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RESEARCH REACTOR CENTER

February 26, 2013

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
2012 Reactor Operations Annual Report

I have enclosed one copy of the Reactor Operations Annual Report for the University of Missouri Research Reactor. The reporting period covers January 1, 2012 through December 31, 2012.

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 me at (573) 882-5319 or FruitsJ@missouri.edu.

Sincerely,

John L. Fruits
Reactor Manager

JLF/djr

Enclosure

xc: Mr. Alexander Adams, U.S. NRC
Mr. Craig Bassett, U.S. NRC

A020
NRR

1513 Research Park Drive Columbia, MO 65211 Phone: 573-882-4211 Fax: 573-882-6360 Web: www.murr.missouri.edu
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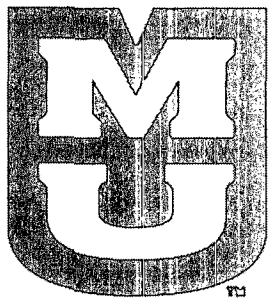

UNIVERSITY OF MISSOURI

UNIVERSITY OF MISSOURI RESEARCH REACTOR

REACTOR OPERATIONS ANNUAL REPORT

January 1, 2012 – December 31, 2012

UNIVERSITY OF MISSOURI
RESEARCH REACTOR FACILITY

REACTOR OPERATIONS
ANNUAL REPORT

January 1, 2012 through December 31, 2012

Compiled by the Research Reactor Staff of MURR

Submitted by: _____

John L. Fruits
Reactor Manager

Reviewed and approved by: _____

Ralph A. Butler, PE
Director

UNIVERSITY OF MISSOURI – COLUMBIA
RESEARCH REACTOR

REACTOR OPERATIONS ANNUAL REPORT

January 1, 2012 through December 31, 2012

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, 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, heterogenous 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 2012. 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) 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 License Amendment No. 35 to Amended Facility License R-103, which approved the addition of an engineered safety device to the reactor protection system which increased the capacity and flexibility of the flux trap, (2) installing and placing a new Cooling Tower on service, (3) performing cleaning and replacement of the plates on primary coolant heat exchangers HX-503A and HX-503B, and (4) responding to Requests for Additional Information for the amendment to MURR Technical Specification 2.1, "Reactor Core Safety Limit." Additionally, in August 2006 MURR submitted a request

to the NRC to renew Amended Facility Operating License R-103. Significant efforts have already been placed in responding to the Requests for Additional Information and these efforts will continue in the upcoming 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.

MURR also hosted the 5th International Symposium of Material Testing Reactors (ISMTR). Since 2008, users, operators, researchers and specialists from Material Testing Reactors (MTR) throughout the world have gathered each year to exchange knowledge and experiences particular to the scope of their activities. The ISMTR encourages participants to engage in teamwork and build relationships that promote the continuous development and expansion of this collaborative worldwide network of specialists, organizations and companies involved in MTR operation. The Symposium also included the 7th Specialist Meeting on Recycling of Irradiated Beryllium. The objective of this meeting was to exchange information on beryllium used at MTRs, especially material selection, recycling of irradiated beryllium, lifetime expansion and waste management.

Reactor Operations Management also wishes to commend the two individuals who received their Reactor Operator certifications and the two 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, 2012 through December 31, 2012

The following table and discussion summarizes reactor operations during the period from January 1, 2012 through December 31, 2012.

Month	Full Power Hours	Megawatt Days	Full Power % of Total Time	Full Power % of Scheduled[1]
January	548.26	261.12	73.7	82.5
February	632.19	263.77	90.8	101.8
March	679.96	283.49	91.4	102.3
April	634.70	264.68	88.2	98.9
May	658.73	274.85	88.5	99.1
June	645.22	269.08	89.6	100.5
July	667.47	278.33	89.7	100.4
August	670.50	279.18	90.1	100.9
September	657.20	274.01	91.3	102.4
October	661.70	275.93	88.9	99.6
November	645.13	269.04	89.6	100.5
December	665.64	277.57	89.5	100.2
Total for the Year	**7766.70**	**3271.05**	**88.45 %**	**99.09 %**

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 2012

The reactor operated continuously in January with the following exceptions: five shutdowns for scheduled maintenance and/or refueling and three unscheduled/unplanned power reductions.

On January 2, during a regularly scheduled reactor shut down with the reactor power level less than 100 kW, a "Power Level Interlock" scram was automatically initiated. The immediate actions of REP-3, "Primary Coolant System Low Pressure or Flow Scram," were performed. Investigation revealed that improper manual adjustment of primary coolant heat exchanger automatic temperature control valve S-1 increased the cool down rate of the primary coolant at a rate greater than what could be automatically compensated by the pressurizer system. Control room operators were counseled on the implications of manual adjustments to components controlling the rate of cooling and the difference of effects while above or below the point of adding heat. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager following previously scheduled maintenance activities.

On January 17, with the reactor operating at 10 MW in the automatic control mode, the reactor was manually shut down after an unexplained 3% step decrease in power level indication was observed on Nuclear Instrumentation Power Range Monitor No. 5. The duty operator noted all other power level and period indications were normal. All

immediate and subsequent actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. During troubleshooting, all safety functions associated with Nuclear Instrumentation Signal Process No. 2 were verified operational. Additional efforts revealed occasional small down spikes on Nuclear Instrumentation Intermediate Range Monitor No. 3 which led to the replacement of the preamplifier, and fission chamber detector and cabling for Nuclear Instrumentation Signal Processor No. 2. An instrument channel calibration and pre-operational checks were performed satisfactorily. The system was response checked with a neutron source and permission to restart the reactor was obtained from the Reactor Manager. The reactor was refueled and subsequently restarted to 10 MW operation.

On January 19, 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 electro-magnet during a routine shimming evolution. The reactor was shut down. An inspection of the offset mechanism pull rod and housing revealed a slight misalignment. The offset housing was realigned and the anvil and magnet were cleaned. The control rod was satisfactorily withdrawn to the full out position as part of the retest by performing Compliance Procedure No. 10, "Rod Drop Times." 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: placing the new cooling tower on service; performing internal cleaning and inspection of primary coolant system heat exchanger HX-503A; replacing preamplifier, fission chamber and associated cabling for Nuclear Instrument Signal Processor No. 2; loading new de-ionization bed 'R' and placing it on pool coolant system service; and refurbishing ventilation exhaust isolation valve 16B solenoid-operated air control valve A-153.

February 2012

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

On February 27, 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 movement of the startup neutron source. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. The flux trap sample holder was verified to be latched to the inner reactor pressure vessel. The operators involved were counseled on the importance of proper handling techniques near the FIRST Support Rig. Permission to restart the reactor was obtained from the Reactor Manager and the reactor was subsequently restarted to 10 MW operation.

Major maintenance items for the month included: implementing Amendment No. 35 "Flux-Trap Irradiations Reactivity Safety Trip Device" to Amended Facility License R-103; completing Modification Record 11-01, "Flux-Trap Irradiations Reactivity Safety Trip (FIRST) Instrument Channels;" completing Modification Record 75-16, Addendum 4, "Reactor Safety System Monitoring Circuit (White Rat) Panel – Revision to Panel Overlays in Support of the FIRST Device;" completing Modification Record 10-02, "Addition of MURR Systems to Lab 251;" completing Modification Record 11-02, "Replace Cooling Tower;" 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 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.

