Test;" and performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B)."

June 2013

The reactor operated continuously in June with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements and two unscheduled/unplanned power reductions.

On June 11, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'A' anvil separated from its electromagnet during a routine sample handling evolution. The reactor was manually scrammed and the immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Inspection of the offset mechanism pull rod and housing revealed a slight misalignment between the anvil and electromagnet. The lower drive limit switch was adjusted and the anvil and electromagnet were cleaned. The control rod was satisfactorily withdrawn to the full out position as part of the retest by performing compliance procedure CP-10, "Rod Drop Times." Permission to perform a "hot reactor startup" was obtained from the Reactor Manager. While conducting the "hot reactor startup," the Reactor Operator noted, immediately after stabilizing reactor power level at 5 MW, that the heights of shim control blades 'B' and 'D' were at 21.90 and 23.10 inches, respectively. This 1.20 inch difference in shim blade height created a deviation from Technical Specification (TS) 3.2.b, which states, "Above 100 kilowatts the reactor shall be operated so that the maximum distance between the highest and lowest shim blade shall not exceed one inch." Licensee Event Report No. 13-03 was submitted to the U.S. Nuclear Regulatory Commission on July 10, 2013.

On June 14, with the reactor operating at 10 MW in the automatic control mode, an unannounced (no audible or visual alarm occurred) rod run-in was automatically initiated. The control room operator immediately noted all four shim control blades moving in the inward direction. The reactor was then subsequently shut down. Subsequent investigation did not identify a failed component. Additional troubleshooting and investigation were unable to reproduce this system response. Operational checks of the rod run-in system were performed satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: performing extensive troubleshooting on the rod run-in system wiring connections; completing Modification Record 13-04, "Rod Run-In Monitoring System;" completing Modification Record 75-01, Addendum 3, "Rod Run-In Electronic Circuit Jumper Panel;" completing Modification Record 13-01, "Replacement of TE-980A and TE-980B Power Supply 2PS5;" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" and replacing the Loss of Voltage to Magnet A and B Scram relay 2K20 and the Loss of Voltage to Magnet C and D Scram relay 2K21.

July 2013

The reactor operated continuously in July with the following exceptions: five shutdowns for scheduled maintenance and/or refueling and two unscheduled/unplanned power reductions. U.S. Nuclear Regulatory Commission inspector arrived at the facility for a routine inspection of Security and Material Control and Accountability. The U.S. Nuclear Regulatory Commission issued Amendment No. 36 to Amended Facility License No. R-103.

On July 3, with the reactor operating at 10 MW in the automatic control mode, a "Power Level Interlock or FIRST" scram was automatically initiated when the FIRST Support Rig was inadvertently bumped while performing a routine

sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The flux trap sample holder was verified to be positively latched to the inner reactor pressure vessel. The operators involved were counseled on the importance of proper handling techniques near the FIRST Support Rig. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On July 15, during a reactor startup with the reactor subcritical, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'B' anvil separated from its electromagnet during a shimming evolution. The reactor was shut down and the immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The mating surfaces between the control rod drive mechanism electromagnet and pull rod anvil were cleaned and proper alignment of the offset mechanism pull rod and housing were verified. The control rod was satisfactorily withdrawn to the full out position as part of the retest by performing compliance procedure CP-10, "Rod Drop Times." Permission to restart the reactor was obtained from the Reactor Manager.

Major maintenance items for the month included: performing a reactivity worth measurement in accordance with reactor procedure RP-RO-200, "Measurement of Differential Worth of a Shim Blade, RTP-11(D);" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" replacing Vent Tank Discharge Check Valve 550A; replacing Pool Below Refuel Level relay 2K5; replacing the chassis edge connectors for the rod run-in system and the reactor safety system Trip Actuator Amplifiers and Non-Coincidence Logic Units; and replacing the air actuator and diaphragm on pressurizer Water Drain Valve 527A.

August 2013

The reactor operated continuously in August with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements, one shutdown for training and four unscheduled/unplanned power reductions.

On August 21, with the reactor operating at 10 MW in the automatic control mode, a "Reactor Loop Low Pressure" scram was automatically initiated. All immediate and subsequent actions of reactor emergency procedure REP-3, "Primary Coolant System Low Pressure or Flow Scram," were performed. No actual low pressure condition indication was present. Investigation determined the most likely cause to be reactor core outlet pressure channels 944A or 944B. Contacts on Reactor Pressure/Flow Interlock relays 2K32 and 2K33 were burnished, reactor core outlet pressure transmitters were vented and applicable sections of compliance procedure CP-22, "Pressure Transmitters PT-944A/B and PT-943," were completed satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On August 23, with the reactor operating at 10 MW in the automatic control mode, a "Reactor Loop Low Pressure" scram was automatically initiated. All immediate and subsequent actions of reactor emergency procedure REP-3, "Primary Coolant System Low Pressure or Flow Scram," were performed. No actual low pressure condition indication was present. Investigation determined the cause to be an intermittent failure of reactor core outlet pressure 944B meter/relay unit. The meter/relay unit was replaced and applicable sections of compliance procedure CP-22 "Pressure Transmitters PT-944A/B and PT-943," were completed satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On August 25, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'D' anvil was separated from its electromagnet during a routine sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The operators involved were counseled on the importance of proper sample handling techniques near the offset mechanisms. Visual verification of the pull rod to housing alignment was performed. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

On August 26, during a reactor startup with the control blades at approximately 11 inches withdrawn (subcritical), a "Channel 2 & 3 Period" scram was automatically initiated when Nuclear Instrumentation (NI) Intermediate Range Channel No. 2 period indication increased above the scram set point. The duty operator noted all power level and period indications other than those from NI Signal Processor No. 1 were normal. All immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Troubleshooting efforts led to the replacement of NI Signal Processor No. 1 fission chamber and its associated cabling. An instrument channel calibration and pre-operational checks were performed satisfactorily, including a response check using the neutron source. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: completing Modification Record 04-05, Addendum 8, "Cooling Tower Electrical Arc Flash Danger Mitigation;" completing Modification Record 12-01, "Replace PT-944A/B with Rosemount Transmitters;" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" performing a chemical cleaning of the secondary coolant side of primary coolant heat exchanger HX-503A; loading new de-ionization bed 'D' and placing it on pool coolant system service; and replacing the fission chamber detector and associated cabling for NI Signal Processor No. 1.

September 2013

The reactor operated continuously in September with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements, two shutdowns for training and two unscheduled/unplanned shutdowns.

On September 16, with the reactor operating at 10 MW in the automatic control mode, a reactor shutdown was initiated after the duty operator observed a blown fuse indication on Annunciator Control Power Fuse 2F7, accompanied, shortly thereafter, by an Uninterruptible Power Supply (UPS) trouble alarm. All other indications for 10 MW operation were normal. Further investigation revealed that the Annunciator 115VAC Supply Breaker on UPS Panel No. 2 was in the tripped condition and the Annunciator inoperable. Troubleshooting efforts determined that the most likely cause of the blown fuse and tripped breaker was a faulty alarm module. The Annunciator alarm module for "Channel 4, 5, or 6 Downscale" function was replaced and an operational test of the Annunciator was completed satisfactorily. Permission to the restart the reactor was obtained from the Reactor Manager. The reactor was subsequently returned to 10 MW operation.

On September 23, with the reactor operating at 10 MW in the automatic control mode, a reactor shutdown was initiated after the duty operator observed a greater than normal lowering of pressurizer liquid level of approximately 2 inches per hour. This abnormal decrease in liquid level was observed shortly after a reactor startup. A reactor refueling had been performed earlier in the day. Subsequent investigation revealed that the source of leakage was from the pressure vessel head packing gland seal, which provides the seal between the pressure vessel head and inner reactor pressure vessel. Note: The pressure vessel head is removed and then subsequently replaced and tightened

after refueling a core has been completed. The packing gland was tightened and permission to restart the reactor was obtained from the Reactor Manager. The reactor was returned to 10 MW operation. Operators were subsequently counseled on proper bolting techniques.

