UNIVERSITY OF MISSOURI-ROLLA
Missouri's Technological University

Nuclear Reactor

Reactor Facility
Rolla, MO 65401-0249
Telephone (573) 341-4236
FAX (573) 341-4237

April 25, 1996

Document Control Room
Attention: Director
Office of Nuclear Reactor Regulations
U.S. Nuclear Regulatory Commission
Mail Stop 10-D-21
Washington, D.C. 20555

Dear Sir:

Please find enclosed the Annual Progress Report 1995-96 for the University of Missouri-Rolla Reactor Facility (License R-79). This report is being filed under the reporting requirements of our Technical Specifications. Copies of this report are also being sent to our Regional Administrator and Project Manager.

Sincerely,

Albert E. Bolon
Albert E. Bolon
Reactor Director

lp

Enclosure

xc: Marvin Mendonca, Project Manager (NRC)
Jack Martin, Region III Administrator (NRC)
Dr. A. E. Bolon, Reactor Director (UMR)
Dr. John Park, Chancellor (UMR)
Dr. Lee W. Saperstein, Dean, School of Mines & Metallurgy (UMR)
Mr. Ray Bono, Director, Health & Safety Services (UMR)
Dr. Robert Mitchell, Dean, School of Engineering (UMR)
Dr. John Fulton, Dean, College of Arts and Science (UMR)
Mr. Bruce Ernst, American Nuclear Insurers
American Nuclear Insurers, c/o Librarian
Dr. Nord Gale, Chairman, Radiation Safety Committee (UMR)
Radiation Safety Committee
University of Missouri-Columbia Research Reactor
Nuclear Engineering Faculty
Reactor Staff

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PROGRESS REPORT

1995-96

UNIVERSITY OF MISSOURI-ROLLA

NUCLEAR REACTOR FACILITY

UNIVERSITY OF MISSOURI - ROLLA

REACTOR

PROGRESS REPORT

FOR THE

UNIVERSITY OF MISSOURI-ROLLA

NUCLEAR REACTOR FACILITY

April 1, 1995 to March 31, 1996

Submitted to
The U.S. Nuclear Regulatory Commission
and
The University of Missouri-Rolla

Albert E. Bolon, Director
David W. Freeman, Manager
Nuclear Reactor Facility
University of Missouri-Rolla
Rolla, Missouri
65401

SUMMARY

During the 1995-96 reporting period the University of Missouri-Rolla Reactor (UMRR) was in use for 524 hours. The major part of this time, about 94%, was used for class instruction, research, and training purposes.

The UMRR operated safely and efficiently over the past year. No significant safety-related incidents or personnel exposures occurred.

The reactor facility supported several UMR courses over the year for a total of 2,001 student-hours. The reactor was visited by about 3,100 visitors during the past year. There were 972 participants in the U.S. Department of Energy Reactor Sharing Program.

The reactor produced 8,914.35 kilowatt-hours of thermal energy using approximately 0.4595 grams of uranium. A total of 325 samples were irradiated at the reactor with most of them being analyzed in the Reactor Counting Laboratory.

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1.0 INTRODUCTION

This progress report covers activities at the University of Missouri-Rolla Reactor (UMRR) Facility for the period April 1, 1995 to March 31, 1996.

The reactor is operated as a university facility, available to the faculty and students from various departments of the university for their educational and research programs. Several other universities, colleges, and high schools have made use of the facility during this reporting period. The facility is also available for the training of reactor personnel from nuclear electric utilities. Trace element analysis using neutron activation and neutron radiography are performed at the facility.

1.1 Background Information

The University of Missouri-Rolla Reactor Facility attained initial criticality on December 9th, 1961. The UMRR was the first operating nuclear reactor in the state of Missouri. The reactor design is based on the Bulk Shielding Reactor at Oak Ridge National Laboratory. The initial licensed power was 10 kW. The licensed power was upgraded to 200 kW in 1966. During the summer of 1992, the reactor fuel was changed from high-enriched uranium (HEU, 90% U-235) fuel to low-enriched uranium (LEU, 19.8% U-235) fuel.

The reactor is a light water open pool-type reactor cooled by natural convection flow. The fuel is MTR plate-type fuel.

The facility is equipped with several experimental facilities including a beam port, thermal column, pneumatic rabbit system and several manual sample irradiation facilities. Additionally, the facility is equipped with a counting laboratory that has gamma and alpha

spectroscopy capabilities. The gamma spectroscopy system includes germanium and sodium-iodide detectors, associated electronics, and modern spectrum analysis software. The alpha spectroscopy system consists of a surface barrier detector and data acquisition equipment.

1.2 Facility Status

The UMRR operated safely and efficiently over the past year. No significant safety-related incidents or personnel exposures occurred.

1.2.1 General

We are continuing efforts to upgrade our console using grant awards from DOE combined with money directly from reactor funds. The total funds received from DOE combined with money committed from the reactor account totals to $167,000 available for the console upgrade. We plan to replace our existing five channel NI system with a three channel system. We have purchased and received three new instrument drawers from Gamma-Metrics; including 1) a wide-range log fission chamber based drawer, 2) a wide-range linear CIC based drawer, and 3) a log and linear CIC based drawer. We presently plan to install these three drawers in our control console as direct replacements for our existing Start-up, Log N and Period, and Linear drawers under the provisions of 10CFR50.59. Parallel with this, we will be submitting a request to NRC for approval for desired console revisions that may involve "unreviewed safety questions".

In February, 1996, we replaced our old Log N drawer with the new Gamma-Metrics Log and Linear drawer. At the same time, we replaced the associated Log N and Period stripchart

recorders with a new two pen single stripchart recorder. The new recorder displays both Log N and Period simultaneously. A detailed 50.59 review was submitted to the UMR Radiation Safety Committee and was approved with the determination that no unreviewed safety question was involved. Revisions were made to the appropriate SAR pages (see Appendix B). The new equipment is performing well and we are quite pleased with it.

In December, 1995, we made a slight modification to our control rod magnet power supply to provide more current to the magnets. Two 12.5 kilo-ohm resistors (R60 and R61) were replaced with 13 kilo-ohm resistors. The change was necessary because the power supply was barely supplying enough current to hold the rods. A detailed 50.59 review was submitted to the UMR Radiation Safety Committee (RSC). RSC approval was obtained on December 7, 1995, with the determination that no unreviewed safety question was involved. Revisions were made to the appropriate SAR pages (see Appendix B).

On November 13, 1995, the UMR RSC approved a change in calibration frequency from semi-annual to annual for our Radiation Area Monitors (RAMs) and portable survey instruments. This change was prompted by discussions with our NRC inspector during our last inspection. The change involved a revision to page 7-5 of the SAR (see Appendix B). A detailed 50.59 review was submitted and approved by the UMR RSC with the determination that no unreviewed safety question was involved.

On June 6, 1995, the last three sentences on page 7-5 of the SAR were revised to change a dose rate restriction from 100 mrem/hr on contact to 100 mrem/hr at a distance of 1 foot (see Appendix B). The restriction is that samples reading in excess of the limit are to be monitored by the Health Physicist. The change was made because the 1 foot dose rate is more applicable

than a contact dose rate. The RSC determined that no unreviewed safety question was involved.

The Reactor Facility was inspected in all areas by NRC inspectors during 1995. No violations or open items were identified.

The Reactor Facility was audited in August of 1995 by an independent auditor from the Missouri University Research Reactor (MURR). We have entered into a new agreement with both the University of Illinois and the University of Missouri-Columbia to rotate audits. We feel this will be very beneficial to all facilities involved.

In January, 1996, four staff members took the NRC licensing examination. All candidates passed. Two qualified for Reactor Operator, one for instant SRO and one SRO upgrade.

The reactor staff has continued to review the operation of the Reactor Facility in an effort to improve the safety and efficiency of its operation and to provide conditions conducive to its utilization by students and faculty. An "outreach" program, implemented over the past years, has been continued in order to let both students and faculty in a number of departments across campus know how the reactor could be used to enhance course work and research. As a result, additional classes have used the Reactor Facility as a part of their laboratory courses, including Physics 4 & 5, "Concepts in Physics"; Chemistry 8, "Qualitative Analysis Laboratory"; Physics 107, "Modern Physics"; Physics 322, "Advanced Physics"; Chemical Engineering 261, "Introduction to Environmental Engineering"; Chemistry 2, "General Chemistry Laboratory"; Mechanical Engineering 229, "Energy Conversion"; Life Science 352, "Biological Effects of Radiation"; Chemistry 251, "Intermediate Quantitative Analysis"; Chemistry 355, "Instrumental Methods Laboratory"; and Engineering Management 386, "Safety Engineering Management".

Much effort has been invested over the past year in revising SOPs to improve our operations and efficiency. The following is a list of SOPs revised during the reporting period:

SOP 102	General Operational Procedures
SOP 103	Reactor Startup to Low Power
SOP 104	Reactor Power Changes and Stable Operations
SOP 105	Reactor Shutdown & Reactor Securing Procedures
SOP 106	Permanent Log, Hourly Log and Operational Data
SOP 308	Restoration of Power
SOP 501	Emergency Procedures for Reactor Building Evacuation (Page 7 only)
SOP 511	Response to Missing Special Nuclear Material
SOP 601	Handling of Radioactive Samples
SOP 603	Release of By-Product Materials On Campus
SOP 655	Radiation Area Monitor (RAM) Calibrations (Page 1 only)
SOP 702	Request for Irradiation
SOP 800	Semi-Annual Checklist
SOP 801	Log N and Period Channel
SOP 810	Weekly Check

The above listed SOPs are provided in Appendix A.

Certain revisions have also been made to the facility's Safety Analysis Report (SAR), primarily as a result of new console equipment installed under 10CFR50.59. Revised SAR pages are provided in Appendix B.

In addition, the Emergency Plan was recently updated and revised (Rev. 6, December 30, 1994) under the provisions of 10CFR50.54q. Efforts are currently underway to submit proposed revisions to the Emergency Plan that will reduce the number of emergency categories for NRC approval.

2.0 REACTOR STAFF AND PERSONNEL

2.1 Reactor Staff

Name	Title
Albert E. Bolon	Director
David Freeman	Reactor Manager
Linda Pierce	Senior Secretary
William Bonzer	Senior Electronics Technician
James Jackson	Senior Lab Mechanic
Hatem Khouaja	Reactor Operator

2.2 Licensed Operators

Name	License
Albert E. Bolon	Senior Operator
David Freeman	Senior Operator
Hatem Khouaja[1)]	Senior Operator
William Bonzer[1)]	Senior Operator
James Jackson[1)]	Reactor Operator
Jason McDaniel[1)]	Reactor Operator

[1)] Licensed as of 1/29/96.

2.3 Radiation Safety Committee

The Radiation Safety Committee meets quarterly. The committee met on 6/6/95, 7/25/95, 12/7/95, and 3/27/96 during the reporting period. The committee members are listed below:

Name	Department
Dr. Nord L. Gale (chairman)	Life Sciences
Mr. Ray Bono (secretary, ex-officio, non-voting)	Occupational Health and Safety Services
Dr. Ernst Bolter	Geology and Geophysics
Dr. Oliver K. Manuel	Chemistry
Dr. Albert E. Bolon	Reactor Director
Dr. Nick Tsoulfanidis	Radiation Safety Officer
Dr. Edward Hale	Physics
Dr. Arvind Kumar	Nuclear Engineering
Mr. David Freeman (ex-officio, non-voting)	Nuclear Reactor
Mr. Randy Stoll	Director, Business Services

2.4 Health Physics

Health Physics support is provided through the Occupational Health and Safety Services (formerly the Environmental Health and Risk Management) Department which is organizationally independent of the Reactor Facility operations group. Health Physics personnel are listed below:

Name	Title
Dr. Nick Tsoulfanidis	Radiation Safety Officer
Mr. Ray Bono	Director, Occupational Health & Safety Services and Campus Health Physicist
Mr. Chad Little	HP Technician
Mr. Darrell Liles[1)]	HP Technician
Ms. Rebecca Steinman	HP Technician
Mr. Brian Richardson	HP Technician
David Wells[2)]	HP Technician
Scott Gizzie[3)]	HP Technician

[1)]Terminated effective October 6, 1995.

[2)]Employed effective September 19, 1995.

[3)]Employed effective January 16, 1996.

3.0 REACTOR OPERATIONS

Core designation 101W is presently in use. The "W" mode core is completely water reflected and is used for normal reactor operations. The "T" mode (core positioned near graphite thermal column) may be used for various experiments, including beam port and thermal column experiments.

Table 3-1 presents pertinent core data and Figure 3-1 shows the core configuration of core 101W. The excess reactivity, shutdown margin, and rod worths were measured in cold clean conditions.

Tables 3-2 and 3-3 present a listing of unscheduled shutdowns (scrams, rundowns, and unplanned normal shutdowns) along with their causes and corrective actions.

Maintenance activities are listed in Table 3-4. Table 3-5 shows facility use other than the reactor and Table 3-6 shows reactor utilization.

Table 3-1. Core 101W Technical Data

Parameter	Value
Rod 1	2.73% Δk/k
Rod 2	2.69% Δk/k
Rod 3	3.22% Δk/k
Reg Rod	0.371% Δk/k
Excess Reactivity	0.496% Δk/k
Shutdown Margin*	4.92% Δk/k

*) Assumes Rod 3 (highest worth rod) and Reg Rod are fully withdrawn.

Figure 3-1. UMRR Core Configuration

DATE July 28, 1992 LOADING NUMBER 101W

	1	2	3	4	5	6	7	8	9
A									
B					S				
C				F-8	F-4	C-4			
D			F-13	C-1	F-3	F-2	F-12	F-15	
E			F-10	C-2	F-1	C-3	F-9	F-14	
F			CR	F-5	F-6	F-7	BR		

KEY TO PREFIXES

F - Standard Elements
C - Control Elements
BR - Bare Rabbit
CR - Cadmium Rabbit
S - Source Holder

Table 3-2. Scrams

Date	Cause
08/01/95	Period < 5 Second Scram Cause: AC Power flicker during a thunderstorm. Reactor power was stable at 40 kW. Corrective Action: No corrective action taken. SRO permission to restart granted.
08/01/95	Scram Cause: AC Power flicker during a thunderstorm during reactor startup. All annunciator lights lit up. Could not determine which trip actually scrammed the reactor. Corrective Action: No corrective action taken. SRO permission to restart granted.
12/06/95	Period < 5 Second Scram Cause: Spurious noise in Period Channel. Power was stable at 180 kW and Period Recorder did not show any deviation. Corrective Action: No corrective action taken. SRO permission granted to restart.
12/06/95	Period < 5 Second Scram Cause: Spurious noise in Period Channel. Power was stable at 180 kW. Period recorder displayed a 60 second spike. Corrective Action: No corrective action taken. SRO permission granted to restart.
03/04/96	Scram Cause: AC Power flicker. Reactor power was stable at 200 kW. All annunciator lights except one illuminated. Corrective Action: No corrective action taken. SRO permission granted to restart.

Table 3-3. Rundowns And Unplanned Shutdowns

Date	Cause
04/18/95	120% Demand Rundown. Cause: Student failed to properly downscale Linear meter. Corrective Action: Student instructed on switching scales. SRO permission to restart granted.
05/03/95	120% Demand Rundown. Cause: Noisy switches in pico-amp meter. Corrective Action: No corrective action taken. Replacement switches have been ordered.
11/14/95	120% Demand Rundown Cause: Student failed to properly upscale Linear meter. Corrective Action: Student instructed on switching scales. SRO permission to restart granted.
12/12/95	Unplanned Shutdown Problem: Log N recorder indicated at 0.35 kW when reactor power was 20 kW. Tapped on recorder and indicator went to 20 kW. Corrective Action: Reactor was immediately shut down. Log N recorder was inspected and determined to need lubrication. Log N recorder was lubricated and checked for proper operation. SRO permission to restart granted.
12/27/95	Unplanned Shutdown Cause: Magnet #2 dropped rod. Corrective Action: SRO on duty granted permission to increase magnet current #2 and to restart reactor.
03/04/96	120% Demand Rundown Cause: Switch noise occurred during upscaling on Linear meter. Corrective Action: No corrective action taken. SRO permission to restart granted.
03/04/96	120% Full Power Rundown Cause: Spurious noise from auto-controller when auto-controller tripped into manual. No power increase was observed on Log N recorder. A slight increase in power from 80% power to 83% power was observed on the Linear recorder. Corrective Action: No corrective action taken. SRO permission granted to restart.

Table 3-4. Maintenance

Date	Cause
06/05/95	Problem: Routine Semi-Annual Calibration of reactor instrumentation. Corrective Action: Performed the calibration.
06/05/95	Problem: Planned maintenance to replace switches in the Linear Channel pico-amp meter. Corrective Action: Replaced switches in pico-amp meter and checked calibration of channel.
06/09/95	Problem: Bridge RAM went up to 20 mrem/hr, then meter dropped to a zero reading on meter and would not respond to the internal check source. No external radiation caused this increase. Reactor was not operating at the time. Corrective Action: High Voltage to the detector was lower than normal due to a diode that was shorted out by a printed circuit board mounting screw. An insulated washer was installed to isolate the diode from the screw. The RAM was checked for proper operation.
06/09/95	Problem: Beam Room RAM meter reading went up to 60 mrem/hr during Semi-Annual Calibration. No external radiation caused this increase. Reactor was not operating at the time. Corrective Action: Resoldered a defective solder joint on the 5 Volt regulating transistor located in the RAM power supply. The RAM was checked for proper operation.
09/11/95	Problem: Heat detector in reactor engineering office failed during testing. Too much heat was applied during testing. Corrective Action: Replaced the heat detector. Staff cautioned not to hold heat gun too close to detector during testing.
09/27/95	Problem: Servo-controller window shifted from ± 2% to - 4%, 0%. Corrective Action: Mechanically tightened the servo-controller setter control.
10/04/95	Problem: Servo-controller would not go into auto-permit. Corrective Action: Repositioned the servo-controller cams located in the Linear Recorder.
11/10/95	Problem: Log N Recorder lost AC Power with the on/off switch in the on position. Corrective Action: Replaced the on/off power switch.