March 2012

The reactor operated continuously in March 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 the air actuator on Primary Coolant Demineralizer Inlet Isolation Valve 527E; refurbishing Reactor Pool Below Refuel Level Relay 2K5; 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-203, "Measurement of the Primary Coolant/Moderator Temperature Coefficient of Reactivity, RTP-19," in support of a Nuclear Engineering Department practicum; and replacing the secondary coolant supply header piping from Temporary Cooling Isolation Valve S-238 to the through-wall portion of the secondary coolant pump suction piping.

April 2012

The reactor operated continuously in April with the following exceptions: five shutdowns for scheduled maintenance and/or refueling and four shutdowns for physics measurements. There were no unscheduled/unplanned power reductions this month. U.S. Nuclear Regulatory Commission regional inspector arrived at the facility for a routine inspection of the Radiation Protection Program and Shipping.

Major maintenance items for the month included: performing four 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-200, "Measurement of Differential Worth of a Shim Blade, RTP-11(D);" replacing the Regulating Blade Drive Rotary Limit Switch; and completing the biennial change-out of Control Blade 'B' Offset Mechanism and associated retesting.

May 2012

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

On May 19, with the reactor operating at 10 MW in the automatic control mode, a manual scram was initiated when an operator discovered the drive sprocket on the regulating blade rotary limit switch assembly not rotating during a normal regulating blade movement. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Subsequent investigation discovered that the set screws that secure the drive sprocket to the drive shaft had disengaged. The regulating blade rotary limit switch drive sprocket and associated set screws were replaced. All functions initiated by the regulating blade rotary limit switch assembly were tested satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager.

Failure of the regulating blade rotary limit switch assembly to be operable during reactor operation resulted in a deviation from Technical Specification 3.4.c, which states, "*The reactor shall not be operated unless the following rod run-in functions are operable. Each of the rod run-in functions shall have 1/N logic where N is the number of instrument channels required for the corresponding mode of operation.*" The two rod run-in functions associated with "*Regulating Blade Position*" are the "*< 10% withdrawn and bottomed.*" Licensee Event Report 12-01, providing a detailed description of this event and the corrective actions taken, was submitted to the U. S. Nuclear Regulatory commission with the 30-day reporting requirements.

On May 26, 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 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.

On May 27, with the reactor operating at 10 MW in the automatic control mode, a manual scram was initiated after the duty operator observed a greater than abnormal lowering of pressurizer liquid level. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Subsequent investigation discovered leakage from primary demineralizer inlet filter F-201 housing lower sealing gasket. All gaskets on the filter housing were replaced and satisfactorily leak checked. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager.

On May 30, 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 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.

Major maintenance items for the month included: completing Modification Record 09-03, "Lab Impex Stack Monitoring System;" completing Modification Record 09-03, Addendum 1, "Update to Lab Impex Stack Monitoring System;" completing compliance procedure CP-26, "Containment Building Compliance Test;" installing replacement plates in primary coolant heat exchanger HX-503B; loading new de-ionization bed 'L' and placing it on pool coolant system service; 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 2012

The reactor operated continuously in June with the following exceptions: four shutdowns for scheduled maintenance and/or refueling, one shutdown for physics measurements and one unscheduled/unplanned power reduction. U.S. Nuclear Regulatory Commission regional inspector arrived at the facility for a routine inspection of Security and Material Control and Accountability.

On June 28, with the reactor operating at 10 MW in the automatic control mode, a manual scram was initiated after the duty operator observed a greater than normal lowering of pressurizer liquid level. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Upon investigation of Mechanical

Equipment Room 114, which contains a large portion of the cooling equipment for the reactor, primary coolant was found leaking from primary heat coolant system exchanger HX-503A Outlet Valve 540A. The valve was isolated and that section of the primary coolant system drained in order to remove the bonnet for an internal inspection of the valve. It was discovered that the valve diaphragm had ruptured. The diaphragm was replaced, the system refilled and then leak tested satisfactorily. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager.

Major maintenance items for the month included: completing Modification Record 05-01, Addendum 3, "Pneumatic Tube System Changes in Lab 227;" performing a reactivity worth measurement in accordance with reactor procedure RP-RO-202, "Measurement of Reactivity Worth of Movable Samples, RTP-6;" and performing a reactivity worth measurement in accordance with reactor procedure RP-RO-201, "Measurement of Reactivity Worth of Flux Trap Loading or Individual Samples, RTP-17(B).

July 2012

The reactor operated continuously in July with the following exceptions: five 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: 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 the air actuator on Primary Coolant Demineralizer Inlet Valve 527E; completing Modification Record 01-09, Addendum 4, "Emergency Electrical Power System in Room 231;" completing Modification Record 98-02, Addendum 1, "Sulfuric Acid System Changes in Support of Cooling Tower Replacement;" completing Modification Record 03-03, Addendum 3, "Fire Protection System Changes in Support of Cooling Tower Replacement;" and replacing the diaphragm on primary coolant system heat exchanger HX-503A Outlet Valve 540B.

August 2012

The reactor operated continuously in August with the following exceptions: four shutdowns for scheduled maintenance and/or refueling and two unscheduled/unplanned power reductions. Additionally, two reactor startups and one reactor shutdown were performed in support of U.S. Nuclear Regulatory Commission operator licensing examinations. Received notification from the U.S. Nuclear Regulatory Commission that two new Reactor Operator and two new Senior Reactor Operator licenses had been issued.

On August 21, with the reactor operating at 10 MW in the automatic control mode, a "Power Level Interlock or FIRST" scram was automatically initiated when an operator attempted to replace a lamp in the light box of Control Rod Drive Mechanism 'A' "Power On" indication. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Further investigation determined that the new lamp had dropped from the light box into the indication housing assembly, thereby momentarily causing a short across the power supply contacts. The resultant voltage drop was sufficient to initiate a Power Level Interlock scram. The reactor was refueled and permission to restart the reactor was obtained from the Reactor Manager.

On August 23, 2012, with the reactor operating at 10 MW in the automatic control mode, the control room operator discovered that the automatic control switches for Pressurizer Water Drain Valve 527A were in the manual and closed positions. The automatic/manual switch for valve 527A was immediately placed in the automatic position. This valve is required to be in the automatic position whenever the reactor is in operation. At the time, pressurizer liquid level was approximately 3.0 inches below centerline (-3), which is within the normal operating band of +4 to -7 inches. With Pressurizer Water Drain Valve 527A switch in the manual position, a valve interlock would have prevented Pressurizer Water Fill Valve 527B from opening and primary coolant charging pump P-533 from starting had pressurizer liquid level decreased to a set point of -6 inches.

Primary coolant charging pump P-533 delivers makeup water to the primary coolant system via the pressurizer from makeup water storage tank T-300. In accordance with Technical Specification 3.10.b, "*the reactor shall not be operated unless the reactor makeup water system is operable and connected to a source of at least 2,000 gallons of primary grade water.*" The basis for this Technical Specification is to provide "*...an adequate supply of primary grade water for makeup during all modes of operation.*" With the potential of coolant charging pump P-533 not starting as required by system demand, the reactor makeup water system was in a degraded state and not considered operable. Licensee Event Report 12-02, providing a detailed description of this event and the corrective actions taken, was submitted to the U. S. Nuclear Regulatory commission with the 30-day reporting requirements.

