UNIVERSITY OF MISSOURI-ROLLA

Nuclear Reactor Facility

Nuclear Reactor
Rolla, Missouri 654[illegible]-0249
Telephone: (314) 341-4236

April 29, 1985

United States
Nuclear Regulatory Commission
Washington, D.C. 20545

Re: License R-79, University of Missouri - Rolla Reactor Docket No. 50123.

Dear Sirs:

The following Progress Report for the University of Missouri - Rolla Reactor (R-79) for the period April 1, 1984 to March 31, 1985, is sent for you review and inspection.

Sincerely,

Albert E. Bolon

Albert E. Bolon, SO

M Straka

Milan Straka
Reactor Manager, SO

AEB/sr
Enclosure (10 copies)

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Progress Report

1984-1985

University of Missouri-Rolla

Nuclear Reactor Facility

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PROGRESS REPORT
FOR THE
UNIVERSITY OF MISSOURI-ROLLA
NUCLEAR REACTOR FACILITY

APRIL 1, 1984 to MARCH 31, 1985

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

By
Albert E. Bolon, Director
Milan Straka, Manager
Nuclear Reactor Facility
University of Missouri-Rolla
Rolla, Missouri
65401

Summary

During this reporting period the nuclear reactor at the University of Missouri-Rolla was in operation for about 526 hours. The major part of this time, 78%, was used for class instruction and training purposes. About 8% of the reactor time was used for research and irradiation and 14% was needed for the maintenance runs.

There were 44 UMR students enrolled for courses at the Reactor Facility. The facility was thus committed to over 52 student-hours of classes during the summer, fall, and spring semesters. The reactor was visited by about 2100 visitors during the past year. Their response to the facility and its mission is usually very positive. An educational program was established for students and their instructors from colleges and universities which do not own a nuclear reactor. The Reactor Facility is reimbursed for this program from the Reactor Sharing Program funded by the Department of Energy. There were about 50 participants in this program.

The reactor produced approximately 9.4 MW-hrs of energy using about 0.5 g of U-235. A total of 121 samples were irradiated during this reporting period with most of them being analyzed at the Reactor Facility. The reactor staff successfully accomplished the process of the license renewal for the UMR Reactor. The operating license has been renewed until November 20, 1989.

Research activities at the reactor concentrated on further improvements in the trace element analysis. Three research projects for material irradiation and neutron activation analysis were performed for on-campus investigators. Both the reactor staff and equipment were necessary to support these research projects.

Four one-week training programs for reactor operator trainees of a Midwest utility were organized during this reporting period. The reimbursement helps to defray the facility costs and also to improve its research and instructional capabilities. A paper on the facility uses for various training programs was presented at the International Education Conference in Rochester, NY.

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I. Introduction

This progress report is prepared in accordance with the requirements of the Nuclear Regulatory Commission 10 CFR 50.71 concerning the operation of the University of Missouri-Rolla Nuclear Reactor Facility (License R-79).

The reactor, a swimming pool-type, modified BSR is operated as a university facility available to the faculty and students of the various departments of the university for their educational and research programs. Several other universities and colleges have made use of the facility during this reporting period. The facility is also made available for the purpose of training reactor personnel for the nuclear industry and electric utilities.

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 from this and other universities. The following sections of this report are intended to provide a brief description of the various aspects of the operation of this facility, including its utilization for education and research.

II. License Renewal

The license to operate the UMR Reactor was renewed on January 14, 1985 and is valud until November 20, 1989. During the review proceedings the NRC was asked for an additional ten years extension of the operating license. The notice of this application was published in the Federal Register on February 13, 1985.

Since the evaluation period in the NRC Safety Evaluation Report for the UMR Reactor extends beyond 1989, the reactor staff expects that the application for the license extension can be accomplished with the minimum time and effort.

III. Reactor Staff and Personnel

A. Reactor Staff

Name	Title
Albert E. Bolon	Director
Milan Straka	Reactor Manager
Daniel Carter[1)]	Reactor Maintenance Engineer
Carl Barton	Senior Electronic Technician
Karen Lane[2)]	Senior Secretary
Juls Williams	Lab Mechanic
Scott Linn[3)]	Student Assistant Level II
Francis Jones[4)]	Reactor Maintenance Engineer
Bryan Daiber[5)]	College Work Study Student
Robert Savage[5)]	College Work Study Student
Gail French[6)]	Senior Secretary