Major maintenance items for the month included: completing Modification Record 01-02, Addendum 10, "Intercommunication and Paging System Changes in Support of MURR Industrial Building (Room 299), Room 243, Room 246 and Room 271 Renovations;" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" completing a change-out of Control Blade 'A' Offset Mechanism and associated retesting; and replacing the "Channel 4, 5 or 6 Downscale" annunciator alarm module.

October 2013

The reactor operated continuously in October with the following exceptions: four shutdowns for scheduled maintenance and/or refueling and one shutdown for physics measurements. There were no unplanned/unscheduled shutdowns this month.

Major maintenance items for the month included: completing Modification Record 04-03, Addendum 1, "Liquid Radioactive Waste System in MURR Industrial Building;" completing Modification Record 13-06, "Modifications to MURR Industrial Building (Room 299) in Support of the NS-99 Project;" replacing Nuclear Instrumentation Power Range "Channel 4 Downscale (95%)" relay unit K58; flooding and draining Beamport 'D' and back filling with helium; performing the biennial change-out of Control Blade 'C' Offset Mechanism and associated retesting; and performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B)."

November 2013

The reactor operated continuously in November with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, two shutdowns for physics measurements and one unscheduled/unplanned power reduction. Three additional reactor startups and shutdowns were performed in support of NRC operator license examinations. U.S. Nuclear Regulatory Commission inspector arrived at the facility for a routine inspection of Reactor Operations and Emergency Preparedness. MURR received notification from the U.S. Nuclear Regulatory Commission that three new Reactor Operator and three new Senior Reactor Operator licenses had been issued.

On November 11, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in was automatically initiated when control blade 'D' anvil separated from its electromagnet during a routine sample handling evolution. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The operators involved were counseled on the importance of proper sample handling techniques near the offset mechanisms. Visual verification of the pull rod to housing alignment and operability tests were performed satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Lead Senior Reactor Operator. The reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: performing a reactivity worth measurement in accordance with reactor procedure RP-RO-200, "Measurement of Differential Worth of a Shim Blade, RTP-11(D);" and performing pre-beryllium change-out center test hole flux profile measurements.

December 2013

The reactor operated continuously in December with the following exceptions: five shutdowns for scheduled maintenance and one shutdown for physics measurements. There were no unscheduled/unplanned power reductions this month.

Major maintenance items for the month included: completing Modification Record 13-05, "T-300 and T-301 Level Sensing System;" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" loading new de-ionizing bed 'R' and placing on pool coolant system service; and performing a chemical cleaning of the secondary coolant side of pool coolant system heat exchanger HX-521.

SECTION II

MURR PROCEDURES

January 1, 2013 through December 31, 2013

As required by administrative Technical Specification 6.1.h (4), this section of the Annual Report includes a summary of procedure changes. These procedure changes were reviewed by the Reactor Manager or Reactor Health Physics Manager, as applicable, and others to assure compliance with the requirements of 10 CFR 50.59. These procedure changes were also reviewed by the Reactor Procedure Review Subcommittee of the Reactor Advisory Committee to meet the requirements of Technical Specification 6.1.c (1).

A. CHANGES TO REACTOR OPERATIONS PROCEDURES

As required by the MURR Technical Specifications, the Reactor Manager reviewed the Reactor Operations Procedures and found them to be adequate for the safe and reliable operation of the facility.

There were sixty-two (62) revisions issued to the reactor operations procedures, forms and operator aids. The majority of the revisions were strictly format or editorial in nature, such as cover page changes. The following is a list of the new and revised procedures, forms and operator aids:

Number	Name	Rev.	Revision Date	Notes
AP-RO-130	Crane Operation	6	3/29/2013	Cover Page
AP-RR-003	10 CFR 50.59 Evaluations	8	6/5/2013	Minor Editorial
EX-RO-105	Reactor Irradiation Experiments	19	5/22/2013	Minor Editorial
FB-SH-110	Type B Shipment of spent Fuel Using the BEA Research Reactor Package	2	4/16/2013	Minor Editorial
FB-SH-110	Type B Shipment of spent Fuel Using the BEA Research Reactor Package	3	5/14/2013	Full Review
FM-11	Reactor Shutdown Checksheet	6	12/20/2013	Cover Page
FM-15	10 CFR 50.59 Qualified Reviewers List	15	6/5/2013	Minor Editorial
FM-15	10 CFR 50.59 Qualified Reviewers List	16	12/19/2013	Minor Editorial
FM-21	ARMS Trip Setpoints	9	6/6/2013	Minor Editorial
FM-33	Containment Building Restricted Materials	5	12/9/2013	Cover Page
FM-43	Nuclear and Process Data	17	3/29/2013	Cover Page
FM-43	Nuclear and Process Data	18	10/17/2013	Minor Editorial
FM-55	Startup Nuclear Data Sheet	7	3/29/2013	Minor Editorial
FM-56	Reactor Routine Patrol	16	3/29/2013	Minor Editorial
FM-57	Long Form Startup Checksheet	20	5/2/2013	Minor Editorial
FM-57	Long Form Startup Checksheet	21	10/31/2013	Minor Editorial
FM-58	Short Form Startup Checksheet	11	10/31/2013	Minor Editorial
FM-63	DI Water Makeup Log	9	1/31/2013	Cover Page
FM-66	Customer Sample Pre-Encapsulation Evaluation Worksheet	7	6/10/2013	Minor Editorial
FM-68	Target Material Control Checksheet	12	6/10/2013	Minor Editorial
FM-93	Post Maintenance Valve Line-up Checksheet	5	6/10/2013	Cover Page
IRR-PSO-111	Customer Sample Pre-Encapsulation Evaluation	7	6/10/2013	Minor Editorial

Number	Name	Rev.	Revision Date	Notes
OP-RO-100	Main Air System	10	3/29/2013	Minor Editorial
OP-RO-101	Instrument Air System	10	3/29/2013	Minor Editorial
OP-RO-210	Reactor Startup-Normal	13	5/22/2013	Cover Page
OP-RO-211	Reactor Startup - Hot	11	6/25/2013	Minor Editorial
OP-RO-211	Reactor Startup - Hot	12	8/22/2013	Minor Editorial
OP-RO-212	Reactor Startup - Recovery from Temporary Power Reduction	11	12/9/2013	Cover Page
OP-RO-220	Reactor Shutdown or Power Reduction	8	6/25/2013	Minor Editorial
OP-RO-230	Changing Reactor Power Level	8	6/25/2013	Minor Editorial
OP-RO-310	Nuclear Instrumentation - Signal Processor #1	10	5/22/2013	Cover Page
OP-RO-311	Nuclear Instrumentation - Signal Processor #2	11	5/22/2013	Cover Page
OP-RO-312	Nuclear Instrumentation Power Range Monitor - Channel 6	13	5/22/2013	Cover Page
OP-RO-330	Nuclear Instrumentation - Wide Range Monitor	10	5/22/2013	Cover Page
OP-RO-340	Nuclear Instrumentation Adjustment	10	5/22/2013	Cover Page
OP-RO-350	Reactor Power Calculator Flow Potentiometer Adjustment	9	9/24/2013	Cover Page
OP-RO-410	Primary Coolant System	11	5/2/2013	Minor Editorial
OP-RO-420	Primary and Pool Water Analysis	6	9/24/2013	Cover Page
OP-RO-460	Pool Coolant System – Two Pump Operation	14	9/24/2013	Minor Editorial
OP-RO-461	Pool Coolant System - One Pump Operation	14	9/24/2013	Minor Editorial
OP-RO-465	Pool Level Control – Skimmer System	8	3/29/2013	Minor Editorial
OP-RO-480	Secondary Coolant System	17	9/24/2013	Minor Editorial
OP-RO-480	Secondary Coolant System	18	12/9/2013	Minor Editorial
OP-RO-510	Nitrogen System	7	5/2/2013	Minor Editorial
OP-RO-515	Emergency Air System	9	9/24/2013	Minor Editorial
OP-RO-516	Valve Operation Air System	9	8/22/2013	Cover Page
OP-RO-525	Chill Water System	7	6/25/2013	Minor Editorial
OP-RO-530	Demineralized Water Supply System	13	8/22/2013	Cover Page
OP-RO-531	Primary and Pool Sample Station	11	9/24/2013	Cover Page
OP-RO-555	Fire Protection System	10	1/31/2013	Minor Editorial
OP-RO-555	Fire Protection System	11	11/19/2013	Minor Editorial
OP-RO-710	Radiation Monitoring - Area Monitors	8	8/22/2013	Cover Page
OP-RO-720	Radiation Monitoring - Stack Monitor Operational Check	11	6/25/2013	Minor Editorial
OP-RO-730	Facility Exhaust System	14	3/29/2013	Minor Editorial
OP-RO-741	Waste Tank System Operation	13	5/2/2013	Minor Editorial
OP-RO-741	Waste Tank System Operation	14	12/19/2013	Minor Editorial
POL-20	Special Nuclear Materials Manual	1	3/3/8/2013	Minor Editorial
REP-RO-100	Reactor Emergency Procedures	16	1/31/2013	Cover Page
RM-RO-400	Waste Tank System Filter Replacement	7	3/29/2013	Minor Editorial
RP-RO-300	Receipt, Inspection and Accounting of Unirradiated Fuel	3	5/22/2013	Minor Editorial
SM-RO-200	Manual Operation of Airlock doors 276 and 277	2	5/7/2013	Minor Editorial
SM-RO-300	Control Console And Instrument Panel – Securing Power	10	9/24/2013	Cover Page