On August 30, with the reactor operating at 10 MW in the automatic control mode, a "Rod Not in Contact with Magnet" rod run-in automatically initiated. The duty operator noted no additional indications of a rod not in contact with its magnet and initiated a manual reactor scram. The immediate actions of reactor emergency procedure REP-2, "Reactor Scram," were performed. Troubleshooting efforts discovered that a solder connection on the magnet engaged circuit for Control Rod Drive Mechanism 'A' had failed. The connection was repaired and operation of the Control Rod Drive Mechanism retested satisfactorily. The reactor was refueled and 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-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" and completing compliance procedure CP-31, "Calibration of the Eberline Radiation Stack Monitor."

September 2012

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

Major maintenance items for the month included: 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-202, "Measurement of Reactivity Worth of Moveable Samples, RTP-6;" and loading new de-ionization bed 'V' and placing it on pool coolant system service.

October 2012

The reactor operated continuously in October with the following exceptions: five shutdowns for scheduled maintenance and/or refueling and one shutdown for physics measurements. There were no unscheduled/unplanned power reductions this month. U.S. Nuclear Regulatory Commission regional inspector arrived at the facility for a routine inspection of Reactor Operations and Emergency Preparedness.

Major maintenance items for the month included: performing a zero and span procedure on Pool Coolant Heat Exchanger Outlet temperature element TE-901D; replacing the motor for primary coolant circulation pump P-501A; completing Modification Record 01-02, Addendum 8, "Intercommunication and Paging System Changes in Support of the Sterility Suite Rooms 2045A and 2045B;" completing compliance procedure CP-29, "Calibration of Lab Impex Stack Monitor;" 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 2012

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

On November 13, with the reactor operating at 10 MW in the automatic control mode, a "Bldg Air Plenum and Bridge Hi Activity" reactor scram and containment building isolation were automatically initiated. The immediate actions of emergency procedure EP-RO-012, "Reactor Isolation," were performed. Remote monitoring (external to the reactor containment building) of all containment area radiation monitors indicated normal radiation levels with the exception of Containment Building Exhaust Plenum - No. 2 Radiation Monitor, whose indication was pegged high off scale. After re-entry into the reactor containment building, troubleshooting efforts determined that Containment Building Exhaust Plenum - No. 2 Radiation Monitor detector assembly had failed. The detector assembly and electronic control module were replaced. Proper operation was verified by performance of the applicable portions of compliance procedure CP-30, "ARMS and 16-Inch Valve Cabinet and Associated Horns and Lights." The reactor was refueled and 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-201, "Measurement of Reactivity Worth of Flux Trap Loadings or Individual Samples, RTP-17(B);" replacing the displacer cable for the anti-siphon system level controller, LC965; replacing the motor for primary coolant demineralizer pump P-513A; and performing a calibration of the iodine chart recorder for the Lab Impex Stack Monitor.

December 2012

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

Major maintenance items for the month included: completing compliance procedure CP-31, "Calibration of the Eberline Radiation Stack Monitor;" completing the biennial change-out of Control Blade 'D' Offset Mechanism and

associated retesting: 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 three 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)."

SECTION II

MURR PROCEDURES

January 1, 2012 through December 31, 2012

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 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-four (64) revisions issued to the reactor operations procedures, forms and operator aids. Additionally, one (1) outdated procedure was obsoleted. 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-110	Conduct of Operations	17	2/8/2012	Minor Editorial
AP-RO-110	Conduct of Operations	18	11/16/2012	Minor Editorial
AP-RO-135	Reactor Utilization Requests	1	2/8/2012	Minor Editorial
AP-RO-135	Reactor Utilization Requests	2	10/24/2012	Minor Editorial
EX-RO-105	Reactor Irradiation Experiments	16	3/5/2012	Minor Editorial
EX-RO-105	Reactor Irradiation Experiments	17	6/8/2012	Minor Editorial
EX-RO-105	Reactor Irradiation Experiments	18	12/4/2012	Minor Editorial
EX-RO-120	Beamport "A" Operation	10	8/21/2012	Cover Page
EX-RO-121	Beamport "B" Operation	10	8/21/2012	Cover Page
EX-RO-122	Beamport "C" Operation	10	8/21/2012	Cover Page
EX-RO-123	Beamport "D" Operation	10	8/21/2012	Cover Page
EX-RO-124	Beamport "E" Operation	11	8/21/2012	Cover Page
EX-RO-125	Beamport "F" Operation	12	8/21/2012	Cover Page
EX-RO-126	Thermal Column Door	8	12/4/2012	Cover Page
FM-11	Reactor Shutdown Checksheet	5	1/12/2012	Cover Page
FM-15	10 CFR 50.59 Qualified Reviewers List	14	7/31/2012	Minor Editorial
FM-18	Deviation From Procedure Report	6	12/4/2012	Cover Page
FM-19	Unscheduled Power Reduction Report	4	1/12/2012	Cover Page
FM-33	Containment Building Restricted Materials	4	12/4/2012	Cover Page
FM-43	Nuclear and Process Data	16	3/5/2012	Minor Editorial
FM-47	Deviation From Procedure Report	6	10/17/2012	Minor Editorial
FM-56	Reactor Routine Patrol	15	3/5/2012	Minor Editorial
FM-57	Long Form Startup Checksheet	18	3/5/2012	Minor Editorial
FM-57	Long Form Startup Checksheet	19	12/4/2012	Cover Page

Number	Name	Rev.	Revision Date	Notes
FM-58	Short Form Startup Checksheet	10	12/4/2012	Cover Page
FM-63	DI Water Makeup Log	8	2/8/2012	Cover Page
FM-68	Target Material Control Checksheet	10	8/1/2012	Minor Editorial
FM-68	Target Material Control Checksheet	11	10/10/2012	Minor Editorial
OA-4	Valve Operation Air Compressor	6	12/4/2012	Minor Editorial
OA-5	Emergency Air Compressor	6	12/4/2012	Minor Editorial
OP-RO-100	Main Air System	9	3/5/2012	Minor Editorial
OP-RO-101	Instrument Air System	9	3/5/2012	Minor Editorial
OP-RO-210	Reactor Startup-Normal	12	8/1/2012	Minor Editorial
OP-RO-211	Reactor Startup - Hot	10	8/1/2012	Minor Editorial
OP-RO-212	Reactor Startup - Recovery from Temporary Power Reduction	10	8/1/2012	Minor Editorial
OP-RO-220	Reactor Shutdown or Power Reduction	7	6/29/2012	Cover Page
OP-RO-230	Changing Reactor Power Level	7	6/29/2012	Cover Page
OP-RO-310	Nuclear Instrumentation - Signal Processor #1	9	6/8/2012	Minor Editorial
OP-RO-311	Nuclear Instrumentation - Signal Processor #2	10	6/8/2012	Minor Editorial
OP-RO-312	Nuclear Instrumentation Power Range Monitor - Channel 6	12	6/8/2012	Cover Page
OP-RO-330	Nuclear Instrumentation - Wide Range Monitor	9	6/8/2012	Cover Page
OP-RO-340	Nuclear Instrumentation Adjustment	9	6/8/2012	Cover Page
OP-RO-350	Reactor Power Calculator Flow Potentiometer Adjustment	6	8/16/2012	Cover Page
OP-RO-410	Primary Coolant System	10	11/16/2012	Minor Editorial
OP-RO-461	Pool Coolant System - One Pump Operation	13	6/29/2012	Minor Editorial
OP-RO-480	Secondary Coolant System	15	8/1/2012	Minor Editorial
OP-RO-480	Secondary Coolant System	16	12/4/2012	Minor Editorial
OP-RO-515	Emergency Air System	8	10/24/2012	Cover Page
OP-RO-520	Emergency Diesel Generator	10	10/24/2012	Cover Page
OP-RO-525	Chill Water System	6	6/8/2012	Minor Editorial
OP-RO-530	Demineralized Water Supply System	12	8/16/2012	Minor Editorial
OP-RO-531	Primary and Pool Sample Station	10	6/29/2012	Minor Editorial
OP-RO-555	Fire Protection System	9	2/8/2012	Minor Editorial
OP-RO-710	Radiation Monitoring - Area Monitors	7	8/16/2012	Minor Editorial
OP-RO-720	Radiation Monitoring - Stack Monitor Operational Check	9	3/5/2012	Minor Editorial
OP-RO-720	Radiation Monitoring - Stack Monitor Operational Check	10	6/29/2012	Minor Editorial
REP-RO-100	Reactor Emergency Procedures	14	2/15/2012	Minor Editorial
REP-RO-100	Reactor Emergency Procedures	15	9/11/2012	Minor Editorial
RP-RO-100	Fuel Movement	11	9/19/2012	Minor Editorial
RP-RO-202	Measurement of Reactivity Worth of Movable Samples, RTP-6	3	6/8/2012	Minor Editorial
SM-RO-100	Draining and Filling the Primary Coolant Side of Primary Coolant System Heat Exchangers	1	2/7/2012	Minor Editorial
SM-RO-105	Replace Primary and Pool Coolant System Heat Exchangers and Piping	1	2/7/2012	Cover Page