B. Licensed Operators

Name	License
Albert E. Bolon	Senior Operator
Daniel Carter[1)]	Senior Operator
Carl Barton	Senior Operator
Karen Lane[2)]	Reactor Operator
Milan Straka[7)]	Senior Operator

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1) terminated on May 24, 1984
2) terminated on June 1, 1984
3) terminated on April 22, 1984
4) started on October 22, 1984
5) started on August 20, 1984
6) started on July 9, 1984
7) effective on December 13, 1984

C. Radiation Safety Committee

Name	Department
Dr. Nord L. Gale (chairman)	Life Sciences
Mr. Ray Bono (secretary) (ex officio)	Environmental Health and Risk Management
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

This committee is required to meet at three month intervals. However, in practice the frequency of the meetings is usually greater.

D. Health Physics

Name	Title
Dr. Nick Tsoulfanidis	Radiation Safety Officer
Mr. Ray Bono[1)]	Director, Environmental Health and Risk Management
Mr. Jim Little	Health Physics Technician

1) title and position changed January 1, 1985 from Campus Health Physicist to Director, Environmental Health and Risk Management

E. Independent Audit

Two independent audits of the facility consisting of reviewing records, procedures, and operating methods were performed during the reporting period. Reports about both audits are enclosed in Appendix A.

IV. Supporting Facilities

Several supporting facilities are either operated or maintained by the reactor staff for users of the reactor. These greatly contribute to the efficiency of research and educational programs available to the faculty and students of the University of Missouri-Rolla, as well as other universities.

Activation Analysis Laboratory: The activation analysis laboratory has proven to be the most-utilized supporting facility. The laboratory contains a 4096 channel analyzer, with NaI or GeLi selectable detector input. Included in the auxiliary equipment is a tape punch, multi-scaler programmer, a scope camera, and a teletype terminal. Three scalers are included in the laboratory equipment with the appropriate detectors for counting alpha, beta, and gamma radiation. A shielded detector with four ton low-background lead shield housing two "3X3" sodium iodide crystals, is also available for coincidence counting. These detectors are used in conjunction with the multi-channel analyzer. Several other units of equipment are available for the detection and evaluation of radioactive materials.

Pneumatic Tube Assembly: A dual tube pneumatic system is installed adjacent to the core of the reactor. One tube is cadmium lined, and the other is bare. This system is a positive pressure type and uses nitrogen as the propellant.

V. Improvements

A continuous effort to enhance availability and reliability of the facility is being undertaken by the reactor staff. During this reporting period the following improvements have been made:

1) One additional staff member became licensed by the NRC. The facility has now 3 Senior Reactor Operators and 1 Reactor Operator Trainee.
2) The Multichannel Analyzer is being interfaced with a Apple II^+ computer.
3) A moveable proportional neutron counter was installed in order to study geometry effects on the 1/M-curve.
4) A file system for the Standard Operating Procedures was created using the Apple II^+ computer.
5) A new Safety Analysis Report has been compiled and approved by the NRC during the course of the license renewal process.

VI. Reactor Operations

A. Facility Use

Table 1 depicts the current core loading which is designated as core 67. The number 67 denotes the sixty-seventh core configuration (assembly and location), that has been used at the Reactor Facility since the original operating license was issued in 1961. This core 67 has been in use since December of 1978 and is periodically checked for all parameters listed in Table 8 (core data).

Tables 2 through 7 give pertinent information about the Reactor Facility and its operation during the reporting period. Listing of semi-annual electronic checks is included in Appendix B.

Table 1. UMRR Core Configuration and Rack Storage Form

DATE 31 March, 1985

LOADING NUMBER 67T or 67W*

R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15
									HF-1		F-13	F-20	F-22	

RACK STORAGE FACILITY

R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30
										F-2	F-5	F-3	F-18	F-21

	1	2	3	4	5	6	7	8	9
A									
B					S				
C			HR-1	F-14	F-1	C-4			
D			F-8	C-1	F-16	F-9	F-4	F-10	
E			F-6	C-2	F-19	C-3	F-12	F-11	
F			BRT	F-17	F-15	F-7	CRT		

BRIDGE SIDE

UMRR CORE STATUS

KEY TO PREFIXES

F - Standard Elements

C - Control Elements

HF - Half Front Element

HR - Half Rear Element

S - Source Holder

Other BRT- Bare Rabbit Tube

CRT- Cadmium Rabbit Tube

Elem.	Pos.	Mass	Elem.	Pos.	Mass	Elem	Pos.	Mass
HR-1	C3	84.912	F-16	D5	170.270	F-12	E7	168.774
F-8	D3	170.229	F-19	E5	170.264	F-10	D8	170.193
F-6	E3	169.160	F-15	F5	168.889	F-11	E8	168.969
F-14	C4	170.210	C-4	C6	102.112			
C-1	D4	102.112	F-9	D6	170.178			
C-2	E4	102.125	C-3	E6	101.978			
F-17	F4	169.111	F-7	F6	170.154			
F-1	C5	170.223	F-4	D7	170.206			

Total Mass Grams 2869.744

* T designates the thermal column-reflected mode, and W designates the water-reflected mode.