Table 3-4. Maintenance (cont.)

Date	Cause
11/28/95	Problem: The Linear Recorder's red pointer for the servo-controller was repositioned by the recorder's black pointer. This changed the servo-controller window from ± 2% to + 8%, + 12%. Corrective Action: Lubricated the recorder. Adjusted main shaft clutch, control cam clutch, and slidewire clutch. Replaced servo-controller cam switches.
12/14/95	Problem: A 20 second period spike would occur at 140 kW when going to a higher power. Corrective Action: Calibrated the Log N Drawer.
12/20/95	Problem: Observed an irregular signal on the Startup Channel while performing the Pre-Startup Checklist. Corrective Action: Replaced HV connector at the HV power supply. Channel tested the Startup Channel and proceeded with startup.
12/21/95	Problem: Startup Channel count rate increased when it should have decreased, during Pre-Startup Checklist. Reactor was shut down at the time. Corrective Action: Recycled all cable connectors, replaced - 25 V power supply in the Log Count Rate Drawer, and replaced 2 transistors in the pre-amp.
12/28/95	Problem: Magnet current power supply could not be adjusted for surplus magnet current. Corrective Action: Replaced two resistors in magnet current power supply (under 50.59) to increase magnet current capability. Performed rod drop tests.
01/09/96	Problem: Routine Semi-Annual Calibration of reactor instrumentation. Corrective Action: Performed the calibration.
01/26/96	Problem: Rod Drive 3 would not hold its position and would lower to 0 inches. Corrective Action: Replaced a broken clutch band on Rod Drive #3.

Table 3-5. Experimental Facility Use Other Than The Reactor

Facility	Hours
Bare Rabbit Tube	6.78 hr.
Cadmium Rabbit Tube	1.70 hr.
Beam Port	12.60 hr.
Other Core Positions	23.32 hr.
Total	44.40 hr.

Table 3-6. Reactor Utilization

1.	Reactor use		523.87 hr.
	a.	Research and irradiation runs	166.52 hr.
	b.	Instruction runs (NE Classes)	298.25 hr.
	c.	Maintenance runs (2)	32.85 hr.
	d.	Training (3)	26.25 hr.
2.	Time at power		225.23 hr.
3.	Energy generated		8914.35 kW/hr
4.	Total number of samples		325
5.	U-235 Burned		0.3882 g
6.	U-235 Burned and Converted		0.4595 g

4.0 PUBLIC RELATIONS

The reactor staff continues to educate the public about applications of nuclear science. Over 3,100 persons visited the facility during this reporting period. Tour groups are typically given a brief orientation and/or demonstration by a member of the reactor staff.

Table 4-1 lists some of the major occasions or groups and number of visitors for each event.

Table 4-1. Public Relations Program

DATE	PARTICIPANTS	NUMBER
04/12/95	UMR Physics 107, Modern Physics, Dr. A. Pringle	43
04/19/95	UMR Eng Mgmt 386, Safety Engineering Management, Dr. Murray	13
04/00/95	Scott Miller/James Stange, Physics 322, Advanced Physics, Individual Project (Magnets)	2
05/01/95	Gene Black, Chem 8, Quantitative Analysis, Individual Project, (Copper Alloy)	1
06/05/95	UMR Jackling Tours	47
06/12/95	UMR Jackling Tours	38
06/14/95	UMR Intro to Engineering	27
06/15/95	UMR Intro to Engineering	6
06/19/95	UMR Jackling Tours	39
07/12/95	UMR Intro to Engineering	43
08/02/95	UMR Intro to Engineering	20
09/01/95	Senior Citizens, Central Bank	25
09/05/95	GM Coop Students	16
09/18/95	UMR Chemistry Laboratories, Dr. T. Bone	81
09/19/95	UMR Chemistry Laboratories, Dr. T. Bone	235
09/20/95	UMR Chemistry Laboratories, Dr. T. Bone	135

Table 4-1. Public Relations Program		
DATE	PARTICIPANTS	NUMBER
09/21/95	UMR Chemistry Laboratories, Dr. T. Bone	208
10/14/95	UM Rolla Day Open House	100
10/21/95	UMR Parents Day Open House	135
11/13/95	UMR NE 105, Fund of Nuclear Eng., Dr. N. Tsoulfanidis	14
11/17/95	UMR Society of Black Engineers High School	12
11/17/95	UMR Chem 251/355, Chemistry Analysis, Dr. Callahan	12
12/04/95	UMR Physics 107, Modern Physics, Dr. A. Pringle	44
12/18/95	UMR Reactor Offsite Personnel Emergency Training	8
01/23/96	UMR NE 204, Nuclear Radiation Measurements	10
01/26/96	Rolla Daisy Troop 226	6
02/12/96	UMR Chemistry Laboratories	39
02/12/96	UMC NE 404, Advanced Reactor Laboratory	4
02/14/96	UMR Chemistry Laboratories	47
02/15/96	UMR TEAMS Testing	34
02/17/96	Boy Scouts Merit Badge Day	36
03/04/96	UMR EngMgmt 386, Safety Engineering Management	10
03/23/96	UMR Spring Open House	32
03/29/96	UMR NE 203, Interactions of Radiation with Matter	12

5.0 EDUCATIONAL UTILIZATION

The reactor facility supported several UMR courses in the past year for a total of 3,001 student-hours. The number of UMR students utilizing the facility was 957. This increased usage is a direct result of an aggressive and continuing campus wide "outreach" program. The reactor facility provided financial support for three students with hourly wages and one PhD candidate with a 0.5 FTE Graduate Research Assistantship. Additionally, students from several universities, colleges and high schools have used the facility.

Table 5-1 lists UMR classes taught at the facility along with associated reactor usage for this reporting period.

The Reactor Sharing Program, which is funded by the U.S. Department of Energy, was established for colleges, universities, and high schools which do not have a nuclear reactor. This year, 972 students and instructors from 35 institutions participated in this program. Table 5-2 lists those schools and groups that were involved in this year's Reactor Sharing Program. The majority of our participants were high school students. We coordinate with the Admissions Office to schedule high school students to see other items of interest at UMR after they have visited our facility, such as the Computer Integrated Manufacturing Lab, Mineral Museum, Computer Center, Experimental Mine, Solar Car, Electron Microscope, and Stonehenge. The Reactor Sharing Program serves as a strong campus-wide recruiting tool by getting high school students to the university and hopefully sparking some interest in our campus.

Table 5-1. UMR Classes at Reactor Facility 1995-96 Reporting Period				
DATE	CLASS NUMBER/TITLE	# OF STUDENTS	TIME AT REACTOR (hrs)	STUDENT HOURS
04/12/95	Physics 107 - Modern Physics	43	0.5	22.0
04/19/95	EngMgmt 386 - Safety Engineering Management	13	1.0	13.0
04/05/95	Scott Miller/James Stange, Phys 322 - Advanced Physics - Ind Project (Magnets)	2	4.0	8.0
05/01/95	Gene Black, Chem 8 - Quantitative Analysis - Ind Project (Copper Alloy)	1	2.0	2.0
Summer 1995	NE 300 - Special Problems	2	24.0	48.0
Summer 1995	NE 490 - Research	1	80.0	80.0
Fall 1995	NE 304 - Reactor Laboratory	16	53.0	848.0
Fall 1995	NE 306 - Reactor Operations	6	36.0	216.0
Fall 1995	NE 490 - Research	2	47.5	95.0
09/18/95	Chemistry 2 - General Chemistry Laboratory	81	0.5	20.5
09/19/95	Chemistry 2 - General Chemistry Laboratory	235	0.5	117.5
09/20/95	Chemistry 2 - General Chemistry Laboratory	135	0.5	67.5
09/21/95	Chemistry 2 - General Chemistry Laboratory	208	0.5	104.0
11/13/95	NE 105 - Fundamentals of Nuclear Engineering	14	0.5	7.0
11/17/95	Chemistry 251/355 - Chemistry Analysis	12	2.5	30.0
12/04/95	Physics 107 - Modern Physics	44	0.5	22.0

Table 5-1. UMR Classes at Reactor Facility 1995-96 Reporting Period				
DATE	CLASS NUMBER/TITLE	# OF STUDENTS	TIME AT REACTOR (hrs)	STUDENT HOURS
Winter 1996	NE 300 - Special Problems	1	40.0	40.0
Winter 1996	NE 306 - Reactor Operations	7	36.0	252.0
Winter 1996	NE 308 - Reactor Laboratory II	14	60.0	840.0
Winter 1996	NE 490 - Research	2	40.0	80.0
01/23/96	NE 204 - Nuclear Radiation Measurements	10	3.0	30.0
02/12/96	Chemistry 2 - General Chemistry Laboratory	39	0.5	19.5
02/14/96	Chemistry 2 - General Chemistry Laboratory	47	0.5	23.5
03/04/96	EngMgmt 386 - Safety Engineering Management	10	1.0	10.0
03/29/96	NE 203 - Interactions of Radiation with Matter	12	0.5	6.0
	TOTAL	**957**	**435**	**3001.5**

Table 5-2. Reactor Sharing Program (1995-1996)		
DATE	PARTICIPANTS	NUMBER
04/12/95	Waynesville High School, Hope Creel, Instructor	36
04/25/95	Southwest Missouri State University, Dr. Robert Mayanovic, Instructor	10
04/25/95	Scott Sidener, Truman Elementary, Individual Project	1
04/26/95	John F. Hodge High School, St. James, Jim Jenkins, Instructor	9
04/28/95	Potosi 8th Grade, Alan Ziegler, Instructor	9
05/02/95	Seckman Junior High School, Vera McCullough, Instructor	15
05/02/95	Strain-Japan Elementary, Nona Miller, Instructor	58
05/03/95	St. Charles West High School, Gary Randolph, Instructor	31
05/05/95	Zachary Roetemeyer, Jefferson City High School, Individual Project	1
05/11/95	Viburnum High School, Judy McGee, Instructor	26
05/11/95	Salem Middle School	67
05/18/95	Crossroads High School, Tanda Pommier, Instructor	22
05/22/95	Rolla High School, Gayle Lucien, Instructor	38
05/24/95	Whitfield High School, Tom Rodgers, Instructor	25
07/07/95	Cuba Schools, 7-12, Kim Robertson, Instructor	34
09/15/95	Ellen Eye, Individual Project, Potosi HS, Bill Nelson, Instructor	2
09/15/95	Andrea Bone, Individual Project, Potosi HS, Bill Nelson, Instructor	2
10/03/95	St. Louis 8th Grade, Ken Roberts, Instructor	47
10/18/95	Dixon High School, Bill Veaseman, Instructor	27
10/20/95	Cuba High School, Sarah Decker, Instructor	10
10/25/95	Eminence High School, Shelly Williams, Instructors	13
11/01/95	Van Buren High School, Daniel Freeman, Instructor	29
11/18/95	Conway High School, Phil Davis, Instructor	11
11/15/95	Parkway Central High School, Valerie Michael, Instructor	21
11/17/95	St. Clair High School, Harvey Richards, Instructor	35
11/30/95	Newburg High School, Peggy Brown, Instructor	16

Table 5-2. Reactor Sharing Program (1995-1996)		
DATE	**PARTICIPANTS**	**NUMBER**
12/01/95	Rolla Technical Institute Radiography, Maggie Ogden, Instructor	14
12/06/95	Brentwood High School, Rich Nieman, Instructor	39
12/07/95	Waynesville 9th Grade, J. Sanders, Instructor	45
12/11/95	Stoutland High School, Liz Sanders, Counselor	6
01/24/96	Rolla 8 & 9 Grade, Gayle Lucien, Instructor	17
01/30/96	Sullivan High School, David Miller, Instructor	33
02/07/96	St. Pats 8th Grade, Christie Rosenburg, Instructor	11
02/14/96	Potosi High School, Bill Nelson, Instructor	7
02/22/96	Washington High School, Rick Schwentker, Instructor	40
03/05/96	Rolla 5th Grade, Elaine Edgar, Instructor	63
03/05/96	East Central College, Debbie Schatz, Instructor	16
03/06/96	Hazelwood-West High School, Gail Haynes, Instructor	12
03/13/96	Waynesville High School, Hope Creel, Instructor	43
03/20/96	Lebanon High School, John Sode, Instructor	31
	TOTAL	972

6.0 REACTOR HEALTH PHYSICS ACTIVITIES

The health physics activities at the UMR Reactor Facility consist primarily of radiation and contamination surveys, monitoring of personnel exposures, airborne activity, pool water activity and waste disposal. Releases of all by-product material to authorized, licensed recipients are surveyed and recorded. In addition, health physics activities include calibrations of portable and stationary radiation detection instruments, personnel training, special surveys and monitoring of non-routine procedures.

6.1. Routine Surveys

Monthly radiation exposure surveys of the facility consist of direct gamma and neutron measurements. No unusual exposure rates were identified. Monthly surface contamination surveys consist of 20 to 40 swipes counted separately for alpha, and beta/gamma activity. No significant contamination outside of contained work areas was found.

6.2. By-Product Material Release Surveys

There were no shipments of by-product material released off-campus from the reactor facility during this reporting period.

6.3. Routine Monitoring

Thirty-six reactor facility personnel and students involved with operations in the reactor facility are currently assigned film badges. Six are read twice per month (Reactor Staff) and thirty are read once per month. There are four area beta-gamma/neutron badges assigned. Nineteen campus personnel and students are assigned beta-gamma film badges, and frequently TLD ring badges for materials and X-ray work on campus. There are 18 monitor and spare badges assigned on campus. In addition, 9 digital direct-reading and 3 ion-chamber dosimeters are used for visitors and high radiation area work. There have been no significant personnel exposures during this reporting period.

Visitors are monitored with direct reading dosimeters. No visitor received in excess of 5 millirem.

Airborne activity in the reactor facility is monitored by a fixed-filter, particulate continuous air monitor (CAM) located in the reactor bay. Low levels of Argon-41 are routinely detected during operations.

Pool water activity is monitored monthly to ensure that no gross pool contamination or fuel cladding rupture has occurred. Gross counts and spectra of long-lived gamma activity are compared to previous monthly counts. From April 1995 through March 1996 sample concentrations averaged 9.64E-7 μCi/ml.

6.4. Waste Disposal

Release of gaseous and particulate activity through the building exhausts is determined by relating the operating times of the exhaust fans and reactor power during fan operation to previously measured air activity at maximum reactor power. During this period 46.065 millicuries were released into the air. The released isotope was identified as Ar-41.

Solid waste, including used water filters, used resins and contaminated paper is stored and/or transferred to the campus waste storage area for later shipment to a commercial burial site. Water is analyzed for radioactive contamination and approval is required before the water is released. During this period one 55 gallon drum of solid waste containing waste, filters, and resins was transferred to the Dangerous Materials Storage facility. The total gross activity was 7.37E-3 millicurries.

6.5. Instrument Calibrations

During this period, portable instruments and area monitors were calibrated at six month intervals.

7.0 PLANS

The reactor staff will be heavily involved in four major projects during the next reporting period; 1) installing new reactor nuclear instrumentation (NI), 2) shipping HEU fuel offsite, 3) continued characterization of the LEU fuel and core, and 4) continued expansion of research capabilities.

7.1. Reactor Instrumentation Upgrade

We have acquired three new NI channels from Gamma-Metrics which will ultimately replace our existing five channel system. Additionally, we have recently purchased three Leeds and Northrup strip chart recorders. A total of $167,000 has been secured for the console upgrade. The U.S. DOE has provided $137,000 and $30,000 is being directly provided by the UMR Reactor.

As instruments are installed, extensive review documentation will be established and appropriate approvals will be obtained. Many changes will be made under the provisions of 10CFR50.59. Several changes will require NRC approval.

Detailed testing is now being performed on the equipment and extensive operational data is being collected. We feel that the funds we now have are sufficient for providing almost a complete console upgrade. As the new equipment is installed, the reliability and efficiency of console operations will be greatly increased.

7.2. Shipment of HEU Fuel Offsite

Efforts will continue during the next reporting period to ship our HEU fuel offsite. We plan to complete the project within the next year. Measurements and analyses have been completed that have characterized dose rates associated with each element.

Once the HEU fuel is shipped offsite, we plan to submit a revised Security Plan to NRC to reduce some of our current security requirements.

7.3. LEU Fuel Characterization

Over the past year we have continued with characterization studies for the new LEU fuel. We plan to continue the studies and to that end we have submitted a proposal to DOE for funding. In particular, we would like to do detailed gold wire flux mapping of the core, detailed energy spectrum characterization of our experimental facilities, and a precise measurement of reactor kinetics parameters.