Number	Name	Rev.	Revision Date	Notes
SM-RO-625	Measuring Control Blade Pull Weight and Blade Drop Time with the Test Magnet Assembly, RTP-21	2	10/24/2012	Cover Page
SM-RO-650	Cleaning the Acid Day Tank Sight Glass	1	4/15/2011	Obsoleted
SM-RO-660	Replacement of Inner and Outer Pressure Vessels	3	2/7/2012	Minor Editorial

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 eight (8) 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-015	Emergency Notifications	8	10/30/2012	Minor Editorial
FM-104	Emergency Call List	19	1/20/2012	Minor Editorial
FM-104	Emergency Call List	20	6/12/2012	Minor Editorial
FM-104	Emergency Call List	21	10/30/2012	Minor Editorial
OA-10	Fire Extinguisher Locations and Types	8	12/28/2012	Minor Editorial
OA-20	Emergency Equipment	12	1/20/2012	Minor Editorial
OA-20	Emergency Equipment	13	9/19/2012	Minor Editorial
OA-20	Emergency Equipment	14	12/28/2012	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 fifty-one (51) 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, and eight (8) outdated procedures were obsoleted. 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-119	High Radiation Area Access	4	5/31/2012	Minor Editorial
AP-HP-120	Beamport Area	5	11/23/2010	Obsoleted
AP-HP-121	Isotope Closet	5	12/30/2010	Obsoleted
AP-HP-123	Visitor Dosimetry - Reception Desk	8	1/12/2012	Cover Page
AP-HP-125	Review of Unplanned Radiation Exposure	4	2/22/2012	Minor Editorial
AP-SH-002	In-House Radioactive Shipping Request Form Instructions	1	9/19/2012	Minor Editorial

Number	Name	Rev.	Revision Date	Notes
BPB-SH-002	20WC-1 Packaging and Shipment of Type B Non-Waste Radioactive Material	11	7/25/2012	Minor Editorial
BPB-SH-005	DOT 6M Packaging of Type B Non-Waste Radioactive Material	10	3/29/2012	Minor Editorial
BPB-SH-020	Receipt Inspection Of Type B Byproduct Material Shipping Containers	3	12/5/2012	Minor Editorial
BPB-SH-025	Type B(U) ZA/NNR1005 (Beatrice) Packaging of Type B Non-Waste Radioactive Material	1	1/4/2012	Minor Editorial
BPB-SH-026	Type B(U) F-327 Series Packaging of Type B Non-Waste Radioactive Material	1	9/19/2012	Minor Editorial
BPB-SH-027	Survey and Decontamination of Returned Shipping Containers	0	8/2/2012	New Procedure
BPB-SH-028	TYPE B(U) USA/9337/B (U)-96 (LS) Packaging of Radioactive Material	0	12/12/2012	New Procedure
BP-SH-052	Radioactive Material Shipment Package Documentation and Labeling	8	8/2/2012	Minor Editorial
BP-SH-052	Radioactive Material Shipment Package Documentation and Labeling	9	10/2/2012	Minor Editorial
BP-SH-059	Packaging and Shipment of Radioactive Material Using Spectratek Services Reusable Type A Package	3	6/12/2012	Cover Page
BP-SH-059	Packaging and Shipment of Radioactive Material Using Spectratek Services Reusable Type A Package	4	12/12/2012	Minor Editorial
BP-SH-099	Packaging of Radioactive Material Using MURR Model 1500	3	1/4/2012	Minor Editorial
FM-17	Radiation Work Permit	10	12/26/2012	Minor Editorial
FM-27	In-House Radioactive Shipping Request Form	10	9/19/2012	Minor Editorial
FM-39	Control Checksheet for Excepted Package Radioactive Materials Shipment	11	3/9/2012	Minor Editorial
FM-52	Control Checksheet for Documentation and Labeling of Radioactive Material Shipment	10	10/2/2012	Minor Editorial
FM-59	Control Checksheet for Spectratek Services Reusable Type A Package Radioactive Materials Shipment	5	3/9/2012	Cover Page
FM-59	Control Checksheet for Spectratek Services Reusable Type A Package Radioactive Materials Shipment	6	12/12/2012	Minor Editorial
FM-79	Lutetium Chloride Radiation Protection Data Sheet B	7	12/17/2012	Minor Editorial
FM-89	Control Checksheet for Type A F-327 Series Radioactive Material Shipment	9	1/4/2012	Cover Page
FM-91	Declaration of Pregnancy	4	2/22/2012	Cover Page
FM-120	Individual Type B QA Training Certification	4	1/4/2012	Cover Page
FM-125	Lutetium Chloride Process Notification	2	3/22/2012	Cover Page
FM-135	Control Checksheet for Type B(U) ZA/NNR1005 (Beatrice) Radioactive Materials Shipment	1	3/9/2012	Cover Page
FM-137	Type B Qualified Shipper List	0	12/12/2012	New Form