Table 2.

Use of Core Grid Plate Locations

Location	Hours
B4	0.483
B6	0.417
C3	0.250
C5	1.083
C7	10.767
C8	0.500
D2	0.167
D5	2.167
D8	1.700
D9	0.383
E5	0.467
E8	0.167

Table 3.

Other Facilities

Facility	Hours
Bare Rabbit Tube	21.72
Beam Port	1.28
Reactor Console	484.76
Total	507.76

Table 4.

Reactor Utilization

Reactor use	526 hr
Research & Irradiation runs	43 hr
Instruction runs	410 hr
Maintenance runs	73 hr
Time at power	209 hr
Heat generated	9418.86 kW-hr
Total number of samples	121 hr
Sample hours	88.22 hr
Research & Instruction usage(1)	21.8 hr
U-235 burned	0.411 g
U-235 burned and converted	0.485 g

(1) Based on 2080 working hrs. per year.

Table 5a.

Rundowns

Date	Time	Cause
4-18-84	1458	Apparent spurious signal.
5-18-84	0928	(120% demand) Moved fuel element close to Linear CIC.
5-18-84	0938	(120% demand) Moved fuel element too close to linear detector.
6-12-84	0920	(120% demand) Student operator switched micro-microammeter the wrong way.
6-21-84	1011	(120% demand) Switched scales before recorder reached the proper level.
6-22-84	1447	Hi Rad channel noisy, no radiation was found.
7-6-84	1520	Less than 15 Period while trying to calibrate ss rod no. 3.
9-25-84	1431	Reg Rod on insert limit on auto. Cautioned operator.
10-8-84	1003	(120% demand) Linear not switched to higher scale.
10-23-84	1504	(120% demand) Due to noise on linear channel.
10-30-84	1423	(120% demand) Due to moving void tube past Linear CIC.
10-30-84	1455	Less than 15 Period due to moving void tube past Log N CIC.
11-1-84	1539	(120% demand) Due to moving void tube past Linear CIC.
11-8-84	1031	Hi Rad rundown. Checked with PIC-6A. No high level radiation. Reading on demin. channel dropped immediately to 9 mrem.
11-14-84	0951	(120% demand) Due to turning scale wrong way.
11-14-84	1030	(120% demand) Due to trainee not switching scales.
12-4-84	1017	(120% demand) Due to operator switching scales the wrong way.
12-11-84	1357	(120% demand) Due to student operator turning scale the wrong way.
12-17-84	1155	(120% demand) Due to operator turning scale wrong way.

Table 5a.(continued).

Rundowns

Date	Time	Cause
12-17-84	1221	Reg Rod on insert limit on Auto. Operator went into Auto with rod on insert limit.
2-1-85	1504	(120% demand) Student operator switched linear wrong way.
2-21-85	1439	(120% demand) Student kicked cable on connector on bridge.
3-29-85	1239	Power fluctuation caused 120% demand on linear.

Table 5b.

Scrams

Date	Time	Cause
4-11-84	1041	Loss of console power. *Staff was notified not to turn equipment on or off while reactor was operating. Unnecessary loads were removed from regulated power.
5-2-84	1101	Intentional for Emergency Evacuation drill.
10-8-84	1614	Intentional for Training purposes.
11-15-84	1033	Intentional for Training purposes.
1-4-85	1130	Intentional for Training purposes.
1-22-85	0941	Less than 5 sec. period and 150% full power while check connections for noise on period channel.
1-29-85	1539	Intentional for Training purposes.
1-30-84	1500	Intentional for Training purposes.
2-7-85	1446	Intentional for Training purposes.
2-26-85	1430	Intentional for Training purposes.
3-19-85	1235	Magnet No. 3 current causing all three rods to drop. Magnet No. 3 fuse blown. Replaced fuse.
3-29-85	0937	Due to power fluctuation. Causing regulated power to trip.

Table 6.