B. CHANGES TO THE MURR SITE EMERGENCY PROCEDURES AND FACILITY EMERGENCY PROCEDURES

As required by the MURR Technical Specifications, the Reactor Manager reviewed the Emergency Plan Implementing Procedures and found them to be adequate for the safe and reliable operation of the facility.

There were thirteen (13) revisions issued to the emergency procedures, forms and operator aids. The majority of the revisions were strictly format or editorial in nature. The following is a list of the revised procedures, forms and operator aids:

Number	Name	Rev.	Revision Date	Notes
EP-RO-002	Emergency Responsibilities	4	5/7/2013	Minor Editorial
EP-RO-006	Radiological Emergency	5	5/7/2013	Minor Editorial
EP-RO-013	Facility Evacuation	5	5/7/2013	Minor Editorial
EP-RO-015	Emergency Notifications	9	4/4/2013	Minor Editorial
EP-RO-015	Emergency Notifications	10	5/7/2013	Minor Editorial
EP-RO-015	Emergency Notifications	11	10/29/2013	Minor Editorial
EP-RO-018	Emergency Radiation Exposure	5	5/7/2013	Minor Editorial
FM-104	Emergency Call List	22	4/4/2013	Minor Editorial
FM-110	Fire Flowchart	4	5/7/2013	Minor Editorial
OA-09	Combined Emergency Flowcharts	5	7/8/2013	Minor Editorial
OA-10	Fire Extinguisher Locations and Types	9	12/12/2013	Minor Editorial
OA-20	Emergency Equipment	15	7/8/2013	Minor Editorial
OA-20	Emergency Equipment	16	12/12/2013	Minor Editorial

C. CHANGES TO HEALTH PHYSICS PROCEDURES, BYPRODUCT MATERIAL SHIPPING PROCEDURES, and PREPARATION OF BYPRODUCT MATERIAL FOR SHIPPING PROCEDURES

As required by the MURR Technical Specifications, the Reactor Health Physics Manager reviewed the procedures for radioactive materials handling, shipping, and preparation for shipping of byproduct materials.

There were eighty-four (84) revisions issued to the health physics, radioactive materials shipping, and preparation for shipping procedures and forms. Additionally, three (3) new forms and four (4) new procedures were issued. The majority of the revisions were strictly format or editorial in nature. The following is a list of the revised procedures and forms:

Number	Name	Rev.	Revision Date	Notes
AP-HP-117	MURR Initial Radiation Worker Training Program	11	3/22/2013	Minor Editorial
AP-HP-119	High Radiation Area Access	5	1/3/2013	Minor Editorial
AP-HP-123	Visitor Dosimetry - Reception Desk	9	4/29/2013	Minor Editorial
AP-HP-123	Visitor Dosimetry - Reception Desk	10	8/5/2013	Minor Editorial
AP-HP-129	Hot Cell, HC-01 Control	9	2/7/2013	Minor Editorial
AP-SH-002	In-House Radioactive Shipping Request Form Instructions	2	6/18/2013	Minor Editorial
AP-SH-002	In-House Radioactive Shipping Request Form Instructions	3	9/17/2013	Minor Editorial

Number	Name	Rev.	Revision Date	Notes
AP-SH-002	In-House Radioactive Shipping Request Form Instructions	4	12/19/2013	Minor Editorial
BPB-SH-005	DOT 6M Packaging of Type B Non-Waste Radioactive Material	11	10/9/2013	Minor Editorial
BPB-SH-020	Receipt Inspection Of Type B Byproduct Material Shipping Containers	4	4/29/2013	Minor Editorial
BPB-SH-023	Type B Equipment Calibration	2	12/20/2013	Minor Editorial
BPB-SH-024	Type B(U) F-458 Series Packaging of Type B Non-Waste Radioactive Material	2	10/9/20103	Minor Editorial
BPB-SH-025	Type B(U) ZA/NNR1005 (Beatrice) Packaging of Type B Non-Waste Radioactive Material	2	10/9/2013	Minor Editorial
BPB-SH-026	Type B(U) F-327 Series Packaging of Type B Non-Waste Radioactive Material	2	10/9/2013	Minor Editorial
BPB-SH-027	Survey and Decontamination of Returned Shipping Containers	1	10/9/2013	Minor Editorial
BPB-SH-029	TYPE B(U) USA/0656/B(U)-96 (Ganuk) Packaging of Radioactive Material	0	11/5/2013	New Procedure
BP-SH-016	Packaging and Shipment of Radioactive Material Using USA DOT 7 A Model H or I Package	3	10/9/2013	Minor Editorial
BP-SH-017	Packaging and Shipment of Radioactive Material Using Tracerco LS-6 Reusable Type A Package	0	7/18/2013	New Procedure
BP-SH-052	Radioactive Material Shipment Package Documentation and Labeling	10	2/6/2013	Minor Editorial
BP-SH-052	Radioactive Material Shipment Package Documentation and Labeling	11	7/26/2013	Minor Editorial
FB-SH-110	Type B Shipment of spent Fuel Using the BEA Research Reactor Package	2	4/16/2013	Minor Editorial
FB-SH-110	Type B Shipment of spent Fuel Using the BEA Research Reactor Package	3	5/13/2013	Full Review
BP-SH-099	Packaging of Radioactive Material Using MURR Model 1500	3	1/4/2012	Minor Editorial
FM-17	Radiation Work Permit	11	11/19/2013	Minor Editorial
FM-27	In-House Radioactive Shipping Request Form	12	9/17/2013	Minor Editorial
FM-52	Control Checksheet for Documentation and Labeling of Radioactive Material Shipment	11	2/6/2013	Minor Editorial
FM-52	Control Checksheet for Documentation and Labeling of Radioactive Material Shipment	12	7/26/2013	Minor Editorial
FM-62	Radiation Instrument Certificate of Calibration	7	7/11/2013	Cover Page
FM-69	Control Checksheet for Reusable Type A Radioactive Materials Shipment (5 to 30 Gallon Drums)	8	10/11/2013	Minor Editorial
FM-70	Control Checksheet for Tracerco LS-6 Reusable Type A Package Radioactive Materials Shipment	0	7/18/2013	New Form
FM-74	Control Checksheet for Type B USA DOT 6M Radioactive Materials Shipment	14	10/9/2013	Minor Editorial
FM-91	Declaration of Pregnancy	5	8/5/2013	Cover Page
FM-94	Exclusive Use Shipment Controls	4	2/6/2013	Minor Editorial
FM-94	Exclusive Use Shipment Controls	5	4/29/2013	Minor Editorial
FM-94	Exclusive Use Shipment Controls	6	7/26/2013	Minor Editorial