Number	Name	Rev.	Revision Date	Notes
FM-138	Control Checksheet for Leak Testing of the LS Shipping Container Using the CALT 9 Leakage Testing Device	0	12/12/2012	New Form
FM-156	Required Documentation for Non-MURR Owned Type B Shipping Containers	2	7/25/2012	Minor Editorial
FM-158	NOA Waste Tank Sample Analysis	1	7/12/2012	Minor Editorial
FM-158	NOA Waste Tank Sample Analysis	2	7/25/2012	Minor Editorial
FM-162	Mo-99 Process HP Check Sheet	0	6/7/2012	New Procedure
FM-163	Control Checksheet for Type B(U) USA/9337/B(U)-96 (LS) Packaging of Radioactive Material	0	12/12/2012	New Form
HC-PSO-002	Hot Cell Preparation of Radioactive Material for Shipment	11	12/10/2012	Minor Editorial
HC-PSO-003	Glove Box Preparation of Radioactive Material for Shipment	9	12/10/2012	Minor Editorial
HC-PSO-005	Hot Cell Loading of Host Cans	9	1/19/2012	Minor Editorial
HC-PSO-005	Hot Cell Loading of Host Cans	10	12/10/2012	Minor Editorial
IC-HP-300	Calibration - Radiation Survey Instruments	6	3/7/2012	Minor Editorial
IC-HP-305	Calibration - Electrostatic Discharge Dosimeter	7	1/13/2012	Cover Page
IC-HP-318	NMC Model RAK Stack Monitor Offsets/Multipliers/High Voltages Determination	5	2/15/2008	Obsoleted
IC-HP-319	Calibration - NMC Model RAK Monitor - Particulate Channel	4	4/4/2007	Obsoleted
IC-HP-320	Calibration - NMC Model RAK Monitor - Iodine Channel	4	4/4/2007	Obsoleted
IC-HP-321	Calibration - NMC Model RAK Monitor - Gas Channel	4	4/18/2007	Obsoleted
IC-HP-349	Calibration - Lab Impex Stack Monitor-Particulate Channel	3	12/26/2012	Minor Editorial
IC-HP-352	Calibration - Lab Impex Stack Monitor-Flow Calibration	2	5/31/2012	Minor Editorial
IC-HP-353	Calibration - Lab Impex Monitor - DP2001	1	12/26/2012	Minor Editorial
IRR-PSO-112	Preparing Shipping Paperwork	6	10/10/2012	Minor Editorial
OP-HP-200	Air Sampling- Containment Building Tritium	5	1/13/2012	Minor Editorial
OP-HP-220	Tritium Bioassay	8	8/2/2012	Cover Page
OP-HP-355	NOA Waste Tank System Operation	1	1/13/2012	Minor Editorial
OP-HP-356	Operation - Lab Impex Stack Monitor - Filter Change and Source Checks	2	2/22/2012	Minor Editorial
OP-HP-356	Operation - Lab Impex Stack Monitor - Filter Change and Source Checks	3	10/15/2012	Minor Editorial
OP-HP-400	Gemstone Shipping Barrel Analysis	8	4/12/2012	Cover Page
OP-HP-400	Gemstone Shipping Barrel Analysis	9	10/15/2012	Minor Editorial
QA-SH-002	Sodium Iodide Spectral Analysis for Excepted, License-to-License, Type A, and Type B Radioactive Materials Shipments	5	4/20/2012	Minor Editorial
QAB-SH-004	Type B Program Vendor Qualification	2	3/29/2012	Minor Editorial
QAB-SH-007	Leak Testing of the LS Shipping Container Using the CALT 9 Leakage Testing Device	0	12/12/2012	New Procedure

Number	Name	Rev.	Revision Date	Notes
RM-HP-100	Stack Monitor Preventive Maintenance - NMC Model RAK	4	4/4/2007	Obsoleted
RP-HP-110	Survey and Decontamination of Returned Shipping Container	5	4/27/2011	Obsoleted
RP-HP-139	Beamport Radiation Level Monitoring During Reactor Startup	4	8/2/2012	Cover Page
SV-HP-130	Emergency Air Sampling of Exhaust Plume	6	7/25/2012	Cover Page
WM-SH-300	Exclusive Use Shipment of LSA or SCO Radioactive Waste	10	9/19/2012	Minor Editorial

SECTION III

REVISIONS TO THE HAZARDS SUMMARY REPORT

January 1, 2012 through December 31, 2012

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, page 5-8, Section 5.4.3 (as revised in the 1970-1971, 1973-1974 and 1996 Reactor Operations Annual Reports):

Delete: The entire paragraph under Section 5.4.3.

Replace with: "The cooling tower is a stainless steel, induced-draft, cross-flow type, with three cells and two-speed fan assemblies for each cell. The tower is designed to cool 5,400 gallons (20,440 liters) of water per minute to a temperature of 85 °F (29.4 C) from an initial temperature of 115 °F (46.1 C) at a maximum wet bulb temperature of 80 °F (26.7 C). Vibration and low oil cutout switches are mounted on each fan assembly to secure the associated fan motor to prevent damage to the fan or cooling tower structure should an imbalance or low oil level condition develop. The number of fans and fan speed is configured as required to provide sufficient cooling for 10-MW operation."

Original HSR, page 5-10, Section 5.4.6 (as revised in the 1967-1968 and 1972-1973 Reactor Operations Annual Reports):

Delete: "A gravity feed, solenoid valve controlled acid addition line has been provided to serve this purpose."

Replace with: "A metering pump injection system has been provided to serve this purpose."

Original HSR, page 7-17, Section 7.2.4 (as revised by the 1995 and 2004 Reactor Operations Annual Reports):

Delete: ", and a deluge, no-freezing system used in the cooling tower" and "a deluge system used in the cooling tower; "

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

Add: The following after "Room 2041":

"Room 2045A
Room 2045B"

Original HSR, page 8-2, Section 8.2, (as revised in the 1967-1968, 1972-1973, 1996 and 2000 Reactor Operations Annual Reports):

Delete: "Consequently, use of this facility will be subject to a high degree of administrative control to minimize the possibility of inserting or removing a sample with high reactivity worth during reactor operation."

Replace with: "Consequently, use of this facility will be interlocked with the Reactor Safety System to ensure that the reactor will scram should the center test hole canister be removed during reactor operation. The facility will also be subject to a high degree of administrative control to minimize the possibility of inserting or removing a sample with high reactivity worth during reactor operation."

Delete: "A latching device located at the top of the canister positively determines the canister position."

Replace with: "A latching device located at the top of the canister positively determines the canister position and two Reactor Safety System instrument channels positively sense the canister position during reactor operation."

Original HSR, page 8-10, Section 8.5 (as revised in the 1996 and 2001 Reactor Operations Annual Reports):

Delete: "Currently, only two reactor terminals and three sending –receiving stations are in use."

Replace with: "Currently, only two reactor terminals and two sending-receiving stations are in use."

Original HSR, page 9-7, Table 9.1 (as revised by the 1995, 2001, 2004, 2008 and 2009 Reactor Operations Annual Reports):

Add: "61 FIRST "Off-Bypass" 2 Pos. Key Lock"
"62 FIRST "Off-Bypass" 2 Pos. Key Lock"

Original HSR, page 9-28, Figure 9.2, Control Console Layout (as revised by the 2009 Reactor Operations Annual Report):

Replace with: Updated Figure 9.2, Control Console Layout Drawing (dated 2/20/12)

Original HSR, page 9-30, Figure 9.4, Safety System (as revised by the 2009 Reactor Operations Annual Report):

Replace with: Updated Figure 9.4, Safety System (MURR Dwg No. 139 dated 3/14/12)

Original HSR, page 9-22, Section 9.7.3, (as revised by the 1980-1981 and 1999 Reactor Operations Annual Reports):

Delete: The entire paragraph under Section 9.7.3

Replace with: "The Off-Gas Radiation Monitoring system consists of a three-channel radiation detection system designed to measure the airborne concentrations of radioactive particulate, iodine, and noble gas in the exhaust air which is sampled by an isokinetic probe located in the ventilation exhaust plenum. The radiation

detection equipment is an integrated component unit consisting of a fixed particulate filter monitored by either a scintillation or solid-state detector, a charcoal cartridge monitored by a lead-shielded scintillation detector, and a gas chamber monitored by a lead-shielded scintillation detector. The output from each radiation detector is displayed on a local meter, and on a strip-chart, three-pen recorder mounted in the Reactor Control Room. An audible and visual alarm alerts the operator to high activity or abnormal air flow. Minimum concentrations of radioactive wastes are ensured by continuously monitoring the gasses leading to the exhaust stack, and by ensuring maximum dilution of the potentially contaminated air with uncontaminated air."