7.4. Expansion of Research Capabilities

Over the next year, efforts will continue to expand the facility's research capabilities. In particular, we are placing much emphasis on computer interfacing with the new console equipment. The new equipment has been specially designed to provide isolated signal outputs dedicated to interfacing with computer data acquisition stations. There is great interest in this capability with planned research in the areas of artificial intelligence, neural networking and an "operator advisory" system.

APPENDIX A.

STANDARD OPERATING PROCEDURES

CHANGED DURING THE 1995-1996

REPORTING YEAR

A. PURPOSE:

The purpose of the checklist is to verify that reactor systems are operating correctly prior to reactor start-up.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS:

1. A licensed operator shall be responsible for performing the pre-startup checklist. The operator may assign various steps to be completed by unlicensed personnel: however, the operator is still fully responsible for the proper performance of the checklist.

2. The checklist shall be completed prior to the first reactor start-up of the day. The checklist shall be completed prior to a reactor start-up after a "Secure" checklist has been completed.

3. After each step on the checklist is performed the operator will record the readings made, or in cases where no readings are required, will simply check the appropriate blank on the form.

4. Any malfunction or abnormality identified during performance of the checklist shall be immediately reported to the Senior Operator on Duty, and corrected as necessary before completion of the checklist.

C. PROCEDURE

Complete the checklist in accordance with the following steps:

1. **Date** - Record the date using the rubber date stamp. Rev.

2. **Initials** - Record the initials of the person performing the checklist.

3. **Time** - Record the time shown on the console clock.

4. **Core Loading** - Enter core loading number and mode.

5. Verify that the P.A. system is operable. Turn on the bridge intercom and video monitor.

6. **RAM System Check:**

   a. Announce, **"THE BUILDING ALARM WILL SOUND. THIS IS A TEST. DO NOT EVACUATE THE BUILDING."** Rev.
   b. Check that the setpoints and automatic functions of the RAM systems meet the criteria listed below. For each High Radiation Alarm, verify that both the audible alarm and the visual annunciator are actuated. Reset the annunciator panel after each High Radiation Alarm check.

CHANNEL	SETPOINT	AUTOMATIC ACTION
1. Bridge RAM	10 - 18 mR/hr	High Radiation Alarm
2. Bridge RAM	15 - 28 mR/hr	Building Evacuation Alarm
3. Demin RAM	10 - 18 mR/hr	High Radiation Alarm
4. Basement RAM	10 - 18 mR/hr	High Radiation Alarm

   c. Announce, **"TEST COMPLETE, ACKNOWLEDGE ALL FURTHER ALARMS"**.

7. Verify that all monitors read between 1 to 8 mrem/hr.

8. **Beamport and Thermal Column Status:** Record the status of the beamport and thermal column ("open" or "shut") as indicated by 1) the "Beam Port or Thermal Column Open" annunciator light and 2) the Beam Port Indication light. Notify the Senior Operator on Duty if either facility is "open".

9. **Linear Channel:**

   a. Depress the zero check button; verify that the digital display reads ".0000".
   b. Depress the zero check button again to release the check function. Set the Linear compensating voltage to obtain a Linear reading between 0.02 and 0.05 on the 2 W scale. Following a high power run, the SRO on Duty may adjust the Linear compensating voltage as appropriate.
   c. Record the Linear reading. Record the scale.

10. **Linear CIC Voltage:** Record the high voltage (HV) and compensating voltage (CV) settings of the Linear power supply. Values should correspond approximately to the following: Rev.

    HV ~ 480 VDC
    CV ~ 2 to 8 VDC

11. a. Turn on and date the Startup, Linear, and Log/Period recorders. Reset the annunciator panel.
    b. Observe the temperature recorder "RCD" is illuminated in the upper left hand corner of the display.

12. **Core Check:** Turn the pool lights on.

    a. Check the water level in the pool.
    b. Visually inspect the core and pool for abnormalities. Check in-core experiments.
    c. Insert the source into the core source holder.

13. **Start-Up Channel Test:** Turn the Log Count Rate selector switch to 10^2, 10^3, and 10^4. Verify that the meter and recorder follow. Return the selector switch to the "OPERATE" position.

14. **Verify Fission Chamber Response:** Insert the fission chamber until the green Insert Limit light comes on. Observe the count rate. Raise the fission chamber until the count rate shows a definite decrease.

15. Insert the fission chamber to insert limit. Verify that the count rate is greater than 2 cps. (Following a high power run, the SRO on Duty may position the fission chamber as desired as long as a count rate greater than 2 cps is maintained.)

16. **Log and Power Range Test:**

Rev.

a. Depress and hold the 10pA keypad switch on the Log and Linear drawer.
b. Verify receipt of the **"Non-Operative"** scram and **"Low CIC Voltage"** rundown audible and visual alarms.
c. Verify that the digital meter and recorder read within the tolerances of the following table. The bargraph should generally follow the digital display and recorder.

Keypad Switch	Log Scale (%)	Power Range (%)
10pA	9.0 E -6 - 1.1 E -5	0
0.1uA	9.0 E -2 - 1.1 E -1	0
1mA	9.0 E 1 - 1.1 E 2	90 - 100

d. Release the switch and reset the annunciator board.
e. Repeat Steps a. through d. for the 0.1 uA and 1 mA switches.

17. **Period Response Test:**

a. Depress and hold the **3 SEC** keypad switch.
b. Verify receipt of the **"Non-Operative"** scram and "**Low CIC Voltage**" rundown audible and visual alarms.
c. Verify that the Period bargraph, digital meter, and recorder all read about 3 seconds.
d. Verify that the 30 second, 15 second , and 5 second period annunciator alarms are actuated.
e. Release the switch. Clear the annunciator panel.

18. Turn on the magnet power using the key switch. Push the Scram Reset button to energize the magnets. Reset the annunciator panel.

19. Record inlet temperature. Notify the SRO on Duty if the inlet temperature is below 60°F.

20. Record the magnet currents. (Typical readings should be between 25 and 85 mamp.)

21. **150% Power Scram Check:**

    a. Withdraw shim rods to 3 inches.
    b. Depress the test button on safety amp and hold until the 4 red lights come on. Observe that the scram occurs prior to 150%.
    c. Verify that the rods have dropped and that the audible and visual alarms have actuated.
    d. Reset the drawer and annunciator panel.

22. **Log and Linear Drawer Non-Operative Scram and Rundown Test:** Rev.

    a. Withdraw shim rods to 3 inches.
    b. Depress the **NON-OPER** keypad switch. Check for the Non-Operate Scram and Low CIC Voltage Rundown visual and audible alarms.
    c. Verify that the rods have dropped and rod drives are running down.
    d. Try to stop the rundown by lifting the shim joy stick.
    e. Stop the rundown with the rundown reset button.
    f. Reset the scram, rundown, and annunciator panel.

23. **Period Trip Test:**

    Rev.

    a. Withdraw shim rods to 3 inches.
    b. Depress and hold the **PERIOD TEST** keypad switch. Verify that the 30 Second Rod Withdrawal Prohibit annunciator is activated with a simulated period greater than or equal to 30 seconds.
    c. Continue depressing the **PERIOD TEST** keypad switch. Verify that the 15 Second Rundown is activated with a simulated period greater than or equal to 15 seconds.
    d. Continue depressing the **PERIOD TEST** keypad switch. Verify that the 5 Second Scram is activated with a simulated period greater than 5 seconds by observing a loss of magnet current and the annunciators.
    e. Release the switch.
    f. Reset the scram, rundown, and annunciator panel.

24. **Manual Scram:**

    a. Raise shim rods to 3 inches.
    b. Push the manual scram button. Verify that the rods have dropped by visually observing the video display and noting that the blue magnet contact lights are off.
    c. Push the scram reset button and reset the annunciator panel.

25. Push the annunciator test button and check for burned out bulbs. Replace any burned out bulbs. Reset the annunciator panel.

26. Verify that the magnets are on and that all rods are on insert limit.

27. Prepare hourly and permanent logs.

28. **Detector Response Check:**
    a. Inspect the core. Make certain core cooling is clear and experiments are firmly secured.
    b. "Spike" the Log and Linear Channel CIC and the Linear Channel CIC by positioning the neutron source next to the detectors.
    c. Insert the source into the holder.
    d. Observe the Log/ Period and the Linear recorder traces to verify proper response to the source spike.
    e. Observe the Startup Channel recorder to verify that the recorder responded properly with a decreased count rate when the source was moved away from the core.
    f. Reset the annunciator panel.

29. Raise the shim rods to 6 inches. Record the time on both the checklist and in the permanent log.

30. **Nitrogen Diffusers Status:** Turn on nitrogen diffuser pumps as desired. Record status of pumps as "ON" or "OFF". (Note: At least one pump should be turned on for operations in excess of 20 kW.) Rev.

31. Record the intended power level.

32. Announce, "**The Reactor Will Be Started and Taken to a Power of _____ Watts**".

33. Review the Pre-Startup Checklist. Verify that all of the steps have been completed. The licensed operator responsible for performing the checklist will initial the checklist thus verifying that it has been properly completed.

34. The Senior Operator on Duty will initial the checklist verifying that all items have been completed and any problems identified have been satisfactorily resolved.

35. Record the date using the rubber date stamp.

1. Date						Rev.
2. Initials of the Person Performing Checklist						Rev.
3. Time (Console Clock)						
4. Core Loading						
5. P.A., Intercom, Video Monitor On						
6. RAM System Check						
7. Radiation Level Normal						
8. Beam Port and Thermal Column Status						
9. Linear Channel	Zero					
	Meter Reading					
	Scale					
10. Linear C.I.C. Voltages	HV (~480)					Rev.
	CV (~ 2 to 8)					
11. Recorders On and Dated, Check "RCD" Light on Temp. Recorder						
12. Core Check (Lights On)	Level Check					
	Inspect Core					
	Source Inserted					
13. Start-Up Channel Test						
14. Verify Fission Chamber Response						
15. Fission Chamber Inserted, Count Rate > 2 CPS						
16. Log and Power Range Test						Rev.
17. Period Response Test						
18. Magnet Power On, Scram Reset, Board Reset						
19. Inlet Temperature (°F)						

20. Magnet Currents (milliamps)	No. 1					
	No. 2					
	No. 3					
21. 150% Power Scram Test	Raise Rods 3 in. Push "Test" Button					
22. Log and Linear Drawer Non-Operative Scram Test	Raise Rods 3 in. Select "3 Sec" Switch					
23. Period Trip Test						
24. Manual Scram Test	Raise Rods 3 in. Push Manual Scram					
25. Annunciator Test, All Lights On						
26. Magnets On, Rods on Insert Limit						
27. Prepare Hourly and Permanent Logs						
28. Detector Response Check	Inspect Core					
	Log Spike					Rev.
	Period Spike					
	Linear Spike					
	Startup Channel Response					
29. Raise Rods to 6 in., Record Time in Both Logs						
30. Nitrogen Diffuser Status	No. 1					Rev.
	No. 2					
31. Intended Power Level						
32. Announce Intention to Start						
33. Pre-Startup Check Properly Completed (Lic. Op. Initials)						
34. Senior Operator's Initials						
35. Date						

Revised By: David Freeman
David Freeman

Approved By: Albert Bolon
Albert Bolon

A. PURPOSE

To provide a safe and consistent method for performing a reactor startup to a low power level.

B. PRECAUTIONS, PREREQUISITES, LIMITATIONS

1. The Pre-Startup Checklist shall be completed and approved by the SRO on Duty prior to commencing reactor startup.

2. The reactor will be considered "clean" if power levels within the past 52 hours have not exceeded 20 kW-hr.

3. The reactor will be considered "hot" following a shutdown while the neutron population is still decreasing as determined by the Startup Channel count rate.

4. The reactor will be considered "high residual" when it is neither "clean" nor "hot" as defined above.

5. The licensed operator shall control all reactivity changes to the reactor by direct manipulation or by directing the manipulation of the controls and experiments being conducted at the facility.

6. The operator must be alert and attentive at all times during reactor operations. All nuclear instruments (Startup, Linear, Log, Period, Safety No. 1, Safety No. 2 and the Power Range of the Log and Linear drawer) must be closely monitored for proper response. If at any time an improper response is suspected, the Senior Operator on Duty shall be notified and a reactor shutdown initiated as deemed necessary by the Reactor Operator. Rev.

7. The console operator should scram or shut down the reactor without hesitation if any doubt exists about reactor safety.

8. If a scram or rundown occurs permission to restart the reactor can only be authorized by the Senior Reactor Operator on Duty.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

C. STARTUP TO LOW POWER PROCEDURE FOR A CLEAN CORE

1. **Initial Reactor Status -** The Pre-Startup Checklist shall be completed and approved. The shim rods should be at 6 inches and the neutron source inserted into the core.

2. **Withdraw Rods To Shim Range:**

   a. Withdraw the Shim Rods to a position between 12.5 and 13.0 inches. Verify that the yellow Shim Range indicator lights are illuminated.

   b. Withdraw the Regulating Rod to 15.0 inches.

   c. **MILESTONE - VERIFY DOUBLING**: **Verify that the Startup Channel count rate has approximately doubled, showing a clear increase in response to the rod withdraws. If a clear increase is not observed, the startup shall be halted and the SRO on Duty notified.**

3. **Withdraw Shim Rods To 18 Inches:**

   a. During this maneuver, limit the rate of power increase by pausing approximately 5 seconds between each rod pull. If necessary, pause longer between each pull to limit the slope on the Startup Channel recorder to 45 degrees. (This corresponds to an approximate 84 second period.)

   b. Withdraw the Shim Rod bank in one inch (or less) increments, pausing between each pull as specified above.

   c. Verify that the Startup Channel responds properly to each rod pull.

   d. Continue until the Shim Rods are at 18.0 inches.

4. **Withdraw Shim Rods To Instrument Turnaround**:

   a. During this maneuver, limit the rate of power increase by pausing approximately 5 seconds between each rod pull. If necessary, pause longer between each pull to limit the slope on the Startup Channel recorder to 45 degrees. (This corresponds to an approximate 84 second period.) Rev.

b. Withdraw the Shim Rod bank in 0.25 inch (or less) increments, pausing between each pull as specified above.

c. Verify that the Startup Channel responds properly to each rod pull.

d. Closely observe the Linear, Log, and Period indicators for "turnaround" (i.e. rising neutron signal indication). | Rev.

e. **MILESTONE - IDENTIFY "TURNAROUND": Linear, Log, and Period "turnaround" must be identified before the Startup Channel signal reaches full scale. If the Startup Channel nears the top of its scale and proper turnaround is not observed, then the power shall be leveled in the operating range of the Startup Channel and the SRO on Duty notified.** | Rev.

f. After positive "turnaround" is noted on each the Linear, Log, and Period indicators, the fission chamber may be withdrawn to a convenient height (normally the fission chamber should be adjusted to read approximately 100 count per second). | Rev.

g. The Startup Channel signal should not be allowed to increase off scale.

5. **Continue Power Increase and Level At Low Power:**

a. After instrument "turnaround" has been confirmed, limit the rate of power increase to an approximate 50 second period as indicated by the Period indicators. The Senior Operator on Duty may authorize shorter periods. | Rev.

b. Upscale the Linear Channel as necessary when it reaches approximately 60% of the selected scale.

c. The neutron source should be withdrawn from the core when the Linear channel is on the 20 Watt scale. | Rev.

d. Level reactor power between 2 and 20 Watts.

e. Place the reactor in autocontrol as desired.

Revised By: William Bonzer *(signature)*   Approved By: Albert Bolon *(signature)*

f. **RAFT (Reset, Announce, Fission Chamber, Time):**

i) Reset the annunciator panel. Verify that the "Manual" light is off when in auto control.

ii) Announce the reactor power over the building PA.

iii) Position Fission Chamber to read midscale.

iv) Record Time at power in the permanent logbook.

g. Complete the Hourly Log sheet.

6. Refer to the appropriate SOP for further operations.

D. REACTOR RE-START WITH A HOT CORE (DECREASING SOURCE RANGE COUNT RATE FOLLOWING A SHUTDOWN)

1. Position the fission chamber low enough such that the count rate will not go below 2 cps during the startup. At the same time, try to position the detector high enough to have as much range for increasing count rates as possible.

2. Adjust the Linear compensating voltage until the signal follows the actual power decay or until the lower limit of sensitivity is reached. Make sure the Linear signal is positive.

3. Record the intention to restart the reactor and the intended power level in the permanent logbook.

4. If the reactor is being restarted following an automatic scram or rundown or following an unanticipated shutdown, permission to restart must be granted by the SRO on Duty.

5. Withdraw Rods to Shim Range

   a. Withdraw the Shim Rods to a position between 12.5 and 13.0 inches. Verify that the yellow Shim Range indicator lights are illuminated.

b. Withdraw the Regulating Rod to 15.0 inches.

c. Readjust the fission chamber position and Linear Compensating Voltage as needed. Doubling in count rate need not (and most likely will not) be observed at this point.

6. **Withdraw Shim Rods To 18 Inches:**

a. During this maneuver, limit the rate of power increase by pausing approximately 5 seconds between each rod pull. If necessary, pause longer between each pull to limit the slope on the Startup Channel recorder to 45 degrees. (This corresponds to an approximate 84 second period.)

b. Withdraw the Shim Rod bank in one inch (or less) increments, pausing between each pull as specified above.

c. Verify that the Startup Channel responds properly to each rod pull. The rate of decrease in the count rate should slow and may turnaround and begin to rise depending on the power history.

d. Continue until the Shim Rods are at 18.0 inches.