Number	Name	Rev.	Revision Date	Notes
FM-99	Control Checksheet for USA DOT 7A MURR Model 1500 Series	7	12/19/2013	Minor Editorial
FM-129	Control Checksheet for Receipt and Inspection of Type B Byproduct Material Shipping Containers	3	4/16/2013	Minor Editorial
FM-135	Control Checksheet for Type B(U) ZA/NNR1005 (Beatrice) Radioactive Materials Shipment	2	6/18/2013	Minor Editorial
FM-137	Type B Qualified Shipper List	1	4/29/2013	Minor Editorial
FM-149	Personnel Radiation Dose Estimate	0	2/7/2013	New Form
FM-151	Control Checksheet for USA DOT 7A Type A 55-Gallon Radioactive Material Package	8	12/19/2013	Minor Editorial
FM-154	Control Checksheet for USA DOT 20WC-1 Overpack Rod Replacement	3	4/29/2013	Cover Page
FM-155	Quality Assurance Control Checksheet Exterior Painting of USA DOT WC-1, Type B Overpack	2	4/29/2013	Cover Page
FM-156	Required Documentation for Non-MURR Owned Type B Shipping Containers	3	7/26/2013	Minor Editorial
FM-157	Control Checksheet for Type B(U) F-458 Series Radioactive Materials Shipment	2	6/18/2013	Minor Editorial
FM-160	Control Checksheet for Type B(U) F-327 Series Radioactive Materials Shipment	1	10/9/2013	Minor Editorial
FM-163	Control Checksheet for Type B(U) USA/9337/B(U)-96 (LS) Packaging of Radioactive Material	1	3/22/2013	Minor Editorial
FM-167	Control Checksheet for Type B(U) USA/0656/B(U)-96 (Ganuk) Radioactive Materials Shipping	0	11/5/2013	New Form
HC-PSO-002	Hot Cell Preparation of Radioactive Material for Shipment	12	9/11/2013	Minor Editorial
HC-PSO-005	Hot Cell Loading of Host Cans	11	9/11/2013	Minor Editorial
IC-HP-300	Calibration - Radiation Survey Instruments	7	7/11/2013	Cover Page
IC-HP-305	Calibration - Electrostatic Discharge Dosimeter	8	8/2/2013	Cover Page
IC-HP-311	Calibration – Eberline Ping 1A Stack Monitor – Iodine Channel	7	4/9/2013	Minor Editorial
IC-HP-347	Calibration – Protean Model WPC 9550 Alpha-Beta Swipe Counter	9	7/11/2013	Cover Page
IC-HP-348	Calibration – Canberra S5XLB-G & Tennelec Series 4 with Gamma, & Tennelec Series 3	6	7/11/2013	Cover Page
IC-HP-349	Calibration - Lab Impex Stack Monitor-Particulate Channel	4	7/11/2013	Cover Page
IC-HP-350	Calibration - Lab Impex Stack Monitor-Iodine Channel	2	8/2/2013	Minor Editorial
IC-HP-351	Calibration - Lab Impex Stack Monitor-Gas Channel	2	7/11/2013	Cover Page
IC-HP-352	Calibration - Lab Impex Stack Monitor-Flow Calibration	3	7/11/2013	Cover Page
IRR-PSO-112	Preparing Shipping Paperwork	7	8/13/2013	Minor Editorial
OP-HP-200	Air Sampling- Containment Building Tritium	6	8/2/2013	Cover Page
OP-HP-220	Tritium Bioassay	9	8/5/2013	Minor Editorial

Number	Name	Rev.	Revision Date	Notes
OP-HP-222	Air Sampling – Containment Building Ar-41	6	2/7/2013	Minor Editorial
OP-HP-348	Operation – Protean WPC-9550 Swipe Counter	4	7/11/2013	Cover Page
OP-HP-356	Operation - Lab Impex Stack Monitor - Filter Change and Source Checks	4	8/5/2013	Cover Page
QAB-SH-002	Procurement of Type B Packages	2	2/6/2013	Cover Page
QAB-SH-003	Material Control for Type B Shipping Program	3	5/14/2013	Minor Editorial
QAB-SH-004	Type B Program Vendor Qualification	3	5/14/2013	Cover Page
QAB-SH-005	Type B QA Personnel Training	3	2/6/2013	Minor Editorial
QAB-SH-006	Type B Shipping Program Quality Audits	1	2/6/2013	Minor Editorial
QAB-SH-009	Pre-Shipment leak Testing of the Ganuk Shipping Container	0	11/5/2013	New Procedure
RM-HP-102	Stack Monitor Preventive Maintenance – Lab Impex	1	7/11/2013	Cover Page
RP-HP-100	Contamination Monitoring – In Facility	6	4/3/2013	Minor Editorial
RP-HP-105	Transfer of Radioactive Material – In Facility	7	4/3/2013	Minor Editorial
RP-HP-120	Personnel Radioactive Contamination	7	4/29/2013	Minor Editorial
RP-HP-120	Personnel Radioactive Contamination	8	8/5/2013	Minor Editorial
RP-HP-125	Radiation Monitoring – Performing and Documenting a Survey	0	8/5/2013	New Procedure
RP-HP-135	Room 114 Entry – Self Monitored	6	5/22/2013	Minor Editorial
RP-HP-137	Handling Radioactive Material in the Reactor Pool	11	8/5/2013	Cover Page
SI-PSO-008	Post-Irradiation Processing: Exported Flooded Silicon Cans	6	12/11/2013	Minor Editorial
SV-HP-110	Environmental Sampling	5	6/21/2013	Minor Editorial
SV-HP-121	Building Exhaust Stack Effluent – Ar-41 Monitoring	5	8/2/2013	Minor Editorial
TPZ-PSO-002	Irradiation of Gemstone Irradiation Containers	6	12/11/2013	Minor Editorial
TPZ-PSO-003	Loading Gemstone Irradiation Containers	5	12/11/2013	Minor Editorial
TSP-02	Transportation Security Plan	5	12/19/2013	Minor Editorial
WM-SH-100	Radioactive Waste – Preparation and Storage	7	7/26/2013	Cover Page
WM-SH-105	Radioactive Waste Processing	8	2/6/2013	Minor Editorial
WM-SH-105	Radioactive Waste Processing	9	7/26/2013	Cover Page
WM-SH-300	Exclusive Use Shipment of LSA or SCO Radioactive Waste	11	6/18/2013	Minor Editorial
WM-SH-300	Exclusive Use Shipment of LSA or SCO Radioactive Waste	12	11/20/2013	Cover Page

SECTION III

REVISIONS TO THE HAZARDS SUMMARY REPORT

January 1, 2013 through December 31, 2013

These changes were approved by the Reactor Manager and reviewed by licensed staff and members of the Reactor Safety Subcommittee and have been determined not to involve a change to the Technical Specifications. These changes have all been reviewed in accordance with 10 CFR 50.59.

HAZARDS SUMMARY REPORT (ORIGINAL JULY 1, 1965)

Original HSR, pages 3-11, Figure 3.2, Grade Level Plan (as revised by the 1972-1973, 1979-1980, 1990-1991, 1995, 1996 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 3.2, Grade Level Plan (MURR Dwg No. 1145, Sheet 2 of 5)

Original HSR, pages 7-19, Section 7.2.7 (as revised by the 1974-75, 1989-1990 and 1995 Reactor Operations Annual Reports):

Delete: "...beamport ventilation air, air which is drawn from the surface of the pool and exhaust from the film irradiator shield box."