Original HSR, page 9-26, after section 9.8.3.2 add new section:

Add: "9.9 Center Test Hole Instrumentation
The center test hole instrument channels, called the Flux-Trap Irradiations Reactivity Safety Trip (FIRST), detect the position of the center test hole canister, or strainer, when installed. If these channels do not detect that the center test hole canister, or strainer, is in the secured and latched position, a scram is initiated."

ADDENDUM 3 - HAZARDS SUMMARY REPORT (AUGUST 1972)

HSR, Addendum 3, page 15, Figure 2.2, Secondary Coolant System (as revised by the 1989-1990, 1990-1991, 1194, 1995, 2001, 2002, 2003, 2004, 2005 and 2006 Reactor Operations Annual Reports):

Replace with: New Figure 2.2.a, Secondary Cooling System (MURR Dwg No. 502, Sheet 1 of 3, dated 2/28/12)
New Figure 2.2.b, Secondary Cooling System (MURR Dwg No. 502, Sheet 2 of 3, dated 4/26/12)
New Figure 2.2.c, Secondary Cooling System (MURR Dwg No. 502, Sheet 3 of 3, dated 4/10/12)

HSR, Addendum 3, page 23a, Figure 2.3.a, Electrical Distribution (as revised by the 1989-90, 1990-91, 1995, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2009, 2010 and 2011 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.3.a, Electrical Distribution Reactor/Laboratory (MURR Dwg No. 522, Sheet 1 of 5, dated 3/20/12)

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 and 2011 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 11/21/12)

HSR, Addendum 3, page 23c, Figure 2.3.c, Electrical Distribution (as added by the 2004 and revised by the 2005, 2007, 2009, 2010 and 2011 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 11/12/12)

HSR, Addendum 3, page 23d, Figure 2.3.d, Electrical Distribution (as added by the 2007 and revised by the 2008, 2009, 2010 and 2011 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 5/9/12)

HSR, Addendum 3, page 23e, Figure 2.3.e, Electrical Distribution (as added by the 2007 and revised by the 2009, 2010 and 2011 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 11/21/12)

ADDENDUM 4 - HAZARDS SUMMARY REPORT (OCTOBER 1973)

HSR, Addendum 4 page A-10, after section A.3.3.14 add new section:

Add: "A.3.3.15 "Center Test Hole Scram"
Protection against an excessive reactivity step insertion in the Flux Trap region is achieved by two independent position sensing switches mounted on a removable support rig at the top of the pressure vessel head. In the event the Center Test Hole Canister leaves its secured and latched position, a reactor scram is initiated by either or both of these sensing switches, which actuate auxiliary relays K61 and K62, which in turn interrupt logic unit inputs E4A and E3B respectively."

HSR, Addendum 4, page A-14, Section A.3.10, Capability for Sensor Checks after "(unmonitored level controller):

Add: "Center Test Hole Canister position (limit switches).

HSR, Addendum 4, page A-15, Section A.3.14, Indication of Bypasses:

Delete: "Bypass switches are utilized to change the protective system to correspond to the three modes of operation (50 kW, 5 MW, or 10 MW)."

Replace with: "Bypass switches are utilized to change the protective system to correspond to the three modes of operation (50 kW, 5 MW, or 10 MW), and to bypass the center test hole instrument channels."

HSR, Addendum 4, page A-19, Figure A.1, Safety Systems (as revised by the 1995, 2001, 2002, 2003, 2006, 2007 and 2009 Reactor Operations Annual Reports):

Replace with: Updated Figure A.1, Safety System (MURR Dwg No. 139, dated 3/14/12)

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

Replace with: Updated Figure A.1, Annunciator Control 10 MW (MURR Dwg No. 138, dated 4/18/12)

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 and 2011 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 10/19/12)

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 and 2011 Reactor Operations Annual Reports):

Replace with: Updated Figure 2.1, Electrical Distribution Reactor/Laboratory (MURR Dwg No. 522, Sheet 1 of 5, dated 3/20/12)

SECTION IV

PLANT AND SYSTEM MODIFICATIONS

January 1, 2012 through December 31, 2012

For each facility modification described below, the 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 11-01:

Flux-Trap Irradiation Reactivity Safety Trip (FIRST) Instrument Channels

This modification record documents the addition of the FIRST device to the Reactor Safety System that ensures that the Center Test Hole Canister and its contents remain in place during reactor operation. The change is authorized by issuance of License Amendment No. 35 to Amended Facility License R-103. Installation of the FIRST device allows a change in the methodology that was previously used to calculate the reactivity contribution of samples loaded in the flux trap region.

Modification 75-16, Addendum 4:

Reactor Safety System Monitoring Circuit (White Rat) Panel – Revision to Panel Overlays in Support of FIRST Device

This modification record documents a revision to the Reactor Safety System Monitoring Circuit ("White Rat") Panel. New overlays reflect the addition of a series of contacts in both the "green leg" and "yellow leg" of the Reactor Safety System. The new contacts provide a SCRAM function from the Flux-Trap Irradiations Reactivity Safety Trip (FIRST) instrument channel. This modification did not change the function of the "White Rat" Panel itself.

Modification 10-02:

Addition of MURR Systems to Lab 251

This Modification Record documents the conversion of Room 251 to a laboratory (lab) space outfitted for the safe disposal of acids. Room 251 was not originally fitted as a lab space. Therefore all major lab utilities, save Natural Gas and Vacuum, were routed to this space. These include Facility Air, Deionized Water, Domestic Cold Water, Domestic Hot Water, Normal Electrical Power, Exhaust Ventilation, and Radioactive Liquid Waste.

Modification 11-02:

Replace Cooling Tower

This Modification Record documents the replacement of the existing Cooling Tower. The replacement of the Cooling Tower consisted of the demolition of the existing wood structure, removal of an asbestos containing basin liner, conversion of the existing basin to a structural slab, installation of a steel elevating structure, installation of three (3) current generation stainless steel modular towers, installation of associated piping and electrical components and supporting instrumentation, as well as repairs to the existing mechanical building.

Modification 09-03:

Lab Impex Stack Monitoring System

This Modification Record documents the installation of a Lab Impex Stack Monitoring System which provides Off-Gas Radiation Monitoring capability as required by the Hazards Summary Report (HSR) and its addenda. This system replaced a Nuclear Measurements Corporation (NMC) RAK Stack Monitoring System, including the function of release integration, which had reached the end of its operational lifetime.

Modification 09-03, Addendum 1:

Update to Lab Impex Stack Monitoring System

This Modification Record documents an update to the installation of a Lab Impex Stack Monitoring System which provides Off-Gas Radiation Monitoring capability as required by the Hazards Summary Report (HSR) and its addenda. This system was previously installed to replace the existing Nuclear Measurements Corporation (NMC) RAK Stack Monitoring System, including the function of release integration. This addendum contains additional information and documents changes performed since initial installation. Completion of these changes allows the Lab Impex Stack Monitor to be commissioned as a licensed system, subject to surveillance requirements of the Technical Specifications, and relied upon for use in both emergency response and effluent reporting roles.