7. **Withdraw Shim Rods To Instrument Turnaround**:

a. During this maneuver, limit the rate of power increase by pausing approximately 5 seconds between each rod pull. If necessary, pause longer between each pull to limit the slope on the Startup Channel recorder to 45 degrees. (This corresponds to an approximate 84 second period.) |Rev.

b. Withdraw the Shim Rod bank in 0.25 inch (or less) increments, pausing between each pull as specified above.

c. Verify that the Startup Channel responds properly to each rod pull. The rate of decrease in the count rate should slow and eventually turnaround and begin to rise.

d. Closely observe the Linear, Log, and Period indicators for "turnaround" (which means a positive signal response). |Rev.

e. **MILESTONE - IDENTIFY "TURNAROUND": Linear, Log, and Period "turnaround" must be identified before the Startup Channel signal reaches full scale and prior to obtaining shim rod positions less than one inch below the critical rod heights before shutdown. If these conditions are not met, notify the SRO on Duty and insert rods to shim range and reposition the fission chamber and readjust the Linear compensating voltage as necessary. Repeat Steps D.5 through D.7 as necessary to satisfy this requirement.** Rev. Rev.

f. After positive "turnaround" is noted on each the Linear, Log, and Period indicators, the fission chamber may be withdrawn to a convenient height (normally the fission chamber should be adjusted to read approximately 100 count per second). Rev.

g. The Startup Channel signal should not be allowed to increase off scale.

8. **Continue Power Increase and Level At Low Power:**

   a. Complete this step as specified for a clean core.

9. Refer to the appropriate SOP for further operations.

E. STARTUP TO LOW POWER PROCEDURE FOR A HIGH RESIDUAL CORE

1. Perform the startup steps as prescribed for a clean core except:

   a. pause slightly longer between rod withdrawals,

   b. the Linear compensating voltage may be readjusted with shim rods at 6 inches, as necessary. Immediately following a high power run it may not be possible to adjust the compensating voltage as low as 0.05. In such instances, adjust the compensating voltage to obtain the lowest stable positive signal. The SRO on Duty is to be notified in such instances.

   c. be prepared for the reactor to behave differently than usual, and

   d. be prepared for the critical rod heights to be different than for a cold, clean core.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

A. PURPOSE

To provide for a safe and consistent method to 1) change power after the reactor has been leveled at low power and 2) operate the reactor at steady-state power.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. This procedure is applicable after SOP 103, "Reactor Startup to Low Power" has been completed.

2. Both Safety Channels and the Power Range of the Log and Linear drawer should begin to show turnaround at about 5 kW. If turnaround has not been observed by a power of 10 kW, the reactor will be shut down and the SRO on Duty notified. |Rev.

3. At least one nitrogen diffuser should be turned on for operations greater than 20 kilowatts. This requirement may be waived by the SRO on Duty for special tests. Reactor bridge radiation levels shall not be allowed to equal or exceed 30 mr/hr.

4. Prior to taking the reactor to a power level in excess of 100 kW, the reactor must first be leveled at a power between 10 kW and 100 kW and hourly logs taken to verify the proper operation of the reactor instrumentation. This requirement is only applicable to the first power increase above 100 kW for a particular operational run.

5. At least one building exhaust fan shall be turned on for reactor operations at 200 kW.

6. At least one building exhaust fan should be turned on when the constant air monitor reaches a value of about 600 cpm.

7. The licensed operator shall control all reactivity changes to the reactor by direct manipulation or by directing the manipulation of the controls and experiments being conducted at the facility.

8. The operator must be alert and attentive at all times during reactor operations. All nuclear instruments (Startup, Linear, Period, Log, Safety No. 1, Safety No. 2, and the Power Range of the Log and Linear drawer) must be closely monitored for proper response. If at any time an improper response is suspected, the Senior Operator on Duty shall be notified and a reactor shutdown initiated as deemed necessary by the Reactor Operator. |Rev.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

9. The console operator should scram or shut down the reactor without hesitation if any doubt exists about reactor safety.

10. If a scram or rundown occurs, permission to restart the reactor can only be authorized by the Senior Reactor Operator on Duty.

C. POWER INCREASE PROCEDURE

1. Record the intent to increase power with the time in the permanent logbook.

   Example: 1028 Reactor started to 20 kW.

2. Announce the intention to increase power over the PA system.

   Example: "Reactor power will be increased from 20 W to 20 kW."

3. Switch the reactor to "Manual" control.

4. Carefully monitor all nuclear instruments (Startup, Linear, Period, Log, Safety No. 1, Safety No. 2, and the Power Range of the Log and Linear drawer) for proper response during the power transient. Rev.

5. Withdraw rods in small increments while carefully monitoring the "prompt jump" on the Period Channel. The prompt jumps should normally not be allowed to reach a 30 second period.

6. Limit the rate of power increase to an approximate 50 second persistent period as indicated by the Period Channel. The Senior Operator on Duty may authorize shorter periods.

7. Upscale the Linear Channel as necessary when it reaches approximately 60% of scale. If the Linear Channel is reading 60% or greater prior to initiating the power increase, it may be upscaled before beginning the power increase.

8. Level the reactor at the desired power.

9. Place the reactor in autocontrol.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

10. **RAFT (Reset, Announce, Fission Chamber, Time):**

    a. Reset the annunciator panel. Verify that the "Manual" light is off when in autocontrol.
    b. Announce the reactor power over the building PA.
    c. Position Fission Chamber to read midscale.
    d. Record Time at power in the permanent log.

    Example: 1032 Reactor at 20 kW.

11. Complete the Hourly Log Sheet.

D. POWER DECREASE PROCEDURE

1. Record the intent to change power in the permanent logbook.

   Example: 1401 Reactor power decreased to 60 kW.

2. Announce the intention to change power over the PA system.

   Example: "Reactor power will be decreased from 200 kW to 60 kW."

3. Switch the reactor to "Manual" control.

4. Carefully monitor all nuclear instruments (Start-up, Linear, Period, Log, Safety No. 1, Safety No. 2, and the Power Range of the Log and Linear drawer) for proper response during the power transient. Rev.

5. Insert rods to achieve the desired rate of power decrease.

6. Reposition the Fission Chamber as necessary to keep the reading on the upper half of the scale.

7. Downscale the Linear Channel as necessary when the reading reaches about 8%.

8. Level reactor power at the desired power level.

9. Place the reactor in autocontrol.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

10. **RAFT (Reset, Announce, Fission Chamber, Time):**

    a. Reset the annunciator panel. Verify that the "Manual" light is off when in autocontrol.
    b. Announce the reactor power over the building PA.
    c. Position Fission Chamber to read midscale.
    d. Record Time at power in the permanent log.

    Example: 1406 Reactor at 60 kW.

11. Complete the Hourly Log Sheet.

E. STEADY STATE POWER OPERATIONS

1. Constant Power - Automatic Control

   a. In the event an abnormality is detected in the automatic control system, the reactor shall be switched to manual control and the Senior Operator on Duty notified.
   b. The position of the regulating rod should be monitored to assure that it does not reach the insert or withdrawal limit while in auto control. In the event the regulating rod reaches approximately the 6 inch or 18 inch position, switch to manual and reposition rods while maintaining the constant power level. If the safety rods approach the withdrawal limit or lower limit of shim range, the Senior Operator on duty should be notified.
   c. Complete the Hourly Operating Log at hourly intervals.

2. Constant Power - Manual Control

   a. The power level should be maintained constant by manually adjusting rods. The Operator will continuously monitor the instrumentation. All entries in the permanent Log or the Hourly log should be recorded by an assistant.
   b. At hourly intervals, an assistant should be summoned to record the appropriate information in the Hourly Operation Log.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

SOP: 105 TITLE: **REACTOR SHUTDOWN & REACTOR SECURING PROCEDURES**

Revised: February 28. 1996

A. PURPOSE

To ensure a safe and consistent method to shutdown the Reactor from an operating condition and, when advised by a Senior Operator on Duty, to secure the reactor.

B. PRECAUTIONS, PREREQUISITES, AND LIMITATIONS

1. The SRO on Duty will decide if the Reactor is to be "SHUTDOWN" or "SECURED".
2. The Reactor will be secured at the end of the work day. Rev.
3. Any malfunctions or abnormal conditions noted during or after the Shutdown will be recorded in the Permanent Log and the SRO on Duty shall be notified.
4. An operator assistant shall be present if the Reactor is not in "AUTO" before the shutdown begins to take logs.
5. The RO must be alert to the indication of jamming of control rods during the shutdown process. If this occurs, stop driving in the rods and inform the SRO on Duty.
6. At the end of an operational run, the operator should dispose of trash, coffee cups, soda cans, etc. and leave the Control Room in a clean and orderly appearance.

C. "SHUTDOWN" OF REACTOR

1. Log time, initials, followed by "SHUTDOWN" in the hourly log.
2. Log time and "SHUTDOWN" in the permanent log.
3. Announce over the public address system, "The reactor will be shutdown".
4. Trip "AUTO/MANUAL" switch to "MANUAL" (if in "AUTO").
5. Place the "OPERATE/SHUTDOWN" switch in "SHUTDOWN" position or insert safety rods and regulating rod with both joysticks.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

6. Monitor the decrease in reactor power by changing the Linear Meter Selector Button (1 button to left) when the Linear Recorder decreases to about 8% of the present scale. Operation at high power levels will prevent returning to lowest allowed scale (2 watts) and therefore this step is continued only until rods reach their insert limit. |Rev.

7. Maintain Log Count Rate Recorder > 20 cps by inserting fission chamber.

8. When the rods are fully inserted to their insert limits (green lights):

   a. Return "OPERATE/SHUTDOWN" switch to "OPERATE".

   or, b. Return joysticks to the "NEUTRAL" position.

9. Reactor is now "SHUTDOWN".

D. "SECURING" OF REACTOR

Refer to form SOP 105.

1. Use date stamp.

2. All Shim Safety and Reg Rod Insert Limit (Green) Lights on. |Rev.

3. Turn magnet key 90 degrees CCW and remove from console. Hand key to SRO on Duty.

4. Turn off the Log Count Rate, Linear, and Log/Period recorders. Place date at the top of each recorder chart (use date stamp). |Rev.

5. Push Annunciator "RESET". The "MANUAL SCRAM", "RECORDERS OFF" and "MANUAL OPERATION" Annunciators will remain on. |Rev.

6. Push Station #6 (REACTOR BRIDGE) intercom switch to return to the off position (button up).

7. Return "OPERATE/SHUTDOWN" switch to "OPERATE".

8. Turn TV monitor off.

9. Verify both Nitrogen Diffusers are off. Rev.

10. Verify that all vent fans are off.

11. Secure the rabbit system by assuring the controller is turned off and the gas bottle is shut. Return the glove box key to the safe.

12. Log time using the console clock.

13. Initials of person performing checklist.

14. Senior Operator on Duty shall initial.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

SECURE CHECKLIST

1. Date										
2. All Rods on Insert Limit										
3. Magnet Power Off and Key to SRO										
4. Recorders Off and Dated										
5. Reset Annunciator										
6. Reactor Bridge Intercom Off										
7. Shutdown Switch to Operate										
8. TV Monitor Off										
9. Nitrogen Diffusers Off										
10. Ven Fans Off										
11. Rabbit System Secure										
12. Time Completed										
13. Operator's Initials										
14. Senior Operator's Initials										

| Rev.

| Rev.

| Rev.

Revised 2/8/96

William Bonzer

Albert Bolon

Revised By: William Bonzer   Approved By: Albert Bolon

A. PURPOSE

To provide for records of facility operation and major maintenance. Hourly logs will detail specific instrument readings while the reactor is in operation. Rev.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. The licensed Operator on Duty is responsible for the proper completion of all operational logs. Rev.

2. Any work affecting the reactor, its operation and specific use during operation must be clearly and legibly described in the Permanent Log book.

3. The Operator on Duty will report any abnormal conditions entered in the operational logs to the Senior Operator on Duty.

4. All log entries are to be made with times recorded from the console clock.

5. All scrams and rundowns shall be documented in the Permanent Log as described in SOP 150, "Response to Alarms".

6. The reactor operator may make entries in the log book when the reactor is leveled at a stable power with the Reg Rod in "Auto". Otherwise, an operator assistant should record log entries (see SOP 102 or 103 for other conditions prior to log entries).

7. Log entries should be printed, rather than in cursive (except for signatures and initials), and should be in black ink.

C. PROCEDURE

1. Hourly Log Entries

   a. The hourly log sheet will be dated and each person (student, trainee, etc.) operating the reactor will place their signature in appropriate spaces provided at the top of the form. Rev.

b. A new hourly log sheet will be started at the beginning of each operational day, or when all available columns have been filled during the current day of operation, (i.e. a new hourly log sheet is not required for each startup checklist SOP 102).

c. The following procedure steps correspond to the numbered steps on the UMRR Hourly Operating Log form.

1. Time from the console clock.
2. Person at the console, initials (student, trainee, or licensed operator). Rev.
3. Nominal reactor power level (in watts or kilowatts).
4. Linear recorder reading in percent. Rev.
5. Linear Meter Scale.
6. Reg rod in "Auto" and annunciator board reset? Yes or No.
7. Log percent power (digital meter) of the Log and Linear drawer.
8. Check Period Recorder trace for proper indications over the past 10 minutes (approximately) of operation.
9. Log and Linear drawer Power Range reading on digital meter (%). Rev.
10. Record the Log Count Rate Recorder reading.
11. Source removed? Yes or No.
12. Diffuser pumps on? Yes or No.
13. Exhaust fans on? Yes or No.
14. Record the position of Shim Rod #1 to the nearest tenth of an inch.
15. Record the position of Shim Rod #2 to the nearest tenth of an inch.

16. Record the position of Shim Rod #3 to the nearest tenth of an inch.

17. Record the position of the Regulating Rod to the nearest tenth of an inch.

18. Check Radiation Area Monitors (Reactor Bridge, Demineralizer and Beam Room) for approximately the same values observed during completion of startup checklist (SOP 102).

19. Record Reactor Bridge RAM reading in mr/hr.

20. Check Magnet Currents for approximately the same values observed (and recorded) during the startup checklist (SOP 102). Rev.

21. Record the reading on the Safety Channel No. 1.

22. Record the reading on the Safety Channel No. 2.

23. Verify that the time at which a stable power level was obtained is recorded in the Permanent Log. Other entries to the Permanent Log such as samples being irradiated, etc. should also be made at this time. (See section 2 of SOP 104).

24. Record the reactor Inlet Temperature (thermocouple 1 or 3) as displayed on the Pool Water Temperature Recorder.

25. Licensed operator initials.

2. Permanent Log Entries

   a. All entries in the Permanent Log shall be preceded by the date (Use the date stamp).

b. During completion of the Startup Checklist (SOP 102) use the Check Out stamp and complete values as they become available. To the right of the purpose the nature of the experiment should also be shown. See the example below:

0953	**Time Check Out Started**
NE 306	**Purpose**
1027	**Time Rods at 6 Inches**
1046	**Time Reactor at** 0.01 **kw**

c. Reactor power changes are made in accordance with SOP 103 and entries are made prior to the start of a power change and at the new stable power level. The example below indicates Permanent Log entries for a power change including shutdown of the reactor:

1028 Reactor started to 600W.
1030 Reactor at 600W.
1035 Reactor shut down.

d. The Sample-Experiment stamp is used to indicate the irradiation of a sample as a Permanent Log entry. This stamp will be used to indicate the production of by-product material. The example below indicates the use of this stamp.

EXPERIMENT 94-17

OPERATOR William Bonzer

CORE OR FACILITY POSITION	EXPERIMENTER & SAMPLE	START TIME	STOP TIME	TOTAL TIME
BRT	Khouaja (Foil 1)	1538	1539	1 min

Rev

Note: The number in parentheses ( ) indicates the number of samples.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

3. Operational Data (Recorder Charts)

   a. Date all 3 primary recorders in accordance with SOP 102 (startup checklist) and SOP 105 (shutdown checklist). Rev.

   b. Recorder chart paper is to be replaced as soon as possible after the current roll runs out. If a power change is in progress when the chart runs out, wait until the reactor is leveled out at the desired power prior to replacing the chart. During replacement use the new chart box for the old chart storage. Date both the old chart and all sides of the chart box. Place the chart on storage shelves adjacent to the control room.

   c. All chart paper is retained for a period of FIVE YEARS except for the Log/Period Chart which is to be retained for the DURATION of the facility.

4. Ventilation Fan Log Entries

   a. After receiving approval from SRO to start or stop a building exhaust ventilation fan, complete the requested information on the Fan Operation Log (i.e. time, fan #, power level, etc.)

   b. Fan Operation Logs are retained in the Facility Health Physics files.