Replace with: "...beamport ventilation air and air which is drawn from the surface of the pool."

Original HSR, pages 7-20, Section 7.2.9, Table 7.1 (as revised by the 1974-75, 1995, 2001, 2002, 2007 and 2008 Reactor Operations Annual Reports):

Delete: The following from Table 7.1 under Staff Stations:

"Room 288 Health Physics Office"

Add: The following to Table 7.1 under Staff Stations:

"Room 271B Health Physics Office"

Original HSR, pages 7-21, Section 7.2.9, Table 7.2 (as revised by the 1995, 2001, 2007, 2009, 2011 and 2012 Reactor Operations Annual Reports):

Add: The following after "Room 299":

"Corridor C299D
Room 299N
Room 299P
Room 299Q"

Original HSR, pages 9-7 through 9-9, Table 9.2 (as revised by the 1981-82, 1985-86, 1995, 2000, 2001, 2002, 2006 and 2007 Reactor Operations Annual Reports):

Add: "137 Isolated Power Supply (EP 911C) - TE-980 A/B"

Add: "138 Rod Run-In System Monitoring Circuit"

Add: "139 T-300 & T-301 Water Level Display"

Original HSR, Figure 9.3, Instrument Panel Layout (as revised by 1995, 2001, 2004 and 2006 Reactor Operations Annual Reports):

Replace with: Updated Figure 9.3, Instrument Cabinet (MURR Dwg No. 74, Sheet 12 of 12)

Original HSR, Figure 9.5, Rod Run-In System (as revised by 1995 and 2001 Reactor Operations Annual Reports):

Replace with: Updated Figure 9.5, Rod Run-In System (MURR Dwg #140, Sheet 1 of 1, dated 9/10/13)

ADDENDUM 3 - HAZARDS SUMMARY REPORT (AUGUST 1972)

HSR, Addendum 3, page 15, Figure 2.2.b, Secondary Coolant System (as added by the 2012 Reactor Operations Annual Report):

Replace with: Updated Figure 2.2.b, Secondary Cooling System (MURR Dwg No. 502, Sheet 2 of 3, dated 4/24/13)

HSR, Addendum 3, page 18, Figure 2.3.a, Electrical Distribution (as revised by the 1989-90, 1990-91, 1995, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.a, Electrical Distribution Reactor/Laboratory (MURR Dwg No. 522, Sheet 1 of 5, dated 8/20/13)

HSR, Addendum 3, page 23b, Figure 2.3.b, Electrical Distribution (as added by the 1995 and revised by the 2001, 2002, 2003, 2004, 2005, 2007, 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.b, Electrical Distribution North Office Addition (MURR Dwg No. 522, Sheet 2 of 5, dated 10/4/13)

HSR, Addendum 3, page 23c, Figure 2.3.c, Electrical Distribution (as added by the 2004 and revised by the 2005, 2007, 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.c, Electrical Distribution Reactor/Laboratory Panels (MURR Dwg No. 522, Sheet 3 of 5, dated 8/27/13)

HSR, Addendum 3, page 23d, Figure 2.3.d, Electrical Distribution (as added by the 2007 and revised by the 2008, 2009, 2010, 2011and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.d, Electrical Distribution Reactor/Laboratory Panels-2 (MURR Dwg No. 522, Sheet 4 of 5, dated 8/27/13)

HSR, Addendum 3, page 23e, Figure 2.3.e, Electrical Distribution (as added by the 2007 and revised by the 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.e, Electrical Distribution North Office Addition Panels (MURR Dwg No. 522, Sheet 5 of 5, dated 10/7/13)

ADDENDUM 4 - HAZARDS SUMMARY REPORT (OCTOBER 1973)

HSR, Addendum 4, page A-22, Figure A.4.a, Reactor Control System - 10 MW (as revised by 1995, 2001, 2004, 2006 and 2007 Reactor Operations Annual Reports):

Replace with: Updated Figure A.4.a, Reactor Control System (MURR Dwg No. 42, Sheet 1 of 2, dated 8/22/13)

HSR, Addendum 4, page A-25, Figure A.6, 10 MW Process Instrumentation Control & Interlock (as revised by the 1995, 2001, 2002, 2003, 2005 and 2006 Reactor Operations Annual Reports):

Replace with: Updated Figure A.6, 10 MW Process Instrumentation Control & Interlock (MURR Dwg No. 41, Sheet 2 of 4, dated 8/22/13)

HSR, Addendum 4, page A-26, Figure A.7, Annunciator Control 10 MW (as revised by the 1995, 2001, 2002, 2005, 2006, 2007, 2008 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure A.1, Annunciator Control 10 MW (MURR Dwg No. 138, dated 9/11/13)

HSR, Addendum 4, page A-29, Figure A.11, Schematic Diagram of Laboratory and Containment Building Ventilation Systems (as revised by the 1995, 2002, 2005, 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure A.11, Schematic Diagram of Laboratory and Containment Building Ventilation Systems (MURR Dwg No. 1125, Sheet 1 of 4, dated 8/19/13)

ADDENDUM 5 - HAZARDS SUMMARY REPORT (JANUARY 1974)

HSR, Addendum 5, page 15, Figure 2.1, Electrical Distribution (as revised by the 1989-90, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2009, 2010, 2011 and 2012 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.1, Electrical Distribution Reactor/Laboratory (MURR Dwg No. 522, Sheet 1 of 5, dated 8/20/13)

As a result of the issuance of Amendment No. 36 to Amended Facility License No. R-103 on July 8, 2013, the following changes to the MURR Hazards Summary Report and its addenda were performed:

ADDENDUM 3 - HAZARDS SUMMARY REPORT (AUGUST 1972)

HSR, Addendum 3, Section 3.3, Evaluation of Peaking Factors in the MURR 6.2 Kg Core

Delete: Entire section.

Replace with: Revised HSR, Addendum 4, Appendix F, Safety Limit Analysis for the MURR, as submitted with the application to amend Amended Facility License No. R-103, dated August 19, 2011 (Attachment 11).

ADDENDUM 4 - HAZARDS SUMMARY REPORT (OCTOBER 1973)

HSR, Addendum 4, Appendix F, Safety Limit Analysis for the MURR

Delete: Entire section.

Replace with: Revised HSR, Addendum 4, Appendix F, Safety Limit Analysis for the MURR, as submitted with the application to amend Amended Facility License No. R-103, dated August 19, 2011 (Attachment 11).

HSR, Addendum 4, Appendix H, Bases for Limiting Safety System Settings for Modes I and II Operation

Delete: Entire section.

Replace with: Revised HSR, Addendum 4, Appendix H, Bases for Limiting Safety System Settings for Modes I and II Operation, as submitted with the application to amend Amended Facility License No. R-103, dated August 19, 2011 (Attachment 12).

ADDENDUM 5 - HAZARDS SUMMARY REPORT (JANUARY 1974)

HSR, Addendum 5, Section 6, Addendum to the Safety Limit Analysis for the MURR

Delete: Entire section.

Replace with: Revised HSR, Addendum 4, Appendix F, Safety Limit Analysis for the MURR, as submitted with the application to amend Amended Facility License No. R-103, dated August 19, 2011 (Attachment 11).

SECTION IV

PLANT AND SYSTEM MODIFICATIONS

January 1, 2013 through December 31, 2013

For each facility modification described below, MURR has on file the safety screen or evaluation, as well as the documentation of review, performed in accordance with 10 CFR 50.59.

Modification 11-03, Addendum 1:

Addition of Blow-Down Meter to the Data Acquisition Monitoring System

This addendum to modification record 11-03, "Data Acquisition and Monitoring System for Secondary Coolant System" documents the installation of an additional component to the Data Acquisition and Monitoring System for the Secondary Coolant System. A secondary coolant blow-down transmitter and associated indication were installed to assist in monitoring the amount of secondary coolant that is required to be discharged to the sanitary sewer in order to maintain appropriate Secondary Coolant System chemistry control.