Modification 05-01, Addendum 3:

Pneumatic Tube System Changes in Lab 227

This Modification Record documents the removal of the Pneumatic Tube (P-Tube) System from Lab 227. The master control station for Labs 218 and 227 were removed from Lab 227. A new simplified control station is now located in Lab 218. Also, the existing transfer valve for Labs 218 and 227 were replaced with a section of tubing that directs Row 2 to Lab 218.

Modification 01-09, Addendum 4:

Emergency Electrical Power System in Room 231

This Modification Record documents the transfer of loads on the Emergency Electrical Power System in Room 231. The change consisted of transferring the one remaining load from Emergency Lighting Panel Number 1A (ELP-1A) to the Diesel Generator Room Distribution Panel which allowed the removal of ELP-1A.

Modification 98-02, Addendum 1:

Sulfuric Acid System Changes in Support of Cooling Tower Replacement

This Modification Record documents the reconfiguration of the existing Sulfuric Acid System due to replacement of the Cooling Tower cells. The replacement of the Cooling Tower removed the original open sump, resulting in a need to convert the Sulfuric Acid System from a gravity drip system to an injection system. The reconfiguration consisted of demolition of the existing gravity day tank along with the associated transfer equipment and controls, installation of an injection metering pump and piping injector, and installation of supporting piping, electrical power and controls.

Modification 03-03, Addendum 3:

Fire Protection System Changes in Support of Cooling Tower Replacement

This Modification Record documents the removal of the Deluge System in the Cooling Tower due to the replacement of the Cooling Tower cells. Replacement of the Cooling Tower cells, as documented in Modification Record 11-02, provided an all-stainless steel structure and significant reduction of potential

fire loading, resulting in a Factory Mutual (FM) rating for the new Cooling Tower cells. This removed the need for the existing non-freezing deluge system.

Modification 01-2, Addendum 8:

Intercommunication and Paging System Changes in Support of the Sterility Suite Rooms 2045A and 2045B

This addendum to Modification Record 01-2, "Installation of a New Reactor Facility Intercommunication and Paging System," documents changes to the facility intercommunication and paging system that were necessary in order to safely occupy the new sterility suite in the North Office Addition to ensure a prompt and effective response from facility staff to an emergency or abnormal condition.

SECTION V

NEW TESTS AND EXPERIMENTS

January 1, 2012 through December 31, 2012

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

RUR 270, as amended: Palladium

Description: This RUR authorizes an increase in the enrichment of Palladium-110 to 100% in support of research and development activities.

RUR 292: Barium Carbonate

Description: MURR previously irradiated natural barium carbonate, however due to lack of active use, this RUR was placed in an inactive status. This RUR is being reactivated and authorizes the irradiation of up to 200 grams of natural barium carbonate in support of research and development activities.

RUR 420, as amended: Antimony Oxide

Description: This RUR authorizes an increase to the allowable antimony component of the ceramic material from 8% to 10%. The mass and activity limits for the ceramic target material remain unchanged.

RUR 436, as amended: Hydroxyapatite

Description: This RUR authorizes an increase in the allowable mass of hydroxyapatite up to 10 grams and removes the requirement for secondary encapsulation in quartz. Both of these changes are authorized for reflector irradiation only and are in support of research and development activities.

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, 2012 through December 31, 2012

Inspections:

There was one NRC inspection reviewing 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-three (63) refueling evolutions were completed in 2012. Excess reactivity verifications were performed for each refueling. The largest measured excess reactivity value was 3.31%. MURR Technical Specification 3.1(f) requires 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.

Nine (9) reactivity measurements were performed to determine the reactivity worth of all the samples, including the sample holder, loaded in the flux trap region.

Nine (9) 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.

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, 2012 through December 31, 2012

TABLE I
SANITARY SEWER EFFLUENT

January 1, 2012 through December 31, 2012

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

Nuclide	Activity (Ci)
H-3	1.621E-01
S-35	4.839E-03
Co-60	2.722E-03
Lu-177	2.567E-03
P-32	1.162E-03
Zn-65	1.145E-03
Ca-45	8.902E-04
Tc-99m	1.702E-04
Sc-46	1.322E-04
Mo-99	1.302E-04
Cr-51	1.181E-04
Lu-177m	6.508E-05
Fe-59	5.956E-05
Mn-54	2.989E-05
Total H-3	1.621E-01
Total Other	1.403E-02

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

TABLE 2
STACK EFFLUENT

January 1, 2012 through December 31, 2012

Ordered by % Technical Specification (TS) Limit

Isotope	Average Concentration (µCi/ml)	Total Release (Ci)	TS Limit Multiplier	% TS
Ar-41	2.38E-06	1.21E+03	350	68.0000
C-14	2.17E-11	1.03E-02	1	0.7230
I-131	1.01E-13	5.11E-05	1	0.0503
Kr-79	1.18E-08	6.00E+00	350	0.0482
H-3	1.49E-08	7.58E+00	350	0.0426
Co-60	2.47E-15	1.25E-06	1	0.0049
Sb-125	7.69E-14	3.90E-05	1	0.0026
Os-191	6.09E-15	3.09E-06	1	0.0003
Au-196	1.01E-15	5.14E-.07	350	0.0003
Hf-181	9.78E-16	4.97E-07	1	0.0002

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 = ~34,000 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, 2012 through December 31, 2012

Environmental samples are collected two times per year at eight (8) locations and analyzed for radioactivity. Soil and vegetation samples are taken at each location. Water samples are taken at three (3) of the eight (8) locations. Analytical results are shown in Tables 1 and 2.

Table 3 lists the radiation doses recorded by the environmental monitors deployed around MURR in 2012. All doses are approximately 14 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. The environmental monitoring program confirms that no 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 81

Spring 2012

Detection Limits[1]

Matrix	Alpha	Beta	Gamma	Tritium
Water	3.18 pCi/L	5.32 pCi/L	201.21 pCi/L	5.42 pCi/mL of sample
Soil	1.01 pCi/g	4.52 pCi/g	0.75 pCi/g	N/A
Vegetation	3.51 pCi/g	10.18 pCi/g	1.78 pCi/g	5.36 pCi/mL of distillate

Activity Levels - Vegetation

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)	H-3 (pCi/mL)
1V81	< 3.51	30.03	< 1.78	< 5.36
2V81	< 3.51	26.81	< 1.78	< 5.36
3V81	< 3.51	22.43	< 1.78	< 5.36
4V81	< 3.51	29.74	< 1.78	< 5.36
5V81	< 3.51	30.56	< 1.78	< 5.36
6V81	< 3.51	49.28	< 1.78	< 5.36
7V81	< 3.51	38.90	< 1.78	< 5.36
10V81	< 3.51	41.40	< 1.78	< 5.36

TABLE 1 (Cont'd)

Summary of Environmental Set 81

Spring 2012

Activity Levels - Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
1S81	2.00	25.28	4.01
2S81	1.07	13.55	1.06
3S81	1.40	19.59	< 0.75
4S81	1.66	12.40	4.05
5S81	1.51	20.04	3.47
6S81	2.00	12.82	3.99
7S81	1.36	18.85	3.67
10S81	1.54	19.05	3.66