Example of Fan Operation Log

DATE	FAN #	TIME ON	TIME OFF	PEAK POWER/ REMARKS
Feb 10, 1996	2	1450	1500	200 Kw

Rev.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

HOURLY OPERATING LOG

Date ____________ ______ (Start a new form each day)
Operator's Signature: (1) ______________________________ (4) ______________________________
(Including Licensed (2) ______________________________ (5) ______________________________
Operator on Duty) (3) ______________________________ (6) ______________________________

1. Time at Power													
2. Initials - Person at Console													
3. Nominal Power (W or kW)													
4. Linear Recorder (%)													
5. Linear Scale (W or kW)													
6. Auto Set/Board Reset (Y or N)													
7. Log Level (%)													
8. Period Trace Normal (√)													
9. Log and Linear Power Range (%)													
10. Log Count Rate Recorder (cps)													
11. Source Removed? (Y or N)													
12. Diffuser(s) On? (Y or N)													
13. Exhaust Fan On? (Y or N)													
14. Shim Rod No. 1 (inches)													
15. Shim Rod No. 2 (inches)													
16. Shim Rod No. 3 (inches)													
17. Regulating Rod (inches)													
18. Radiation Levels Normal (√)													
19. Bridge Monitor (mr/hr)													
20. Magnet Currents Normal (√)													
21. Power Chamber No. 1 (%)													
22. Power Chamber No. 2 (%)													
23. Permanent Log Entries (√)													
24. Core Inlet Water Temp. (°F)													
25. Licensed Operator Initials													

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

SOP: 308 TITLE: **RESTORATION OF AC POWER FOLLOWING A POWER OUTAGE**

Complete Revision: February 28. 1996

A. PURPOSE

The purpose of this SOP is to ensure that power is restored to equipment in a safe and efficient manner following a trip of unregulated and/or regulated power and to prevent damage to the equipment.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. Personnel restoring unregulated and/or regulated power should be familiar with the operation of the equipment affected.
2. A weekly check should be performed before operating the reactor at a power higher than 20 kW following a loss and restoration of power.
3. Any malfunctions or abnormality of equipment should be immediately reported to the Senior Operator on duty.

C. PROCEDURES

1. Reset the unregulated and regulated power supplies, which are located in the equipment room behind the console panel.
2. All annunciator lights, buzzer and 4 red lights on the safety amplifier will now be on.
3. Push the annunciator acknowledge button to silence the buzzer.
4. Reset the safety amplifier to extinguish the 4 red lights.
5. Reset the Linear power supply located in the control room. (Note: The power supply must warm up for several minutes before it will reset.
6. Press the annunciator panel reset button. The annunciator should now indicate a normal situation. (Note: A normal situation is indicated by all lights being extinguished, except Manual Scram, Recorder Off and Manual Operation.)

Written By: David Freeman
David Freeman

Approved By: Albert Bolon
Albert Bolon

7. Notify the SRO on Duty of the power outage or tag the console to assure a weekly check is completed prior to reactor runs exceeding 20 kW.

8. Start the demineralizer pump by pushing its "Start" button. (Note: The start button is located on the intermediate level, on the wall behind the pump.

9. Check the power to the HPGE and the GELI detectors. **CAUTION:** If power is restored to the germanium detectors without turning the high voltage off, serious damage may occur. If the power is off, proceed as follows:

   a. Turn the high voltage down to zero.
   b. Reset the AC power strip.
   c. Slowly bring the high voltage up (about 3 seconds per 100 V) to operating voltage:

      GELI: 4000 VDC
      HPGE: 4500 VDC

Written By: David Freeman
David Freeman

Approved By: Albert Bolon
Albert Bolon

UMR REACTOR EMERGENCY PHONE LIST

Reactor Staff		HOME	WORK
David Freeman, Mgr., SRO		364-7269	341-4384
William Bonzer, Sr. El. Tech.		368-3727	341-4291
Albert Bolon, Dir., SRO		364-1961	341-4746
Hatem Khouaja, RO		341-3857	341-4236
Ray Bono, Health Physicist		364-5728	341-4240, 4305, 4403
Jim Jackson, Sr. Lab Mechanic		699-4897	341-4291
Linda Pierce, Sr. Sec.		265-3738	341-4236

Rev.

University Administrative Staff			
1. Chancellor, John Park	341-4118	364-6455	341-4114
2. Interim Vice Chancellor for Physical Facilities, Marvin Patton		364-6278	341-4252
3. Director, UMR Police, William Bleckman		364-1294	341-4345
4. Director of Student Activities, Lou Moss		364-1654	341-4208
5. Director, Physical Plant, Marvin Patton		364-6278	341-4252
6. Director, Health Service - Infirmary, Dwight Deardeuff, MD		364-0809	341-4284
7. Dean, School of Mines and Metallurgy, Lee W. Saperstein		368-3782	341-4153
8. Radiation Safety Officer, Nick Tsoulfanidis		341-3595	341-4745

Local		
UMR University Police	341-4300	341-4111
Rolla City Police		9-911
Rolla Fire Department		9-911
Phelps County Hospital		9-911
Rolla Emergency Management Agency (Answered by Police Dept. when closed)		364-1213

State Agencies			
Missouri Highway Patrol			368-2345
Missouri State Emergency Mgt. Agency (24 hr.)		(314)	751-2748
Missouri Dept. of Natural Resources (24 hr.)		(314)	634-2436
Missouri Bureau of Enviromental Epidemiology	(314) 751-6160	(314)	751-2748 (24 hrs)

Federal Agencies			
NRC, Lisle, IL, Region III			1-800-522-3025
NRC Duty Officer (24 hour)	(301) 816-5100	(301) 951-0550	(301) 415-0550

Other			
American Nuclear Insurers		(203)	561-3433
Radiation Emergency Assistance Center	(615) 576-3131	(615)	481-1000 (24 hrs)

Revised 07/21/95

Revised By: David Freeman [signature]

Approved By: Albert Bolon [signature]

SOP: 511 TITLE: **RESPONSE TO MISSING SPECIAL NUCLEAR MATERIAL**

Revised: February 16, 1996

A. PURPOSE

To establish procedures for the proper initial response to missing special nuclear material (SNM). SNM includes reactor fuel, PuBe sources, and fission chambers.

B. PRECAUTIONS, PREREQUISITES, LIMITATIONS

1. SOP 112, "Fuel Management" establishes provisions for the periodic inventory of all SNM housed at the reactor facility.

2. Any threats, implied or otherwise, concerning the potential theft of SNM must be taken very seriously. Any such threats shall immediately be reported to the Reactor Director.

C. PROCEDURE

1. If any reactor fuel is discovered missing, the following persons/agencies shall be contacted immediately (refer to the emergency call list in SOP 501).

   a. Reactor Manager
   b. Reactor Director
   c. UMR Police
   d. Dean, Mines & Metallurgy
   e. Chancellor
   f. NRC, Region III
   g. NRC, Project Manager
   h. Campus Health Physicist

   Note: DOE must be informed in writing as soon as possible and given all pertinent information, i.e. missing fuel serial numbers, total quantity and type of stolen SNM The fuel custodian should be responsible for this contact.

Written By: James Jackson Approved By: Albert Bolon

2. The Reactor Manager and/or staff will immediately try to ascertain the breech of security and cordon off the reactor building of all non-essential persons. Care should be taken not to destroy any physical evidence and latex gloves should be worn by persons in the building.

3. The UMR Police will direct the investigation and necessary followup actions upon arrival at the facility.

4. The Campus HP should be summoned to check for possible contamination in and outside of building. The HP should verify that the campus area in proximity of the reactor building is free of contamination.

4. If a fission chamber or PuBe source is found missing, the following persons/agencies shall be immediately notified:

   a. Reactor Manager
   b. Reactor Director
   c. UMR Police
   d. Campus Health Physicist

   10CFR shall then be consulted to determine the NRC reporting requirements based on the amount and type of material missing.

Albert Bolon

Written By: James Jackson Approved By: Albert Bolon

A. PURPOSE

To ensure that reactor staff, students, and experimenters handle radioactive materials safely and with proper precautions.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. Wear appropriate protective clothing (e.g. glasses, gloves, etc.) when handling radioactive materials.

2. Use tongs or other handling devices to reduce exposure whenever possible.

3. Have at least one portable radiation survey meter available and operational when working with radioactive samples.

4. If any problems or questions arise, contact a member of the reactor staff or the Health Physicist.

C. PROCEDURE

To remove samples from the glove box or reactor pool:

1. Before removing a radioactive sample from the glove box or pool, survey the sample and the sample holding device to make certain that the dose rate is acceptable.

2. The following dose rate restrictions apply:

   a. Samples reading greater than 100 mrem/hr at 1 foot may only be handled with permission from the Health Physicist. In such instances, the Health Physicist (or their designee) shall be present to monitor dose rates.

   b. Samples reading 100 mrem/hr or less at 1 foot may be handled by the reactor staff.

   c. Samples reading between 5 mrem/hr and 50 mrem/hr at one foot may be

handled by students or other experimenters under the direct supervision of the reactor staff or health physics staff.

d. Samples reading less than 5 mrem/hr at one foot may be handled by students or other experimenters with the permission of the reactor staff.

3. After the sample has been removed from the pool or glove box, take it to the radioactive work area for preparation. Keep the sample as far away from your body as possible. Use tongs or tweezers to carry the sample as appropriate. Minimize your exposure time to the extent possible.

4. Remove the sample from the stringer or sample holder and dispose of radioactive wastes in accordance with SOP 600, "General Health Physics".

5. After sample counting or when the experiment is completed, place the sample in an envelope or other suitable container labeled with the following:

   a. "Radioactive Materials" tape or label
   b. Experimenter's name
   c. Date
   d. Contents (isotope, sample description, etc.)
   e. 1 foot radiation level (mrem/hr)
   f. IRF number
   g. Class number, if applicable

   Store the sample in the reactor bay safe.

6. Check all areas where radioactive materials have been used with a portable GM detector to ensure that these areas are free of contamination. If contamination is detected, notify the reactor staff. If necessary, the HP staff will take swipes and count them.

7. Clean up and decontaminate the radioactive work area, if necessary.

8. Check hands, feet, and clothing for contamination with a survey meter and/or at the frisker after handling radioactive samples.

Revised By: Ray Bono Approved By: Albert Bolon

9. Generally clean up the work area and return equipment to its proper location.

10. Make certain that survey meters are turned off.

11. Wash your hands thoroughly after having worked with radioactive material even when gloves were worn.

Revised By: Ray Bono

Approved By: Albert Bolon

A. Purpose

To ensure that proper transport, handling, shielding requirements and regulations are observed in the shipping or release of radioactive materials to licensees **on campus.**

B. Precautions, Prerequisites, or Limitations

1. All shipments or releases of by-product material from the Reactor Building shall be handled as "limited quantity" if possible. Any amounts greater than "limited quantity" require special attention as deemed necessary by Health Physics.

2. The person receiving radioactive material must show that he or she is licensed to possess it. Radioactive materials shall not be released to someone who is not licensed.

3. If there are any questions pertaining to the release of a material, or whether a substance is considered to be "limited quantity," the Health Physicist should be notified.

C. Procedures for Limited Quantities

1. Check 49 CFR 173.421 and 173.423 to ensure that the radioactive material meets the requirements of "limited quantity."

2. Package the limited quantities of radioactivity as specified in 49 CFR 173.421.

3. Check the cosigner's license before releasing the radioactive material to be sure they are authorized to receive it.

4. Fill out a Material Transfer Form (see attached). Make two additional copies. One copy is given to the carrier, the other is given to the Health Physicist, and the original is kept in the Reactor files.

D. UMR Material Transfer Form

1. Name of the authorized individual receiving the material(s).

2. License number and expiration date of the individual listed in 1.

3. Fill in the appropriate information for every material involved in the transfer.

Written By: Ray Bono Approved By: Albert Bolon

Ray Bono Albert Bolon

4. Clearly state that the material to be transferred is "Limited Quantity". If it is not limited quantity contact Health Physics for further instructions.

5. Fill in the date that the material was irradiated, if the material was irradiated at the UMR reactor, otherwise leave this item blank.

6. Specifically describe the type of container the material will be shipped in. The container must meet the specifications of 49 CFR 173.423 (a).

7. List any labels applied to such materials as required by 49 CFR 173.423 (d).

8. Tell where the materials will be transported to.

9. Fill in the required external package dose rates. Include the name and serial number of the instrument used in making the measurements.

10. Fill in the requested package surface contamination values. Include the name and serial number of the instrument used in making the measurement.

11. After properly notifying health physics, one of the personnel will review and sign that the material transfer is approved.

12. The Health Physicist (or their designee) should sign and date the space labeled "Certified by."

Ray Bono

Written By: Ray Bono

Albert Bolon

Approved By: Albert Bolon

UMR REACTOR MATERIAL TRANSFER FORM

1. Ship To ________________________________

____

2. Consignee By-Product License

Number ________________

Exp Date ________________

3.

Target Material	Mass (g)	Physical Form	Radionuclide	Activity	
				Curies	GBq

4. Shipment Type ________________________

5. Irradiation Date ________________

6. Shipping Container ________________________

7. Labels ________________________

8. Transport Routing ________________________

9. External Dose Rate

a. Surface ________________ mr/hr

b. 3 Feet ________________ mr/hr

c. Instrument Used ______________

10. Surface Contamination

a. Beta/Gamma __________dpm/cm^2

b. Alpha ______________dpm/cm^2

c. Instrument Used ______________

11. Health Physics Approval ____________________________ Date ________________

12. "This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package -- limited quantity of material, UN2910.

Certified By ________________________________ Date ________________________

Accepted By (Carrier) ________________________ Date ________________________

Ray Bono
Written By: Ray Bono

Albert Bolon
Approved By: Albert Bolon

A. PURPOSE

To provide for the efficient calibration of the fixed Radiation Area Monitors and to minimize personnel exposure during the calibration.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. The RAMs are to be calibrated annually. Rev.

2. A minimum of two personnel are needed to perform the calibration. One person will be located in the control room to take readings and record values and the other will handle the sources near the monitors.

3. The person who handles the sources must wear a minimum of a pocket dosimeter and a film badge. Ring badges are optional but advisable.

4. The person who handles the source should minimize their exposure time in close proximity to the source.

5. The reactor must be shutdown and only authorized personnel allowed in the calibration area during the calibration to prevent accidental exposure while the sources are being handled. If a whole body dose > 100 mrem could be received, then high radiation area posting and area control are required.

6. Notify the Reactor Manager prior to performing this procedure.

C. PROCEDURE - GAMMA RAM CALIBRATION

1. **Calculate Source to Detector Distances:** Calculate source to detector distances to provide target dose rates of 10 mrem/hr, 30 mrem/hr, 100 mrem/hr, and 200 mrem/hr. Use the inverse square law ($DR_1/DR_2 = d_2^2/d_1^2$) and the exponential decay law ($DR_1 = DR_0 e^{-\lambda t}$).

   The Cs-137 source (SN5049) was certified to read 114 mrem/hr at a distance of 1.64 ft (19.68 inches) on July 23, 1979. The half life of Cs-137 is 30.17 years.

A. PURPOSE

To provide for the thorough Reactor Staff review of all experiments to be irradiated by neutrons from the UMRR. The review evaluates potential 1) reactivity effects, 2) dose hazards to the experimenter, and 3) hazards to the reactor.

B. PRECAUTIONS, PREREQUISITES OR LIMITATIONS

1. All sample irradiations must be performed under an approved Irradiation Request Form (IRF) with two approval signatures.

2. All materials to be irradiated are to either be corrosion resistant or encapsulated in corrosion resistant containers.

3. Approved IRFs remain valid for future irradiations.

4. IRFs will be numbered sequentially following the last two digits of the current year (e.g. 95-1, 95-2, etc.).

5. Radiation Safety Committee approval is required for

   a. experiments worth more than 0.4% $\Delta k/k$,
   b. explosive materials,
   c. fueled experiments, or
   d. untried experiments.

6. The total reactivity worth of all experiments is limited to 1.2% $\Delta k/k$.

7. Experiments having moving parts shall not have an insertion rate greater than 0.05% $\Delta k/k$ per second.

8. Cooling is to be provided as needed to prevent the surface temperature of an experiment being irradiated from exceeding the boiling point of the pool.

Written By: David Freeman
David Freeman

Approved By: Albert Bolon
Albert Bolon

C. PROCEDURE - IRRADIATION REQUEST FORM

The IRF should be completed according to the following steps:

1. **IRRADIATION REQUEST** - This section of the IRF should be completed by the experimenter.

   a. **Sample Description** - Describe the sample material to be irradiated (e.g. dried tobacco leaves, powdered milk, gold foil, etc.)

   b. **Physical Form** - Specify the physical form of the sample material (e.g, powder, ash, liquid, etc).

   c. **Encapsulation** - Check the box marked "Poly-vial" or check "other" and describe.

   d. **Irradiation Location** - Specify the irradiation facility to be used. More than one facility may be authorized on a single IRF. If "Other" is specified, describe the irradiation location (for example: "wire stringer in Grid Position C-3").

   e. **Irradiation Limits** - Specify the irradiation limits as follows:

      1) **Power** - Specify the maximum reactor power for irradiation. Samples may **NOT** be irradiated at powers higher than specified.

      2) **Time** - Specify the irradiation time for the sample(s) at the maximum power. Samples may be irradiated at lower powers for times longer than the specified irradiation time as long as the total fluence (i.e. kW-hrs) does not exceed the product of the specified maximum power and irradiation time.

      3) **Mass** - Specify the maximum sample mass (grams) to be irradiated in any single irradiation.

      Handwritten revisions to the limits are allowed based on the measured dose rate from the initial irradiation(s). Assume dose rate is a linear function of

power, irradiation time, and sample mass. Revised irradiation limits require the review and approval of either the SRO on Duty, Reactor Manager, or Reactor Director as signified by their initials with dates.

f. **Expected Dose Rate** - Specify the expected 1 foot dose rate when the sample comes out of the reactor based on one of the categories below:

Experience - The expected dose rate may be based on measurements made during previous similar irradiations. In such instances, record the IRF number of the previous similar irradiation.