Modification 12-01:

Replace PT-944A/B with Rosemount Transmitters

This modification record documents the replacement of two pressure transmitters, PT-944A and PT-944B, which sense reactor core outlet pressure in the Primary Coolant System. The previous pressure transmitters could not be directly replaced due to obsolescence of both the transmitters and repair parts. The replacement pressure transmitters meet or exceed the performance specifications of the previous transmitters.

Modification 12-02:

Control Blade Fabrication Alternative Using Laser Welding

This modification record documents a fabrication alternative for construction of the control blades. An assembly method using laser welding on the edge channels required a change in the edge channel alloy. A more streamlined connection between the top mounting plate and the BORAL® absorber plate was also documented.

Modification 13-01:

Replacement of TE-980A and TE-980B Power Supply 2PS5

This modification record documents replacement of the power supplies for the temperature instrument channels on Primary Heat Exchanger outlet temperatures, TE-980A and TE-980B. The previous power supply, 2PS5, was obsolete and unavailable for purchase. The replacement power supply EP-911C meets or exceeds the performance specifications of the previous power supplies, and was relocated from behind the Instrument Cabinet to the former General Electric Measurement and Control (GE/MAC) rack on the Instrument Cabinet face.

Modification 04-03, Addendum 1:

Liquid Radioactive Waste System In MURR Industrial Building

This addendum to modification record 04-03, "Liquid Radioactive Waste Modification" documents the changes required to incorporate the MURR Industrial Building (MIB) Liquid Radioactive Waste (LRW) system into the existing facility LRW system.

Modification 75-01, Addendum 3:

Rod Run-In Electronic Circuit Jumper Panel

This addendum to modification record 75-01, "Electronic Circuits Jumper Panel" documents the installation of a jumper panel dedicated to the rod run-in system. This jumper panel supports the use of the rod run-in system monitoring circuit installed under Modification Record 13-04.

Modification 13-04:

Rod Run-In Monitoring System

This modification record documents the implementation of a passive monitoring circuit on the rod run-in system to improve troubleshooting capabilities for rod run-in signals that are too short in duration to detect with the annunciator system. The monitoring circuit works in conjunction with a new jumper panel dedicated to the rod run-in system, and provides additional unused monitoring capacity for future troubleshooting expansion. The monitoring circuit was constructed in a manner similar to the reactor scram system monitoring circuit.

Modification 13-02:

Replacement of Secondary Chemistry Controllers

This modification record documents the replacement of the Secondary Coolant System pH and conductivity controllers. The previous model controllers had become obsolete and repair parts were no longer available. The replacement controllers meet or exceed the performance specifications of the existing controllers.

Modification 13-03:

Replacement of the GH and IJ Wedge with a Single 60-Degree Wedge

This modification record documents the redesign and replacement of the 30-degree "GH" and "IJ" graphite reflector elements with a single 60-degree graphite reflector element (GHIJ). The new reflector element accommodates a 6-inch irradiation position as well as a 3-inch, two 2-inch and two 1-inch irradiation positions designated G-6, B-3, B-2 and R-2, G-1 and H-1, respectively. The 6-inch irradiation position is designed such that a sleeve insert with nickels bands may be installed to allow for manipulation of the flux profile. This insert is bolted securely to the element cover plate, and is inserted and/or removed only when the reactor is shutdown. The reflector element is constructed of aluminum 6061-T6 with graphite in the void area.

Modification 04-05, Addendum 8:

Cooling Tower Electrical Arc Flash Danger Mitigation

This addendum to modification record 04-05, "Cooling Tower Electrical Upgrade Project" documents the changes to Motor Control Center 1 in order to provide for improved arc flash protection and subsequent classification reduction of the cooling tower motor control center.

Modification 01-02, Addendum 9:

Intercommunication and Paging System Changes in Support of MURR Industrial Building (Room 299) Renovations

This addendum to modification record 01-02, "Installation of a New Reactor Facility Intercommunication and Paging System" documents changes to the facility Intercommunication and Paging System that will enhance communications in Rooms 299M, N and O.

Modification 01-02, Addendum 10:

Intercommunication and Paging System Changes in Support of MURR Industrial Building (Room 299), Room 243, Room 246 and Room 271 Renovations

This addendum to modification record 01-02, "Installation of a New Reactor Facility Intercommunication and Paging System" documents changes to the facility Intercommunication and Paging System that will enhance communications in MURR Industrial Building (Room 299), Room 243, Room 246 and Room 271B. It also documents the relocation of the Health Physics Office staff station from Room 288 to Room 271B.

Modification 13-05:

T-300 & T-301 Level Sensing System

This modification to the Reactor Plant Make-Up Water Storage Tank System documents the replacement of the previous level sensing and annunciating instrument channels with current loop transmitters that also display the tank levels in the Control Room.

Modification 13-06:

Modifications to MURR Industrial Building (Room 299) in Support of the NS-99 Project

This modification record documents the remodeling of portions of the MURR Industrial Building (Room 299) to provide the necessary space needs and services required to support the dispensing system for the NS-99 Project.

SECTION V

NEW TESTS AND EXPERIMENTS

January 1, 2013 through December 31, 2013

New tests and experiments approved during this period under a Reactor Utilization Request (RUR) or Reactor License (RL) Project are as follows:

RUR 441: Natural Uranium Oxide Irradiation

Description: This RUR authorizes the irradiation of up to 5.0 grams of natural Uranium Oxide in the reflector region of the reactor in support of research and development activities for medical applications.

RUR 271, as amended: Yttrium Microspheres:

Description: This RUR was amended twice during calendar year 2013. The first amendment authorizes the use of quartz as a primary encapsulation and removed the requirement for the secondary encapsulation of aluminum for the microsphere targets. A second amendment to RUR 271 authorizes the use of discs, a different physical form of the same target material for irradiation.

RL-80: Selective Gaseous Extraction of Fission Products

Description: This RL authorizes the processing of up to 5.0 grams of natural Uranium Oxide to investigate Selective Gaseous Extraction as a novel separation process for producing radioisotopes from the fission of uranium.

Each of these tests or experiments has a written safety evaluation on file and a 10 CFR 50.59 Screen, if applicable, to assure that the test or experiment is safe and within the limits of the Technical Specifications. The safety evaluations have been reviewed by the Reactor Manager, Reactor Health Physics Manager, Assistant Reactor Manager-Physics, and the Reactor Safety Subcommittee, as applicable.

SECTION VI

SPECIAL NUCLEAR MATERIAL AND REACTOR PHYSICS ACTIVITIES

January 1, 2013 through December 31, 2013

Inspections:

There was one NRC inspection reviewing Special Nuclear Material (SNM) activities. All records and activities were found to be in compliance with NRC rules and regulations. No violations were noted.

Reactor Characteristic Measurements:

Sixty-six (66) refueling evolutions were completed in 2013. Excess reactivity verification was performed for each refueling. The largest measured excess reactivity was 3.32%. MURR Technical Specification 3.1(f) requires the excess reactivity to be less than 9.8%.

Reactivity Measurements:

Differential blade-worth measurements of three (3) shim control blades were performed following either a planned replacement of a control blade or characterization of the burn-in effect of a new control blade.

Six (6) reactivity measurements were performed to determine the reactivity worth of all samples, including the sample holder, loaded in the flux trap region.

Four (4) reactivity measurements were performed to determine the reactivity worth of various sample cans irradiated in the flux trap region, including the worth of an empty sample holder.

Two (2) measurements were performed to determine the reactivity worth of the newly constructed GHIJ 60-degree graphite reflector element and the target irradiation positions associated with the new reflector element.

In support of the Nuclear Engineering student labs, one (1) differential blade-worth measurement and one (1) primary coolant temperature coefficient measurement were also performed.