Activity Levels - Water

Sample	Alpha (pCi/L)	Beta (pCi/L)	Gamma (pCi/L)	H-3 (pCi/mL)
4W81	< 3.18	< 5.32	< 201.21	< 5.42
6W81	< 3.18	< 5.32	< 201.21	< 5.42
10W81	< 3.18	6.36	< 201.21	< 5.42

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 82

Fall 2012

Detection Limits[1]

Matrix	Alpha	Beta	Gamma	Tritium
Water	0.00 pCi/L	4.44 pCi/L	193.16 pCi/L	5.68 pCi/mL of sample
Soil	2.32 pCi/g	4.61 pCi/g	1.63 pCi/g	N/A
Vegetation	2.81 pCi/g	10.84 pCi/g	1.61 pCi/g	6.24 pCi/mL of distillate

TABLE 2 (Cont'd)

Summary of Environmental Set 82

Fall 2012

Activity Levels - Vegetation

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)	H-3 (pCi/mL)
1V82	< 2.81	29.72	< 1.61	< 6.24
2V82	< 2.81	46.06	2.44	< 6.24
3V82	< 2.81	18.91	< 1.61	< 6.24
4V82	< 2.81	37.65	1.74	< 6.24
5V82	< 2.81	28.09	< 1.61	< 6.24
6V82	< 2.81	29.24	1.64	< 6.24
7V82	< 2.81	32.13	2.43	< 6.24
10V82	< 2.81	50.13	2.02	< 6.24

Activity Levels - Soil

Sample	Alpha (pCi/g)	Beta (pCi/g)	Gamma (pCi/g)
1S82	< 2.32	13.54	7.27
2S82	< 2.32	18.73	9.37
3S82	4.76	18.73	5.93
4S82	< 2.32	15.46	12.49
5S82	< 2.32	21.95	10.12
6S82	< 2.32	18.17	10.33
7S82	< 2.32	17.39	9.71
10S82	2.82	20.04	8.38

Activity Levels - Water

Sample	Alpha (pCi/L)	Beta (pCi/L)	Gamma (pCi/L)	H-3 (pCi/mL)
4W82	0.18	16.29	225.25	< 5.68
6W82	0.00	< 4.44	< 193.16	< 5.68
10W82	0.35	8.24	< 193.16	22.85

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, 2012 through December 31, 2012

Badge Number	Direction From MURR	Map Distance from MURR Stack (meters)	1st Qtr. 2012 Net mR	2nd Qtr. 2012 Net mR	3rd Qtr. 2012 Net mR	4th Qtr. 2012 Net mR	Total 2012 Net mR
	Control 0	N/A	35.0	26.0	25.0	29.0	115.0
1	Control 1	16600	31.0	24.0	24.0	28.0	107.0
2	Control 2	16600	33.0	25.0	24.0	28.0	110.0
3	WSW	N/A	0.0	0.0	0.0	0.0	0.0
4*							
5*							
6	N	34	0.0	1.0	3.0	0.0	4.0
7	NE	57	0.0	0.0	4.0	4.0	8.0
8	SW	27	3.0	1.0	3.0	7.0	14.0
9	S	27	19.0	17.0	16.0	18.0	70.0
10	NE	149	0.0	0.0	0.0	0.0	0.0
11	NW	149	0.0	0.0	2.0	1.0	3.0
12	ENE	301	0.0	2.0	0.0	0.0	2.0
13	NNE	316	0.0	0.0	0.0	0.0	0.0
14	S	156	0.0	0.0	4.0	0.0	4.0
15	S	65	11.0	14.0	14.0	15.0	54.0
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	1.0	3.0	4.0
22	ESE	168	0.0	0.0	0.0	0.0	0.0
23	NW	110	0.0	0.0	3.0	0.0	3.0
24	SSW	328	0.0	0.0	2.0	0.0	2.0
25	SSW	480	0.0	0.0	1.0	0.0	1.0
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	1.0	2.0	1.0	4.0
29	NW	255	0.0	0.0	3.0	1.0	4.0
30	NNW	328	0.0	0.0	0.0	0.0	0.0
31	NNW	671	0.0	0.0	0.0	absent	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	0.0	2.0	4.0	5.0	11.0
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	absent	0.0	0.0	0.0	0.0
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	0.0	1.0	0.0	1.0
45	S	65	0.0	0.0	1.0	0.0	1.0
46	E	70	4.0	3.0	2.0	1.0	10.0

*These badge numbers are no longer used.

TABLE 4
Number of Facility Radiation and Contamination Surveys

January 1, 2012 through December 31, 2012

	Radiation	Surface Contamination*	Air Samples**	RWP's
January	72	72	47	13
February	67	67	57	11
March	73	73	53	7
April	72	72	54	8
May	72	72	35	9
June	77	77	22	9
July	65	65	50	7
August	77	77	62	8
September	70	70	46	4
October	47	47	53	6
November	63	63	49	1
December	56	56	51	5
TOTALS	**811**	**811**	**579**	**66**

* 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

Chris Schnieders was hired as a Health Physics Technician in January 2012.
Eric Graham was hired as a Health Physics Technician in June 2012.

During calendar year 2012, MURR shipped 703 cubic feet of low-level radioactive waste containing 3,097 mCi of activity.

SECTION IX

Summary of Radiation Exposure to Facility Staff, Experimenters and Visitors
January 1, 2012 through December 31, 2012

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	20	9	6	235	354	217	5	52	53	2437	205	48	76	17	104	4	143	3985
February	8	22	6	15	316	252	5	35	31	1088	143	75	54	32	102	1	35	2220
March	0	21	4	9	285	99	5	30	28	998	119	31	7	21	82	8	16	1763
April	15	16	1	6	502	167	14	18	29	1533	207	43	85	60	142	25	96	2959
May	1	7	0	8	413	161	0	12	12	1536	152	64	22	12	90	0	85	2575
June	4	18	2	7	324	216	3	85	57	1439	176	26	94	13	151	0	24	2639
July	32	24	2	0	379	177	4	55	18	1305	172	52	31	26	73	0	23	2373
August	9	3	0	0	284	161	5	17	28	1150	228	20	9	33	107	5	26	2085
September	1	0	0	15	297	163	4	16	15	1092	243	36	2	22	95	1	20	2022
October	5	10	0	11	417	130	13	39	38	1091	226	51	7	21	93	6	394	2552
November	10	0	0	0	231	98	0	24	26	746	98	37	32	34	118	15	24	1493
December	8	0	0	0	318	140	0	6	31	1451	76	15	28	68	68	2	135	2346
Total for Year	**113**	**130**	**21**	**306**	**4120**	**1981**	**58**	**389**	**366**	**15866**	**2045**	**498**	**447**	**359**	**1225**	**67**	**1021**	**29012**
Monthly Avg	**9**	**11**	**2**	**26**	**343**	**165**	**5**	**32**	**31**	**1322**	**170**	**42**	**37**	**30**	**102**	**6**	**85**	**2418**
Highest WB (annual)	**27**	**86**	**6**	**72**	**981**	**468**	**58**	**118**	**216**	**1275**	**516**	**109**	**112**	**87**	**842**	**17**	**292**	
High EXT (annual)	**343**	**343**	**NR**	**100**	**2525**	**834**	**NR**	**3466**	**509**	**3122**	**5361**	**629**	**1385**	**1995**	**1333**	**182**	**5272**	

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).