Calculations - The expected dose rate may be calculated using the DR=6CE rule (or other appropriate method) where DR is the 1 foot dose rate in mrem/hr, C is the expected activity in mCi, and E is the gamma energy in MeV. The expected activity can be calculated using $A = N\sigma\phi(1-e^{-\lambda t_{irr}})$ where N is the number of target atoms, σ is the cross section, ϕ is the neutron flux, λ is the decay constant and t_{irr} is the irradiation time.

Completely Unknown - A trial irradiation is required if the expected dose rate is completely unknown. The irradiation limits for a trial irradiation are normally reactor power $\leq$ 2 kW, irradiation time $\leq$ 1 minute, and sample mass $\leq$ 1 gram. The reviewers may approve different trial irradiation limits at their discretion. Dose rates for higher powers, masses and times can then be linearly extrapolated based on the measured dose rate resulting from the trial irradiation.

g. **Reactivity Worth** - Estimate the reactivity worth of the sample based on one of the categories below:

Default - A default reactivity worth of <0.05% $\Delta k/k$ may be used for the rabbit facilities if the sample mass is less than 7 grams. A default reactivity worth for core periphery stringers of <0.1% $\Delta k/k$ may be used for holders with a volume of 35 cm^3 or less and a sample mass of 7 grams or less. (Note: The default mass and location values are based on a report by Wagner, 1992.) Beamport and thermal column irradiations have a default reactivity of 0.0%.

Experience - The estimated reactivity worth based on previous "experience" may be specified along with the applicable IRF number. If no previous experience exits, estimate the reactivity worth using SOP 306.

Completely Unknown - If reactivity worth is completely unknown and not easily calculated, it must be experimentally determined.

h. **Comments** - Provide additional comments, if any.

i. **Request Completed By** - The person completing items **a** through **h** above should sign their name in the blank provided.

2. **REVIEW AND APPROVAL** - This portion of the IRF is to be completed by one of the reviewers and approved by both of the reviewers.

a. **Analysis of Potential Hazards** - Reviewers shall analyze potential hazards associated with the experiment with regard to following:

1. **Reactivity** - Review the expected reactivity worth information. Assure that the Technical Specification Section 3.7 requirements are met. Check the box marked "None" or "Other" as appropriate. If "Other" is specified, explain.

2. **Dose Rate** - Review the expected dose rate information and assess potential dose rate hazards. Check the box marked "None" or "Other" as appropriate. If "Other" is specified, explain.

3. **Reactor Equipment** - Verify that no corrosion problems exist. Verify that no explosive materials or fueled experiments are to be irradiated without Radiation Safety Committee approval. Verify that proper provisions for cooling have been made. Evaluate the experiment with respect to potential hazards to the reactor or reactor operations (for example, detector "shadowing"). Check the box marked "None" or "Other" as appropriate. If "Other" is specified, explain.

4. **Other** - Evaluate the experiment for any other types of conceivable hazards to personnel or equipment.

b. **Additional Restrictions/Requirements** - The reviewers are to specify any additional restrictions or requirements deemed appropriate.

c. **Approvals** - Reviewers shall signify approval of the experiment by signing and dating in the appropriate blank. Two signatures are required from either the Director, Manager, SROs, or the Health Physicist.

D. PROCEDURE - SAMPLE IRRADIATION LOG

A Sample Irradiation Log will accompany each IRF to document sample irradiation information. An entry shall be made on the Sample Irradiation Log for each sample irradiated.

1. **Date** - Specify the date of the sample irradiation.

2. **Sample ID** - Specify the sample identification number or name.

3. **Experimenter's Name** - Provide the name of the experimenter responsible for the sample.

4. **Location** - Specify the irradiation location.

5. **Power** - Specify the power level at which the irradiation is performed.

6. **Time In** - Specify the console time at which the irradiation began.

7. **Time Out** - Specify the console time at which the irradiation ended.

8. **Total Time** - Specify the total time of the irradiation.

9. **Dose Rate @ 1 foot** - Record the 1 foot dose rate from the sample at the time of initial sample handling.

10. **Decay Time** - Specify the approximate decay time between the end of the irradiation and the time of the dose rate measurement.

11. **Initials** - Either the console operator (licensed operator, student, or trainee) or the experimenter will provide their initials signifying that sample irradiation information is complete.

IRRADIATION REQUEST FORM

IRF# _____

1. IRRADIATION REQUEST

a. **Sample Description:** ______________________________

____

b. **Physical Form:** __________ c. **Encapsulation** ( ) Poly-Vial ( ) Other __________

d. **Irradiation Location:** ( ) Bare Rabbit ( ) Cad Rabbit ( ) Beam Port ( ) Thermal Column
( ) Other __________

e. **Irradiation Limits:** 1) Power: __________ 2) Time: __________ 3) Mass: __________gm

f. **Expected 1 Foot Dose Rate:**__________mrem/hr **Based on:** ( ) experience (IRF# __________)
( ) calculations (attached)
( ) completely unknown

g. **Expected Reactivity Worth:** __________% k/k **Based on:** ( ) default
( ) experience (IRF#__________)
( ) SOP 306 calculations (attached)
( ) completely unknown

h. **Comments:** ______________________________

____

i. **Request Completed By:** ______________________________

2. REVIEW AND APPROVAL

a. **Analysis of Potential Hazards:**

1.	Reactivity	( ) None ( ) Other __________
2.	Dose Rate	( ) None ( ) Other __________
3.	Reactor Equipment	( ) None ( ) Other __________
4.	Other	( ) None ( ) Other __________

b. **Additional Restrictions/Requirements**______________________________

____

____

____

c. **Irradiation Request Reviewed and Approved (two signatures required):**

Director __________ Date ______, Manager __________ Date ______
SRO __________ Date ______, SRO __________ Date ______
Health Physicist __________ Date ______

Written By: David Freeman
Approved By: Albert Bolon

IRF# ____

Page # ____

SAMPLE IRRADIATION LOG

Date	Sample ID	Experimenter's Name	Irradiation Information: Location	Power	Time In	Time Out	Total Time	Dose Rate @ 1 ft (mR/hr)	Decay Time (Approx.)	Initials

Written By: David Freeman

Approved By: Albert Bolon

Date Commenced________________________ Date Completed________________________ Rev.
Total Hours on Hour Meter____________________

1. **Log and Linear Drawer Calibration**
   a. Log and Linear Log/Period Recorder
      (1) Cleaned chassis as needed

   b. LOW CIC Voltage Rundown
      Set Point at A4TP1: ____________VDC x 200 = ______________VDC
      Verify Rundown Initiated (✓): ______________
      Verify Alarms Received (✓): ______________

   c. 120% Full Power Rundown
      Set Point: ______________%
      Verify Rundown Initiated (✓): ______________
      Verify Alarms Received (✓): ______________

   d. Log and Linear Detector/Cable Resistance Check
      (Cables should read about 10^{10} ohms.)
      (1) Signal Cable Resistance: _______ohms
      (2) High Voltage Cable Resistance: _______ohms
      (3) Comp. Voltage Cable Resistance: _______ohms

   e. Drawer Alignment - Perform the steps listed in the following sections of the drawer Instruction Manual:

      Low Voltage Power Supply Check Complete (Sec. 4.3.1): _______

      High Voltage and Compensating Voltage Check
      - Low Voltage Set Point at J6: _________VDC
      - Low Voltage Set Point at A4TP10-A4TP1: _________VDC
      - NON-OPERATE LED on (✓): _________
      - Reset High Voltage (J6): _________VDC
      - High Voltage (A4TP10-A4PP1): _________VDC
      - NON-OPERATE LED off (✓): _________
      - Compensating Voltage at J7: _________VDC
      - Compensating Voltage at A5TP10-A5TP1: _________VDC

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Rev

Log Displays

Picoamp Current	True Expected Readings	Tolerance for True Expected Reading	Log Bargraph	Log Digital	Log Recorder	Initial	Date
10 pA	1.0E-5%	7.0E-6%--1.4E-5%					
100 pA	1.0E-4%	7.0E-5%--1.4E-4%					
1 nA	1.0E-3%	7.0E-4%--1.4E-3%					
10 nA	1.0E-2%	7.0E-3%--1.4E-2%					
100 nA	1.0E-1%	7.0E-2%--1.4E-0%					
1µA	1.0E -0%	7.0E-1%--1.4E-0%					
10 µA	1.0E-1%	7.0E-0%--1.4E-1%					
100 µA	1.0E-2%	7.0E-0%--1.4E-2%					

Period Displays

Settings	Period Bargraph Display	Period Digital Display	Period Recorder Display	Initial	Date
∞					
3 Sec					

Linear Displays

Pico-amp Current	Tolerance for True Expected Readings	True Expected Reading	Linear Bargraph Display	Linear Digital Display	Voltage Tolerances	Initial	Date
10 µA	8%-12%	10%			0.7V-0.9V		
20 µA	18%-22%	20%			1.5V-1.7V		
30 µA	28%-32%	30%			2.3V-2.5V		
40 µA	38%-42%	40%			3.1V-3.3V		
50 µA	48%-52%	50%			3.9V-4.1V		
60 µA	58%-62%	60%			4.7V-4.9V		
70 µA	68%-72%	70%			5.5V-5.7V		
80 µA	78%-82%	80%			6.3V-6.5V		
90 µA	88%-92%	90%			7.1V-7.3V		
100 µA	98%-102%	100%			7.9V-8.1V		
110 µA	108%-112%	110%			8.7V-8.9V		
120 µA	118%-122%	1[illegible]0%			9.3V-9.7V		
125 µA	123%-127%	125%			9.9V-10.1V		

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f. Isolated Outputs (✓): ______________

g. Keypad Switches

Test Switch	Indication
1 mA	Log: ______________%
	Lin: ______________%
0.1 uA	Log: ______________%
	Per: -100, +100 sec (✓)_______
	Lin: 0± 1% (✓)__________
10 pA	Log: <______________%
3 SEC	Per: 3.0 ± 0.1 sec (✓)_________
NON-OPER	LED On (✓)__________
LOG TEST	Rising Log Level (✓)_________
	Trip #4: ____________%
PERIOD TEST	Rising Period Level (✓)_______
	Trip #1: ____________sec
	Trip #2: ____________sec
	Trip #3: ____________sec
LINEAR TEST	Rising Linear Level (✓)_______

h. Cables Reconnected (✓): _________
Independent Verification of Cable Connections (✓): __________

i. Log and Linear Drawer Calibration Complete: __________(Initials) __________Date

2. **Linear Power Channel**
   a. Linear Power Supply
      (1) Cleaned chassis as needed (✓): _________

   b. Linear Recorder
      (1) Cleaned Chassis as needed (✓): _________

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Albert Bolon
Approved By: Albert Bolon

c. Linear Calibration
(Note: From 10^{-5} to 10^{-8}, the overall accuracy should be better than 2% of full scale. From 10^{-9} to 10^{-10} the overall accuracy should be better than 4%. Any instrument found to be out of calibration should be realigned in accordance with procedures.)

	---------METER--------		------RECORDER------			
PicoAmp Generator	Acceptable Reading	Actual Reading	Acceptable Reading	Actual Reading	Initial	Date
$6.0x10^{-5}$A	(57μA-63μA)	_______	(57%-63%)	_______	_____	________
$6.0x10^{-6}$A	(5.7μA-6.3μA)	_______	(57%-63%)	_______	_____	________
$6.0x10^{-7}$A	(570nA-630nA)	_______	(57%-63%)	_______	_____	________
$6.0x10^{-8}$A	(57nA-63nA)	_______	(57%-63%)	_______	_____	________
$6.0x10^{-9}$A	(5.3nA-6.6nA)	_______	(53%-66%)	_______	_____	________
$6.0x10^{-10}$A	(530pA-660pA)	_______	(53%-66%)	_______	_____	________
$2.0x10^{-10}$A	(130pA-260pA)	_______	(13%-26%)	_______	_____	________

d. Linear CIC Detector/Cable Resistance Check
(Cables should read about 10^{10} ohms.) Rev.

(1) Signal Cable Resistance: _______ohms _____ ________

(2) High Voltage Cable Resistance: _______ohms _____ ________

(3) Comp. Voltage Cable Resistance _______ohms _____ ________

e. Reconnect all cables _____ ________

Reconnection of cables verified _____ ________

3. **Log Count Rate Channel**

a. Log Count Rate Recorder
(1) Cleaned chassis as needed _____ ________

b. Fission Chamber Preamp — Initial / Date

(1) Cleaned chassis as needed ____ ________
(2) Additional Comments

c. Log Count Rate Channel Calibration
(Note: All readings should give 0.7 to 1.4 ratio of true-to-observed readings.)

Pulse Generator	Meter	Recorder	Initial	Date
10				
100				
1,000				
10,000				

d. Reconnect all cables ____ ________

Reconnection of cables verified ____ ________

4. **Safety Channels**
a. Safety Preamp
(1) Cleaned chassis as needed ____ ________

b. Safety Detector UIC #1
(1) Signal Cable Resistance: ______ohms ____ ________ Rev.

(2) High Voltage Cable Resistance: ______ohms ____ ________

c. Safety Detector UIC #2
(1) Signal Cable Resistance: ______ohms ____ ________

(2) High Voltage Cable Resistance: ______ohms ____ ________

d. Safety Amplifier
(1) Cleaned chassis as needed ____ ________

e. Safety Amplifier Adjustments ____ ________

f. Reconnect all cables ____ ________

Reconnection of cables verified ____ ________

	Initial	Date
5. PAT 60 Controller		
a. PAT 60		
(1) Cleaned chassis as needed	____	________

	Resistance	Initial	Date
b. Check dial settings and record the following			
(1) Approach	________	____	________
(2) Proportional Bank	________	____	________
(3) Rate Time	________	____	________
(4) Reset	________	____	________
(5) Gain (if applicable)	________	____	________

6. **Temperature Channel**
(Note: All readings should be ± 2°F.)

a. Verification of Temperature Readings Date________

Temperature Range (Take one reading from each, temperature range)	Thermometer	Thermocouple #1	Initials	Thermometer	Thermocouple #2	Initials	Thermometer	Thermocouple #3	Initials
60°F-70°F									
70°F-80°F									
80°F-90°F									
90°F-125°F									
125°F-135°F									
135°F-145°F									

b. Temperature > 135° Rod Withdrawal Prohibit Test

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Approved By: Albert Bolon

	Thermocouple #1	Thermocouple #3
>135°F Trip Temperature		
>135°F Annunciator		
Audible Alarm		
Rod Prohibit Withdrawal		
Initials		

7. **Regulated Power Supply** — Initial ____ Date ____
   a. Cleaned chassis as needed ____ ____
   b. Additional comments

8. **Conductivity Bridge**
   a. Cleaned chassis as needed ____ ____
   b. Additional comments

9. **Rod Indicator Calibration**

Actual Height	Rod 1	Rod 2	Rod 3	Reg. Rod		
1"	____	____	____	____		
6"	____	____	____	____		
12"	____	____	____	____		
18"	____	____	____	____		
24"	____	____	____	____	____	____

10. **Fire Alarm Check** — Initial ____ Date ____
    a. Cleaned system containers as needed ____ ____
    b. Checked batteries ____ ____
    c. Checked pull stations ____ ____
    d. Checked heat detectors ____ ____
    e. Checked smoke detectors ____ ____
    f. All indicator lamps operate ____ ____

11. **Security System Check**
    a. Door Sensors ____ ____
    b. Motion Detectors ____ ____
    c. Tamper Switch ____ ____

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	Initial	Date
d. Duress Alarm	____	________
e. Battery	____	________
f. Additional Comments		
12. Public Address System		
a. Cleaned chassis as needed	____	________
b. Additional Comments		
13. Area Radiation Monitor		
a. Cleaned chassis as needed	____	________
b. Additional Comments		
14. Portal Detector		
a. Cleaned chassis as needed	____	________
b. Perform Source Check	____	________
c. Additional Comments		
15. Constant Air Monitor		
a. Cleaned chassis and recorder as needed	____	________
b. Perform Source Check	____	________
c. Additional Comments		
16. Rod Drop Test (SOP 813)	____	________
17. Power Calibration (SOP 816)	____	________
18. Thermal Column Open Alarms - Verify that the control room audio and visual alarms, and the basement red flashing light comes on when the thermal column is opened by about 1 inch. Verify that the alarms clear when the thermal column door is closed.	____	________

I have reviewed the results of this Semi-Annual Check on this date and discussed any problems and/or errors with the operating staff.

________________________ ______ ________________________ ______
Director (Date) or Reactor Manager (Date)

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

A. PURPOSE

To provide a consistent method for checking the calibration of the Log and Linear drawer which includes Log N, Period, and Power Range.

B. PRECAUTIONS, PREREQUISITES AND LIMITATIONS

1. This procedure is to be performed semi-annually.
2. A second knowledgeable person shall check all cable connections that have been broken and reconnected.
3. Refer to Section 1, "Log and Linear Drawer Calibration" of the Semi-Annual Checklist (SOP 800) for forms to document this procedure.