SECTION VII

RADIOACTIVE EFFLUENT

January 1, 2013 through December 31, 2013

TABLE 1
SANITARY SEWER EFFLUENT

January 1, 2013 through December 31, 2013

Descending Order of Activity Released for Nuclide Totals > 1.000E-05 Ci

Nuclide	Activity (Ci)
H-3	9.816E-02
S-35	7.312E-03
Lu-177	6.619E-03
Co-60	2.256E-03
Ca-45	1.558E-03
P-32	1.384E-03
Mo-99	9.858E-04
Zn-65	6.517E-04
W-181	3.125E-04
Cr-51	5.560E-05
Ag-110m	3.384E-05
Sc-46	3.075E-05
Tc-99m	2.664E-05
I-131	1.592E-05
As-76	1.052E-05
Total H-3	**9.816E-01**
Total Other	**2.128E-02**

Sanitary Sewer Effluents are in compliance with 10 CFR 20.2003, "Disposal By Release Into Sanitary Sewerage."

TABLE 2
STACK EFFLUENT

January 1, 2013 through December 31, 2013

Ordered by % Technical Specification (TS) Limit

Isotope	Average Concentration (µCi/ml)	Total Release (Ci)	TS Limit Multiplier	% TS
Ar-41	2.73E-06	1.22E+03	350	78.1054
H-3	2.21E-08	9.89E+00	350	0.0633
Kr-79	6.72E-09	3.00E+00	350	0.0274
I-131	3.38E-14	1.51E-05	1	0.0169
K-40	6.02E-14	2.69E-05	1	0.0100
C-14	2.48E-11	1.13E-02	1	0.0083
Co-60	2.70E-15	1.21E-06	1	0.0054
I-125	1.12E-14	4.99E-06	1	0.0037
Sn-113	2.55E-15	1.14E-06	1	0.0003
Xe-135m	1.94E-11	8.65E-03	350	0.0001
Os-191	2.04E-15	9.12E-07	1	0.0001
I-133	1.96E-13	8.76E-05	350	0.0001

Note: C-14 activity is calculated based on the ratio of argon to nitrogen in the air and the (n,p) reaction cross sections for the activation of N-14 to C-14.

Isotopes observed at < 0.0001% Technical Specification limit are not listed.

Stack Flow Rate = ~30,000 cfm

Stack effluent releases are in compliance with University of Missouri-Columbia Research Reactor, License R-103 Technical Specifications.

SECTION VIII

ENVIRONMENTAL MONITORING AND HEALTH PHYSICS SURVEYS

January 1, 2013 through December 31, 2013

Environmental samples are collected two times per year at eight (8) locations and analyzed for radioactivity. Soil and vegetation samples are also taken at each location. Water samples are taken at three (3) of the eight (8) locations. Subsurface soil monitoring commenced in 2013 with six (6) samples taken each period. Analytical results are shown in Tables 1 and 2.

Table 3 lists the radiation doses recorded by the environmental monitors deployed around MURR in 2013. All doses are approximately 20 mRem/year or less, except monitor numbers 9 and 15. These monitors are located near loading dock areas where packages containing radioactive material are loaded on transport vehicles. The doses recorded by these monitors are considered to be the result of exposure to packages in transit. Additionally, during 2013, six (6) monitoring sites around the reactor facility were chosen for subsurface soil monitoring. The subsurface results are presented along with the traditional monitoring locations and results. The environmental monitoring program confirms that minimal environmental impact exists from the operation of the MURR facility.

The number of radiation and contamination surveys performed each month is provided in Table 4.

TABLE 1
SUMMARY OF ENVIRONMENTAL SET 83

Spring 2013

Detection Limits[1]

Matrix	Alpha	Beta	Gamma	Tritium
Water	0.00 pCi/L	3.14 pCi/L	189.00 pCi/L	5.26 pCi/mL of sample
Soil	0.58 pCi/g	3.47 pCi/g	0.61 pCi/g	N/A
Vegetation	0.00 pCi/g	8.94 pCi/g	1.53 pCi/g	6.33 pCi/mL of distillate
Subsurface Soil	1.00 pCi/g	3.32 pCi/g	0.57 pCi/g	N/A

Activity Levels - Vegetation

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)	H-3 (pCi/mL)
1V83	0.35	42.78	2.52	< 6.33
2V83	0.35	30.53	2.25	< 6.33
3V83	0.00	23.13	< 1.53	< 6.33
4V83	0.35	36.54	< 1.53	< 6.33
5V83	0.00	32.50	< 1.53	< 6.33
6V83	0.70	32.40	2.29	< 6.33
7V83	1.38	25.16	< 1.53	< 6.33
10V83	0.70	46.64	2.97	< 6.33

TABLE 1 (Cont'd)
SUMMARY OF ENVIRONMENTAL SET 83

Spring 2013

Activity Levels - Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
1S83	1.47	21.85	3.46
2S83	< 0.58	19.10	0.97
3S83	< 0.58	16.50	2.64
4S83	1.15	21.16	1.72
5S83	2.03	23.04	1.09
6S83	1.67	14.98	2.21
7S83	1.15	27.91	1.96
10S83	< 0.58	26.60	2.29

Activity Levels - Water

Sample	Alpha (pCi/L)	Beta (pCi/L)	Gamma (pCi/L)	H-3 (pCi/mL)
4W83	1.06	3.75	< 189.00	< 5.26
6W83	0.18	4.12	< 189.00	< 5.26
10W83	0.35	12.36	< 189.00	< 5.26

Activity Levels - Subsurface Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
PSS83	1.50	26.88	3.95
NESS83	1.50	25.00	5.51
NSS83	1.50	27.81	3.18
WSS83	1.50	22.38	3.64
ESS83	< 1.00	21.26	4.18
SSS83	1.32	18.82	5.81

Note 1: Gamma and tritium analyses are based on wet weights while alpha and beta are based on dry weights. HPGE spectral analysis was performed on any sample with a gamma activity greater than Minimum Detectable Activity.

TABLE 2
SUMMARY OF ENVIRONMENTAL SET 84

Fall 2013

Detection Limits[1]

Matrix	Alpha	Beta	Gamma	Tritium
Water	0.00 pCi/L	3.64 pCi/L	222.00 pCi/L	5.68 pCi/mL of sample
Soil	0.73 pCi/g	3.98 pCi/g	0.55 pCi/g	N/A
Vegetation	2.53 pCi/g	7.98 pCi/g	1.56pCi/g	5.21 pCi/mL of distillate
Subsurface	0.82 pCi/g	4.35 pCi/g	0.62 pCi/g	N/A

Activity Levels - Vegetation

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)	H-3 (pCi/mL)
1V84	< 2.53	33.88	2.51	< 5.21
2V84	< 2.53	39.64	1.86	< 5.21
3V84	< 2.53	17.26	2.81	< 5.21
4V84	< 2.53	21.19	1.97	< 5.21
5V84	< 2.53	27.72	< 1.56	< 5.21
6V84	< 2.53	12.91	< 1.56	< 5.21
7V84	< 2.53	39.32	< 1.56	< 5.21
10V84	2.84	31.95	< 1.56	< 5.21

Activity Levels - Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
1S84	< 0.73	20.18	3.32
2S84	< 0.73	10.35	2.44
3S84	< 0.73	17.93	2.76
4S84	< 0.73	10.71	2.79
5S84	< 0.73	21.52	4.53
6S84	< 0.73	13.11	2.93
7S84	1.77	17.13	4.57
10S84	1.26	21.68	3.52

TABLE 2 (Cont'd)
SUMMARY OF ENVIRONMENTAL SET 84

Fall 2013

Activity Levels - Water

Sample	Alpha (pCi/L)	Beta (pCi/L)	Gamma (pCi/L)	H-3 (pCi/mL)
4W84	0.63	6.52	< 222.00	< 5.68
6W84	0.16	< 3.64	< 222.00	< 5.68
10W84	0.00	10.11	< 222.00	< 5.68

Activity Levels - Subsurface Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
PSS84	1.07	22.51	6.23
NESS84	0.87	22.62	4.24
NSS84	1.57	26.15	4.47
WSS84	0.88	21.16	3.16
ESS84	1.06	21.91	4.76
SSS84	2.14	23.46	5.48

Note 1: Gamma and tritium analyses are based on wet weights while alpha and beta are based on dry weights. HPGE spectral analysis was performed on any sample with a gamma activity greater than Minimum Detectable Activity.

TABLE 3
ENVIRONMENTAL TLD SUMMARY

January 1, 2013 through December 31, 2013

Badge Number	Direction From MURR	Map Distance from MURR Stack (meters)	1st Qtr. 2013 Net mR	2nd Qtr. 2013 Net mR	3rd Qtr. 2013 Net mR	4th Qtr. 2013 Net mR	Total 2013 Net mR
	Control 0	N/A	28.0	23.0	25.0	33.0	109.0
1	Control 1	16600	27.0	23.0	24.0	32.0	106.0
2	Control 2	16600	24.0	22.0	24.0	31.0	101.0
3	WSW	N/A	0.0	0.0	0.0	0.0	0.0
4*							
5*							
6	N	34	0.0	1.0	5.0	9.0	15.0
7	NE	57	4.0	2.0	5.0	1.0	12.0
8	SW	27	6.0	4.0	3.0	2.0	15.0
9	S	27	22.0	20.0	15.0	26.0	83.0
10	NE	149	0.0	0.0	0.0	0.0	0.0
11	NW	149	0.0	0.0	2.0	0.0	2.0
12	ENE	301	0.0	2.0	3.0	2.0	7.0
13	NNE	316	0.0	0.0	0.0	0.0	0.0
14	S	156	0.0	3.0	0.0	0.0	3.0
15	S	65	19.0	15.0	14.0	17.0	65.0
16	SE	107	0.0	0.0	0.0	0.0	0.0
17	E	293	0.0	0.0	0.0	0.0	0.0
18	NE	476	0.0	0.0	0.0	0.0	0.0
19	NNE	606	0.0	0.0	0.0	0.0	0.0
20	NE	907	0.0	0.0	0.0	0.0	0.0
21	SE	236	0.0	0.0	0.0	1.0	1.0
22	ESE	168	0.0	0.0	0.0	0.0	0.0
23	NW	110	0.0	0.0	0.0	3.0	3.0
24	SSW	328	0.0	0.0	0.0	0.0	0.0
25	SSW	480	0.0	0.0	3.0	0.0	3.0
26	SW	301	0.0	0.0	0.0	0.0	0.0
27	WSW	141	0.0	0.0	0.0	0.0	0.0
28	WNW	210	0.0	0.0	3.0	1.0	4.0
29	NW	255	2.0	0.0	4.0	0.0	6.0
30	NNW	328	0.0	0.0	0.0	0.0	0.0
31	NNW	671	0.0	0.0	0.0	0.0	0.0
32	NNW	724	0.0	0.0	1.0	0.0	1.0
33	E	671	0.0	0.0	0.0	0.0	0.0
34	ENE	587	0.0	0.0	0.0	0.0	0.0
35	SSE	499	5.0	5.0	2.0	4.0	16.0
36	SE	419	0.0	0.0	0.0	0.0	0.0
37	NE	690	0.0	0.0	0.0	0.0	0.0
38	NW	556	0.0	0.0	1.0	0.0	1.0
39	W	491	0.0	0.0	0.0	0.0	0.0
40	N	541	0.0	0.0	0.0	0.0	0.0
41	NNE	137	0.0	0.0	0.0	0.0	0.0
42*							
43*							
44	Spare	N/A	0.0	missing	missing	0.0	0.0
45	S	65	7.0	4.0	6.0	3.0	20.0
46	E	70	0.0	0.0	0.0	0.0	0.0

*These badge numbers are no longer used.

TABLE 4
NUMBER OF FACILITY RADIATION AND CONTAMINATION SURVEYS

January 1, 2013 through December 31, 2013

	Radiation	Surface Contamination*	Air Samples**	RWPs
January	94	94	59	10
February	60	60	44	7
March	97	97	45	9
April	61	61	43	8
May	87	87	36	8
June	97	97	49	4
July	94	94	62	7
August	97	97	63	10
September	80	80	62	8
October	101	101	66	6
November	85	85	45	10
December	74	74	11	9
TOTALS	**1027**	**1027**	**585**	**96**

* In addition, general building contamination surveys are conducted each normal work day.

** Air samples include exhaust stack Ar-41, containment building Ar-41, sump entries, and hot cell entries.

Miscellaneous Notes

Nathan Hogue resigned as Assistant Health Physics Manager in August 2013.

During calendar year 2013, MURR shipped 554 cubic feet of low-level radioactive waste containing 1.205 mCi of activity.

SECTION IX

Summary of Radiation Exposure to Facility Staff, Experimenters and Visitors

January 1, 2013 through December 31, 2013

TOTAL PERSONNEL DOSE (MREM) BY DOSIMETRY GROUP

	AC	BCS	DO	FOE	HC/SH	HP	IRR	NA	NS	OPS	PRO	QA	RES	RP	SIL	TEE	WC	Total
January	12	2	10	4	419	128	7	6	52	1443	121	29	10	47	140	0	27	2457
February	18	3	0	6	346	90	6	9	62	1169	72	8	37	13	107	0	121	2067
March	39	7	0	17	534	121	3	11	34	1371	77	25	24	35	87	0	99	2484
April	14	0	0	0	450	207	13	11	22	1352	109	7	4	48	86	5	254	2582
May	15	10	0	0	414	109	3	2	21	1612	127	65	2	22	78	0	19	2499
June	3	0	0	7	434	219	0	4	84	1995	109	63	100	38	177	4	38	3275
July	0	6	0	0	340	89	9	12	1	1651	153	42	11	25	168	0	16	2523
August	15	13	1	3	335	122	7	15	54	2042	139	82	6	44	224	4	17	3123
September	0	2	0	5	310	111	2	27	42	1598	129	47	4	246	137	8	39	2707
October	7	13	4	3	348	146	7	22	62	1666	130	85	9	65	94	2	101	2764
November	2	2	4	8	411	178	0	21	112	1865	117	21	2	28	411	0	37	3219
December	21	8	7	2	282	101	5	42	58	1725	171	32	7	30	114	2	23	2630
Total for Year	**146**	**66**	**26**	**55**	**4623**	**1621**	**62**	**182**	**604**	**19489**	**1454**	**506**	**216**	**641**	**1823**	**25**	**791**	**32330**
Monthly Avg	**12**	**6**	**2**	**5**	**385**	**135**	**5**	**15**	**50**	**1624**	**121**	**42**	**18**	**53**	**152**	**2**	**66**	**2694**
Highest WB (annual)	**31**	**26**	**6**	**25**	**1565**	**425**	**57**	**64**	**212**	**1236**	**407**	**154**	**144**	**311**	**998**	**8**	**241**	
High EXT (annual)	**479**	**58**	**NR**	**NR**	**3397**	**866**	**NR**	**2929**	**370**	**1556**	**5524**	**513**	**538**	**1832**	**1237**	**168**	**893**	

AC - Analytical Chemistry
BCS - Business & Central Services
DO - Director's Office
FOE - Shops & Support
HC/SH - Hot Cell/Shipping
HP - Health Physics
IRR - Irradiations
NA - Nuclear Analysis
NS - Neutron Scattering
OPS - Operations
PRO - Isotope Processing
QA - Quality Assurance
RES - Research
RP - Radiopharmaceutical
SIL - Silicon
TEE - Trace Elemental Epidemiology
WC - Work Control

WB = Whole Body EXT = Extremities M = Minimal NR = None Reported

Analysis of personnel exposure levels indicates that exposures are significantly below the limits of 10 CFR 20.1201 and are generally maintained ALARA. Radiation workers who are not full time staff members have radiation exposures which are generally lower than full time radiation workers.

NOTES:
Dosimetry services are provided by Mirion Technologies (except self reading dosimetry).