C. PROCEDURES

a. Open the housings of both the Log and Linear drawer and the Log/Period recorders and clean as necessary. Pay particular attention to assure air vents are clear.

b. 80% High Voltage Rundown

1. Obtain the magnet key from the SRO on duty and have a Licensed Operator raise shim rods 3 inches.
2. Adjust A4R4, on the high voltage card A4, to the lower voltage that will cause the Low CIC Voltage Rundown trip to occur.
3. Record the voltage at A4TP1 where the trip had occurred. (200 times the voltage at A4TP1 equals the desired HV)
4. Verify receipt of the visual and audible alarms for Low CIC Voltage. Verify that a rod rundown is initiated.
5. Adjust A4R4 to 540V. (200 times the voltage at A4TPT equals the desired HV)
6. Reset the annunciator panel.
7. Remove the magnet key from the console and return it to the SRO on Duty.

c. 120% Full Power Rundown

1. Disconnect the 3 detector cables (signal, HV, a [illegible]) at the drawer.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

2. Connect the "Bonzer Box" pico-amp source to J5 of the Log and Linear drawer. Adjust current to 100% full power.
3. Reset annunciator panel.
4. Obtain the magnet key from the SRO on Duty and have a Licensed Operator raise shim rods 3 inches.
5. Slowly increase current to obtain a reading of 120%.
6. Observe from the Log digital display when the 120% rundown occurs.
7. Observe the ... % Full Power rundown and annunciator. Record values.
8. Reset the annunciator panel.
9. Remove the magnet key from the console and return it to the SRO on Duty.

d. **Log and Linear Detector/Cable Check** - Discharge each cable through a multimeter by connecting the meter probes to the outer shield and center conductor. Use the highest voltage scale and observe the voltage decline to 0 volts. Measure the resistance of the detector cable with an electrometer at 1000 VDC. Record the results. The cables should read about 10^{10} ohms. Again discharge the cables with the multimeter.

e. **Drawer Alignment** - Perform the steps in Section 4.3.1, "Low Voltage Power Supplies" from the Log and Linear drawer equipment manual.

High Voltage/Compensating Voltage Check

1. Measure HV at J6.
2. Adjust A4R4 as needed to measure 540 VDC.
3. Adjust A4R4 to a lower voltage until the non-operate LED turns on and the Low CIC Annunciator panel alarms.
4. Record the HV at J6 that the trip occurred at.
5. Record the voltage measured from A4TP10-A4TP1.
6. Verify that the keypad non-operate switch LED illuminates. Record the results.
7. Adjust A4R4 to measure 540 VDC at J6.
8. Reset annunciator panel.
9. Verify and record the non-operate keypad switch LED goes off.
10. Record the HV at J6. The high voltage at J6 should be 540 VDC ± 1 V.
11. Record the voltage measured from A4TP10-A4TP1.
12. If the Low CIC Voltage trip point needs to be adjusted follow the Log and

Linear equipment manual steps 4.3.2.1 and 4.3.2.2.

13. Measure compensating voltage at J7. Adjust A5R4 to 5.8 V as needed.
14. Record compensating voltage level at J7. The compensating voltage should be 5.8 VDC ± 1 V.
15. Record voltage at A5TP10-A5TP1.

Log Amplifier Alignment

1. For currents less than 5.0 nA, connect the Keithley pico-amp source to J5 of the Log and Linear drawer. Use the readings from the Keithley pico-amp source for the current settings. Above 5.0 nA, connect the Keithley pico-amp meter in series with the pico-amp source and J5. Use the readings from the Keithley pico-amp current meter for the current settings. Use the "Bonzer Box" pico-amp source for the higher current pico-amp readings.
2. Complete in the Log Displays Table of SOP 800 for the listed current levels.
3. If alignment is necessary follow steps 4.3.3.1-9 of the Log and Linear equipment manual. Repeat Step 3 following any adjustment in alignment.

Period Alignment

1. Perform Section 4.3.4, "Period Amplifier" in the Log and Linear drawer equipment manual. These adjustments determine the accuracy of the period. When performing these steps, the following guidance should be used.
   a. Set the oscilloscope to read 50 mV/cm (DC mode) and 0.2 sec/cm.
   b. Use the single sweep display mode with internal triggering.
   c. Save the ramp using the "save mode". After the ramp has been saved, use the cursor feature to automatically read the voltage change for a time span of about 1 second. (Note: The cursor feature provides a more accurate measurement than manually reading the scope.)
2. Complete the Period Displays Table on the Semi-Annual Checklist.

Linear Amplifier Alignment

1. Use the "Bonzer Box" pico-amp source connected in series with the Keithley pico-amp current meter to the Log and Linear drawer at J5.
2. Connect the voltage meter to ATP10-ATP1.
3. Apply the currents listed in the Linear Displays Table of SOP 800 and

record the displayed readings and voltage.

4. If the Linear Amplifier circuit needs aligned, follow steps 4.3.5.1-3 of the Log and Linear equipment manual.

f. Isolated Outputs - Adjust the zero and span on each isolator, as necessary, for equal inputs and outputs.

g. Keypad Switches - Fill out the Keypad Switch Table by depressing the indicated switch and recording the associated readings.

h. Discharge the detector cables at the connectors and the corresponding jacks at the drawer. Reconnect the detector HV, CV, and signal cables. Have an independent knowledgeable person verify cables are properly connected.

i. The person that performed this calibration procedure shall initial and date that the calibration has been properly completed.

A. PURPOSE

To ensure the proper operation of the control and safety-related instruments of the reactor and to functionally test the Physical Security Alarm System.

B. PRECAUTIONS, PREREQUISITES, OR LIMITATIONS

1. The Weekly Check should be completed on the first working day of each week the reactor is to be operated.

2. The security system and pool conductivity should be checked weekly but under no circumstance shall the surveillance interval exceed 14 days. The remaining portion of the checklist may be omitted if the reactor will not be operated that week.

3. The weekly check should be performed by a licensed operator, or a student/trainee under the direct supervision of a licensed operator.

4. Complete the Weekly Surveillance Checklist form and forward it to the Reactor Manager (or Director) for review and signature. Any abnormalities, problems, or out of service equipment should be brought to the attention of the Reactor Manager (or Director).

C. PROCEDURE

Select the Reactor Bridge Station on the Building Intercom, check the PA system, install the neutron source, turn on and date the Source Range, Linear, and Log/Period recorders. Turn on the core camera and select core on the monitor selector. Obtain Magnet Power Key and turn on magnet power. Reset the Scram and console resets.

1. Rod Prohibits

1.1. Recorders Off - Verify that the rods will not withdraw if any one of 4 primary recorders is turned off. Repeat the following steps for the 1) Source Range recorder, 2) Linear recorder, 3) Log/Period recorder, and 4) Temperature recorder.

a. Turn off the recorder.
b. Attempt to withdraw rods. Verify rods cannot be withdrawn.

William Bonzer

Revised By: William Bonzer

Albert Bolon

Approved By: Albert Bolon

b. Attempt to withdraw rods. Verify rods cannot be withdrawn.

c. Verify that the Recorder Off annunciator illuminates and that the console audible alarm is actuated.

d. Turn the recorder on, reset the annunciator.

1.2. Source Range < 2 CPS

a. Remove source from holder and/or withdraw fission chamber until Source Range CR <2 alarm is received. Record value at which the alarm occurs from recorder.

b. Attempt to withdraw rods. Verify rods cannot be withdrawn.

c. Verify that the CR <2 cps annunciator illuminates and that the console audible alarm is actuated.

d. Insert source and/or insert the fission chamber to the insert limit. Reset annunciator.

1.3. Inlet Temperature Above 135 Degrees

a. Plug the thermocouple simulator into the test input jack for one of the inlet thermocouples (thermocouple #1 or #3). (Randomly alternate which inlet thermocouple is checked from week to week.)

b. Slowly adjust the simulator to a higher setting, until the "Inlet Temperature Above 135°F" annunciator and audible alarm are energized.

c. Attempt to withdraw rods. Verify rods do not withdraw.

d. Record the temperature displayed on the recorder when the "Inlet Temperature Above 135°F" trip occurs.

e. Disconnect the thermocouple simulator from the thermocouple test input jack.

f. Reset annunciator.

1.4. Shim Rods Below Shim Range

Withdraw shim rods between 1/2 inch and 3 inches and attempt to withdraw the regulating rod. Note that the regulating rod will withdraw just far enough to clear the insert limit light. Attempt to withdraw the Shim/Safety rods. Note that further withdrawal cannot be made. Insert all control rods to the insert limit and record these results.

2. Rundowns

2.1. Radiation Area Monitoring (RAM) System

a. Withdraw rods to 3 inches.
b. Announce **"The Building Alarm will sound. This is a test do not evacuate the building."** on the Building PA System.
c. Have a second person check that the audible and visual alarms are functional on the local meters located near the detectors. Using RAM check source switch #1, record the value at which the High Area Radiation rundown and Building Evacuation Alarm occur. Check the automatic reset of the RAM, reset the Building Alarm (Scram Reset Button), acknowledge the annunciator, depress Rundown Reset and Annunciator Reset. Record value of alarms.
d. Repeat step 3 for RAMs #2 and #3 except for the Building Evacuation Alarm.
e. All alarms values shall be $\leq$ 20 mr/hr.
f. Upon completion of testing announce **"Test Complete. Acknowledge all further alarms,"** on the building PA system.

2.2. 120% Demand

a. Withdraw shim rods to 3 inches.
b. Turn off the Linear recorder.
c. Remove Linear recorder potentiometer cover and manually rotate potentiometer arm, note recorder reading when trip point is reached.
d. When inward motion of rods is verified, lower recorder below reset point, reset rundown and all alarms, turn recorder on and replace cover, and compare actual and specified trip points.
e. Record the trip point value and that the audible/visual alarms are functional.

2.3. 120% Full Power

a. Depress "LOG TEST" switch.
b. Observe the Log digital display and record the value at which the 120% full power trip occurs.
c. Release the "LOG TEST" switch.
d. Observe the "120% Full Power" annunciator and audible alarm.
e. Reset the annunciator and rundown.

2.4. Low CIC Voltage Linear Power Supply

a. Withdraw rods to 3 inches.
b. Push and hold alarm test button on Linear CIC Power Supply. Observe High Voltage meter and record the value when the under voltage alarm light comes on. Release the test button.
c. Acknowledge the annunciator alarm and observe Low CIC voltage annunciator light. Check for insertion of control rods (rundown in progress).
d. When the High Voltage on the Linear CIC Power Supply has increased to approximately 500 volts push alarm reset. The under voltage alarm light will go off allowing the operator to reset the rundown (push rundown reset) and the annunciator.
e. Record value of the trip point.

2.5. Regulating Rod on Insert Limit on Auto

a. Withdraw the Shim/Safety rods to 3 inches and Reg Rod to 0.5 inches (use the shim range bypass).
b. Adjust Linear recorder setpoint so that "auto permit" comes on.
c. With regulating rod at approximately 0.5 inches withdrawn, switch the Reg Rod control to "Auto" and reset the annunciator.
d. Adjust the red pointer (auto setpoint) to be slightly below black pointer (Linear signal) so that an insert on the Reg Rod will result.
e. When the Reg Rod reaches insert limit observe rods inserting, Manual Operation and "Reg Rod insert limit on Auto" annunciators.
f. Acknowledge and reset rundown and annunciators.
g. Record results.

3. <u>Scrams</u>

3.1. Bridge Motion Scram

a. Withdraw rods to 3 inches.
b. Release bridge lock and move the bridge a small distance.
c. Observe a Bridge Motion and Manual Scram annunciators illuminate and that the rods scram. Acknowledge the annunciator alarm.
d. Return bridge to original position and reset all annunciators. Re-insert the magnets.
e. Record results.

3.2. Non-Operative Scram and Rundown Test

a. Withdraw rods to 3 inches.
b. Depress the "NON-OPERATE" switch.
c. Verify rods have dropped and control rod drives are inserting.
d. Release the "NON-OPERATE" switch.
e. Verify the "Log N Non-operate" and "Low CIC High Voltage" annunciators and audible alarms are activated.
f. Reset the Scram, Rundown, and Annunciator panel.
g. Depress and release the test switches listed below. For each verify that the "Log N Non-operate" and "Low CIC High Voltage" annunciators and audible alarms are activated. Reset the annunciator after each switch is checked. The following switches are to be checked:
   - 1 mA switch,
   - 0.1μA switch,
   - 10 pA switch, and
   - 3 SEC switch.

3.3. 150% Full Power Scram

a. Withdraw rods to 3 inches.
b. Push Scram test button on Safety Amplifier. Hold button until both power range meters read full scale and 4 red test lights are on, and Magnet power light is off.
c. Push reset on the Safety Amp., acknowledge the annunciator and observe the 150% Full Power Scram annunciator and Magnet Contact lights are off.
d. Reset annunciator and insert the magnets.
e. Record results.

3.4. Manual Scram

a. Withdraw rods to 3 inches.
b. Push Manual Scram button.
c. Acknowledge the annunciator, observe Manual Scram light and all magnet contact lights are off. Push Scram Reset, Annunciator Reset and insert the magnets.
d. Record results.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

4. **Period Trips**

a. Withdraw rods to 3 inches.
b. Depress the "PERIOD TEST" switch to inject a ramp signal and observe the period digital display. Continue holding the switch down throughout the following steps.

4.1. 30 Second Trip - Verify that the <30 second audible and visual alarms are received at an indicated period of 30 seconds or more. Attempt to withdraw the control rods. Verify that rods cannot be withdrawn. Record the value (digital meter) at which the <30 second trip was received. Acknowledge the alarm.

4.2. 15 Second Trip - Continue depressing the "PERIOD TEST" button until the <15 second rundown occurs. Verify that the audible and visual alarms are received and that the rods begin to rundown. Acknowledge the alarm and record the actual trip point (digital meter).

4.3. 5 Second Trip - Continue depressing the "PERIOD TEST" button until the <5 second scram occurs. Verify that the audible alarm is received and that the <5 second and 150% full power annunciators are activated. Record the value (digital meter) at which the <5 second alarm occurs.

4.4. Release the "PERIOD TEST" switch, reset the scram, rundown, and annunciator panel.

5. **Rod Drop Currents**

Perform SOP 305 on any rod that has an inoperable magnet contact light. Write "SOP 305" in the space provided on the checklist.

a. Withdraw rods to 3 inches.
b. Perform the following steps for all rods with operable magnet contact lights:
c. Using a screwdriver slowly reduce magnet current using current adjustment #1, until the #1 magnet contact light goes out (you should also hear an audible "click" from the Reactor Bridge Intercom Station). Record this drop current value.
d. Repeat Steps 1 and 2 for Shim Rod No. 2 and No. 3.
e. Insert all Shim Rods to insert limit.
f. Set all Magnet Currents to "normal" (i.e. Drop Current plus 10 ma).

6. **Test of Annunciators**

6.1. Beam Room High Neutron Flux

a. Lower alarm set point by turning red needle on log rate meter to the left. Alarm occurs when black needle is hard against the red needle.
b. Check for local red alarm light and for white annunciator light on control panel. Return red needle to normal (10K) set point, reset alarm and annunciator.
c. Record results.

6.2. Interlock Bypass

Bypass each interlock one at a time to ensure that each individual bypass operates the annunciator and the bypass lights are functional.

6.3. Servo Limits

a. Note linear level recorder reading.
b. Change the automatic set point for auto permit by adjusting the star wheel. Note linear level at which the auto permit light comes on (<+2%). Continue to lower and note reading until the auto permit light goes off (> -2%).
c. Record results.

6.4. Pool Demineralizer Effluent Conductivity High

a. Record pool and demin effluent readings.
b. Check the alarm setpoint by dialing setpoint knob on the resistivity meter to match the needle reading. The local alarm (red alarm light) on the resistivity meter should come on and the console annunciator should alarm.
c. Reset the alarm to a setpoint of 0.5 MΩ-cm (2.5%) and switch the selector switch to display Demin effluent resistivity ("Meas B").

7. **"REACTOR ON" Lights**

With magnet key inserted and all scrams reset check the "reactor on" lights (1) above console (2) at reactor entrance and (3) basement level.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

8. **Building Evacuation Alarm**

   1. Announce over the PA, **"The Building Alarm will sound. This is a test. Do not evacuate the building."**
   2. Push the Building Evacuation Alarm and note the audible alarm.
   3. Reset Building Evacuation Alarm by pushing Scram Reset.
   4. Announce over building PA **"Test complete. Acknowledge all further alarms."**

9. **Nitrogen Diffusers**

   1. With the bridge intercom station selected, start diffuser #1. The green operation light should illuminate. Note the sound level of the pump and no unusual noise.
   2. Shutdown the #1 pump and repeat step 1 for the #2 nitrogen diffuser.
   3. Record results on form SOP 810.

10. **Beam Port Warning Lights**

   1. Announce over the building PA. **"Attention personnel, stand clear of the Beam Port".**
   2. Open the Beam Port by holding the beam port control switch in the open position until the "Red" (open) light comes on.
   3. Acknowledge the annunciator alarm and verify that the Basement Level Warning Light (Flashing Red) activates.
   4. Close the Beam Port by holding the Beam Port Switch until the Green (closed) light comes on. Reset the annunciator and observe that the light goes out.
   5. Announce over the Building PA **"Beam Port secured"**. Complete SOP 810.

11. **Shutdown Check** - Complete a Shutdown Checklist (SOP 103) to ensure that all console equipment is secured.

12. **Security System Check**

Inform the campus police (4300) that the security system will be checked.

12.1. Security Door

   a. Have police remain on line for the security checks.
   b. Hold in or close dead bolt on the security door.

c. Reset the alarm system.
d. Open dead bolt switch by releasing or opening dead bolt and ensure alarm occurs in campus police dispatch station.

12.2. Ultrasonics

a. Hold or close dead bolt on security door. Reset alarm system.
b. While holding the dead bolt switch, move around or have someone walk toward one of the UT's. Have campus police notify you when the alarm occurs. A different ultra sonic detector should be tested each week.
c. Allow the ultrasonic to reset by moving clear of the detector or stand still.

12.3. Duress

a. Inform the campus police that the duress alarm will be tested.
b. Momentarily depress the alarm button. The campus police should indicate the satisfactory operation of this alarm.

12.4. Doors

a. While holding the dead bolt switch closed, reset the alarm.
b. Open one of the exterior doors equipped with an intrusion alarm. A different door should be tested each week.
c. Have the campus police acknowledge the alarm when the door is opened.
d. Repeat steps a, b, and c for one of the interior doors equipped with an intrusion alarm. A different door should be tested each week.
e. When all intrusion channels have been tested, ask campus police to check the battery circuit. This completes the security check.
f. When all channels of the security system have been functionally tested and operate properly, initial the weekly checklist, Form SOP 810.

13. **Checklist Completed By** - The person who performed the checklist should sign and date in the blanks provided. If a nonlicensed operator performed the checklist, the licensed operator who supervised the checklist shall also sign and date the form.

14. **Reviewed and Approved** - The Reactor Manager or Reactor Director shall review and approve the checklist. Review and approval of the Weekly Checklist may be delegated to a Senior Reactor Operator in the event that both the Reactor Manager and Reactor Director are unavailable for the review.

William Bonzer
Revised By: William Bonzer

Albert Bolon
Approved By: Albert Bolon

WEEKLY SURVEILLANCE CHECKLIST

Date Performed ____________________

1. Rod Prohibits

1.1. Recorder Off

	Alarms (✓)	Prohibit (✓)
• Source Range recorder	______	______
• Linear recorder	______	______
• Log/Period recorder	______	______
• Temperature recorder	______	______

	Set Point	Alarms (✓)	Prohibit (✓)
1.2. Source Range <2 cps	______cps	______	______
1.3. Inlet Temperature >135°F	______°F	______	______
1.4. Shim Rods below shim range	N/A	N/A	______

2. Rundowns

2.1. RAM System

Station	Rundown Set Point	Bldg. Alarm Set Point	Alarms (✓)	Remote and Local Alarm (✓)
Bridge	______mrem/hr	______mrem/hr	______	______
Demin	______mrem/hr	N/A	______	______
Basement	______mrem/hr	N/A	______	______

	Rundown Set Point	Alarms (✓)
2.2. 120% Demand rundown	______%	______
2.3. 120% Full Power Rundown	______%	______
2.4. Low CIC Linear P.S.	______VDC	______
2.5. Regulating Rod on Insert Limit on Auto	N/A	______

3. Scrams

	Alarms (✓)	Scram (✓)
3.1. Bridge Motion Scram	______	______
3.2. Log and Linear Non-Op. Scram		
• Non-operate switch (raise rods 3")	______	______
• 1 mA switch	______	______
• 0.1 μA switch	______	______
• 10 pA switch	______	______
• 3 sec switch	______	______
3.3. 150% Full Power Scram	______	______
3.4. Manual Scram	______	______

William Bonzer Albert Bolon

Revised By: William Bonzer Approved By: Albert Bolon

Date ______________________

4. Period Trips	Set Point	Alarms (✓)	Trip Operational (✓)
4.1. 30 Sec RWP			
4.2. 15 Sec Rundown			
4.3. 5 Sec Scram			

5. Rod Drop Currents	Drop Current	Contact Light Off (✓) or SOP305
5.1. Rod #1	______ mA	
5.2. Rod #2	______ mA	
5.3. Rod #3	______ mA	

6. Test of Annunciators

	Local Alarm Light (✓)	Annunciator (✓)
6.1. Beam Room High Neutron Flux		

6.2. Interlock Bypass	Alarms (✓)	Operational (✓)
• Shim range		
• 30 second period		
• Radiation area high		
• <2 CPS		

6.3. Servo Limits: Lin. Rec. Reading ______% Permit on at ______% Permit off at ______%

6.4. Pool/Demineralizer Resistivity

Pool	Demin	Local Alarm (✓)	Annunciator (✓)
______ MΩ-cm	______ MΩ-cm		

7. "Reactor on" Lights	Operational (✓)
7.1. Main Entrance	
7.2. Control Room	
7.3. Beam Room	

8. Building Evacuation Alarm Operational (✓): ______________

9. Nitrogen Diffusers	Pump Operational (✓)	Indicator Light On (✓)
#1		
#2		

10. Beam Port Warning Light: Annunciator (✓) ______________ Flashing Light (✓) ______________

11. Shut down Check List: Completed (✓): ______________

12. Security System Check: Completed (✓): ______________

13. Checklist Completed By: ____________________________ Date ______________

14. Reviewed and Approved: ____________________________

Manager or Director

(Rev. 2/15/96)

Revised By: William Bonzer Approved By: Albert Bolon

APPENDIX B.

REVISED SAR PAGES

FOR THE 1995-96 REPORTING YEAR

3.5.2 Linear Power Channel

The signal from a compensated ion chamber (CIC 1) is fed to a linear micro-microammeter which is a solid-state electrometer designed and constructed especially for measuring small currents. The major panel controls are the range switch enabling switching ranges from about 10^{-1} W to full power and the button to check the zero indication on the panel meter. An output is provided for driving a linear recorder-controller which, in conjunction with the servo-amplifier, provides automatic control of reactor power. If the reactor power, as indicated on the recorder, exceeds 120%, a signal is obtained from the recorder which actuates the reactor rundown system.

3.5.3 Log and Linear Power Monitor

Rev. 2/28/9[illegible]

The Log and Linear Power Monitor monitors three parameters; 1) log power, 2) period, and 3) linear power range. The system is comprised of the following three components:

1. CIC detector,
2. Log and Linear drawer, and
3. Two pen strip chart recorder.

Figure 19b presents a block diagram of the system.

The CIC detector is powered by high voltage (HV) and compensating voltage (CV) power supplies located inside of the Log and Linear signal processing drawer. The signal from the detector is fed to the log amplifier portion of the processing drawer.

The drawer monitors log percent power from 10^{-6} to 140% full power without switching interruptions. Log percent power is displayed on an LCD bargraph (range of 10^{-6} to about 108%) and digital meter (range of 10^{-6} to 140%) located on the front panel of the signal processor drawer. The drawer provides a log percent power output signal for the stripchart recorder. The drawer provides a relay trip output which actuates a reactor rundown if reactor log percent power reaches 120% of full power.

The signal processing drawer monitors reactor period over a range of -30 seconds to +3 seconds. The log amplifier feeds a signal to the period amplifier which takes the time derivative of the log signal. The period signal is displayed on an LCD bargraph and on a digital meter

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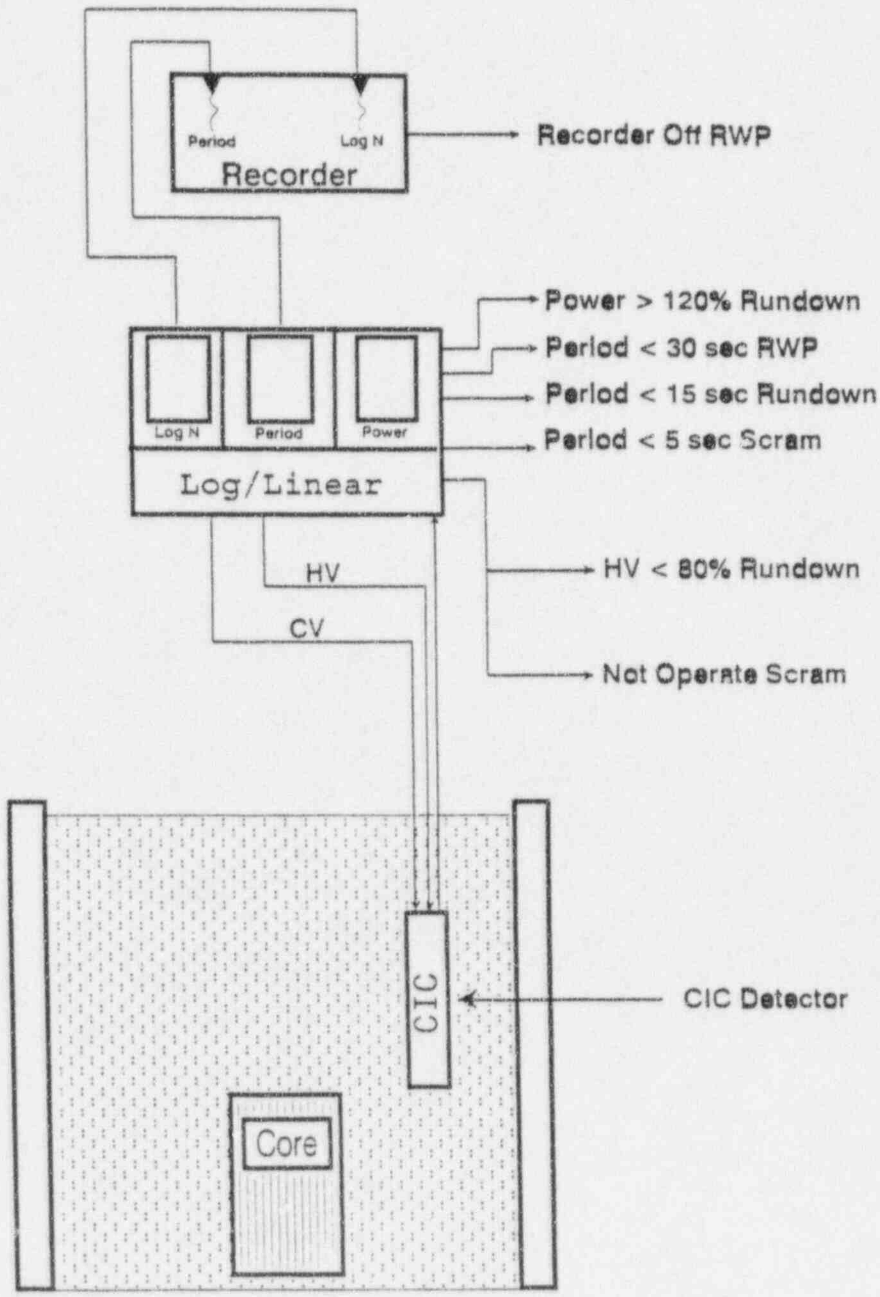

Figure 4. Block Diagram of Replacement Log and Linear Channel

located on the front panel of the drawer. The drawer also provides a period output signal for the stripchart recorder. The drawer provides the following three relay trip outputs for reactor period: Rev. 2/28/9

1. Period < 30 second rod withdrawal prohibit (RWP)
2. Period < 15 second rundown
3. Period < 5 second scram

The signal processing drawer also monitors linear power range from 0 to 125%. The linear power signal is displayed on an LCD bargraph display and a digital meter on the front panel of the drawer.

The drawer status is monitored by a Non-Operate circuit. The following conditions cause the Non-Operate circuit to trip a relay which initiates both a reactor scram and reactor rundown:

1. Detector HV ≤ 80% of nominal operating voltage
2. 1 mA, 0.1 μA, 10 pA, 3 sec, or Non-Operate test switch is activated
3. +15 V power supply output is low
4. -15 V power supply output is high

The recorder is a two pen analog strip chart recorder. One pen records the Log Percent Power signal while the other records the Period signal. The recorder provides a relay trip to actuate a rod withdraw prohibit trip when the recorder is off.

3.5.4 Pool Water Temperature Channel

The pool water temperature channel consists of two (2) core inlet thermocouples placed just below the core, and one (1) outlet thermocouple placed about five (5) feet above the core. The thermocouples feed their signals to a recorder. The recorder provides a permanent record of core inlet and outlet temperatures while the reactor is operating.

of full power, is fed into the control logic system which actuates an automatic control rod rundown.

Another output of the log power amplifier is used to feed a solid-state operational amplifier of the reactor period channel. The reactor period is defined as the time required for the neutron flux to change by a factor of e. For a visual indication, the period channel is equipped with a meter on the front panel of the drawer and with a period recorder. From this recorder three control signals are derived, two of which actuate the "Rod Withdrawal" prohibit system, and one which initiates the reactor rundown. In addition, the period channel initiates a reactor scram when the reactor period becomes shorter than 5 seconds. As the period decreases, the dc output of the period amplifier goes in a positive direction. When the level corresponding to a 5 second period is reached, the subsequent bistable circuit trips and de-energizes the scram relay, i.e. the scramming circuit of the safety amplifier (see Section 3.5.6).

3.5.4 Pool Water Temperature Channel

The pool water temperature channel consists of two (2) core inlet thermocouples placed just below the core, and one (1) outlet thermocouple placed about five (5) feet above the core. The thermocouples feed their signals to a recorder. The recorder provides a permanent record of core inlet and outlet temperatures while the reactor is operating. Rev.

Table IX. Protective Actions

Rev 2/28/

Situation	Detector	Unit Initiating Action	Protective Action
Manual Scram	Operator	Scram Button	Scram
Period < 5 sec.	CIC	Log & Linear Drawer	Scram
150% Full Power	UIC (2)	Safety Amplifier	Scram
Bridge Motion	Motion Switch	Motion Switch	Scram
Log & Linear Drawer Non-Operate (Includes low CIC voltage)	Log & Linear Drawer	Log & Linear Drawer	Scram & Rundown
120% Demand	CIC	Linear Recorder	Rundown
Period < 15 seconds	CIC	Log & Linear Drawer	Rundown
Reg. Rod on Insert Limit in Auto-Control	Micro-Switch	Micro-Switch	Rundown
120% Full Power	CIC	Log & Linear Drawer	Rundown
High Radiation[1]	GM Tube (3)	RAM System	Rundown
Period < 30 Sec[1]	CIC	Log & Linear Drawer	RWP[2]
Recorder Off	Relay	Relay	RWP
Log Count Rate < 2 CPS[1]	Fission Chamber	Log Count Rate System	RWP
Core Inlet Water Temp. 135°F	Thermocouple	Relay	RWP
Safety Rods Below Shim Range[1]	Micro-Switch	Relay	Reg Rod RWP
Basement Sump Level High	Micro-Switch	Micro-Switch	Operator Response

Table IX. Protective Actions (Cont.)

Situation	Detector	Unit Initiating Action	Protective Action
Interlock Bypassed	Key Switch	Key Switch	Operator Response
Effluent Pool Demineralizer Conductivity High	Conductivity Bridge	Relay	Operator Reponse
Beam Port or Thermal Column "Open"	Micro-Switch	Micro-Switch	Operator Response
High Neutron Flux in Beam Room	Neutron Detector	Relay	Operator Response
Manual Operation	Relay	Micro-Switch	Operator Response

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1 Indica es that the situation may be key bypassed.

2 RWP = Rod Withdrawal Prohibit.

be scrammed are summarized in Table IX.

3.5.8 Scram Logic

The scram logic circuitry for the 5 second period scram and the 150% full power scrams contained in the power safety amplifier are discussed in Section 3.5.6. In this section the logic and operation of the circuit processing bridge motion, Log and Linear non-operative, and manual scram signals will be described. Rev. 2/28/9

The scram circuit for the bridge motion, Log and Linear non-operative and manual scrams consists of a set of open-on-failure relay contacts wired in series with a scram relay. Therefore, any of these scram signals or component failure will result in de-energizing the scram relay. This in turn opens the circuit of regulated power to the magnet power supply causing the current in the safety magnets to cease and to release the shim/safety rods. The scram relay can only be reset after the condition causing a scram has been removed and the reset relay energized by manually pushing the reset button.

The bridge motion scram is controlled by a micro-switch on the reactor bridge. As long as this switch is closed, a relay in the circuit is energized. A slight change in the position of the bridge, approximately 0.25 cm (0.1 in), will open the contact, de-energizing the motion relay which opens its contacts in the scram circuit.

As discussed in Section 3.5.3, the status of the Log and Linear drawer is monitored by a Non-Operative circuit. If the ±15 VDC power supply, CIC HV power supply, or certain test switches are activated, the Non-Operative circuit de-energizes a relay which breaks the scram circuit by de-energizing the scram relay thus causing a reactor scram. Additionally, the Non-Operative relay also initiates a reactor rundown. Rev. 2/28/

When the manual scram button is pressed two contacts are mechanically opened: one of them causes the scram relay to de-energize and another one interrupts regulated power to the magnet power supply. Hence, the ac power circuit to the magnet power amplifier is opened in two different and independent ways.

In addition, the scram circuit also contains contacts of the relay which monitors the unregulated ac power. In the case when electrical power is lost the scram circuit opens and initiates a reactor scram.

a) Semi-annual sealed source leak tests,

b) Annual radiation area monitor calibration,

c) Annual Health Physics Instrument calibration of portable survey instruments, Rev. 11/14/9

d) Monthly contamination surveys,

e) Monthly air release calculations,

f) Waste water analysis (as needed),

g) Monthly area radiation surveys,

h) Monthly pool water analysis,

i) By-Product material releases as required,

j) Semi-annual pool water H-3 analysis.

Health physics procedures have been prepared and placed in the reactor SOP Manual, that address the above-listed activities. However, the reactor staff participates in the calibration of radiation area monitors and portable health physics instruments. They also collect liquid samples, and ensure that activated samples are monitored to ensure that they do not leave the reactor pool unless a sample is <100 millirem per hour at a distance of one foot. Samples reading greater than 100 millirem/hr at a distance of one foot will be monitored by the Health Physicist. Rev. 6/7/95