Maintenance

Date	Time	Event
6-1-84	0900	Removed magnet No. 3 found coil open.
6-4-84	1400	Coil rewound and magnet installed on reactor.
7-5-84	0730	150% full power alarm. Reactor not operating. R16 in safety amp changed values. Replaced R16.
7-6-84	0745	No magnet power. Replaced R16 again.
9-10-84	1130	Removed broken demineralizer probe in pool side of demineralizer.
9-12-84	1300	Moved probe from demineralizer outlet side to inlet side (pool side).
12-10-84	0915	Magnet No. 1 not operating. Magnet No. 3 contact light not operating. Changed V3 and V5 in magnet power supply.
12-20-84	0929	Magnet No. 1 not picking up rod. Checked magnet power supply. Changed V3 and V5. Magnets operating except for No. 1 and No. 2 contact lights.
1-21-85	1045	Reg rod limit switch (insert) inoperable. Replaced switch.
1-22-85	2035	Set point on linear recorder not properly set. Repositioned set point.
1-28-85	0853	Linear noisy. Cleaned switch.
1-28-85	0918	Linear noisy. Replaced signal cable from bridge and linear amp.
2-1-85	1030	Conductivity cell replaced in demineralizer outlet.
2-25-85	0904	Magnet current on No. 1, 2 and 3 erratic. Replaced adjust pot. on both No. 1 and 2 magnet current. Also replaced S2 (magnet current switch).

Table 6. (continued).

Maintenance

Date	Time	Event
2-25-85	1500	Found wire broken on power voltage point. Resoldered wire.
2-28-85	0945	Removed bare rabbit tube and replaced tubing. Replaced bare tube in proper place.
3-5-85	1130	Found magnet No. 2 current decreases while current is energized. Replaced V4 (magnet current tube) in safety amplifier.

Table 7.

Core Loading and Unloading*

Date	
4-17-84	UL (67W to subcrit) to prepare to determine critical mass in 67W mode.
4-17-84	RL (subcrit to 67W) to determine critical mass in 67W.
4-18-84	UL (67T to subcrit) to prepare to determine critical mass in 67T mode.
4-18-84	RL (subcrit to 67T) to determine critical mass in 67T mode.
4-19-84	UL (67T to subcrit) to perpare to determine critical mass in 67T mode.
4-19-84	RL (subcrit to 67T) to determine critical mass in 67T mode.
5-15-84	UL (67W to subcrit) to inspect control rods.
5-18-84	RL (subcrit to 67W) return to previous configuration.
9-18-84	UL (67W to subcrit) to prepare to determine keff in storage pool area.
9-19-84	(subcrit to subcrit) moved fuel elements to different locations to determine keff of storage pool.
9-20-84	(subcrit to subcrit) continuation to determine storage pool keff.
9-21-84	(subcrit to subcrit) continuation to determine storage pool keff.
9-24-84	(subcrit to subcrit) continuation to determine storage pool keff.
9-24-84	RL (subcrit to 67W) reload to original 67W mode.
11-9-84	UL (67W to subcrit) fuel handling practice taught to operator trainees from Arkansas Power & Light.

* UL - unload
RL - Reload

11-9-84	RL (subcrit to 67W) reload to previous configuration.
11-16-84	UL (67W to subcrit) same as above, operator training.
11-16-84	RL (subcrit to 67W) reload to previous configuration.

B. Core Data

During this reporting period only one core designation has been used. The "W" mode core was used for normal reactor operations, since students are not supposed to operate the reactor when the excess reactivity is above 0.7%. The "T" mode is used for extended operation (>3 hrs), or beam port and thermal column experiments. The excess reactivity was measured for cold, clean critical conditions. In day-to-day operation the excess reactivity is quite often lower due to the temperature increase of the pool.

Table 8. Core Technical Data

Average Thermal Flux	$1.6X10^{12}$ n/cm^2-sec at 200 kW
Maximum Thermal Flux	$2.8X10^{12}$ n/cm^2-sec at 200 kW
Average Epithermal Flux	$1.6X10^{11}$ n/cm^2-sec at 200 kW
Worth of Thermal Column	0.46%
Worth of Beam Port	not detectable

Rod Worth (in "T" mode)

Date	4-16-79	4-16-79	4-16-79	10-10-83
	I 2.64%	II 2.65%	III 3.36%	Reg. 0.347%

Excess Reactivity (in "T" mode) 0.73% Shutdown Margin (in "T" mode) 4.56%.

Void Coefficient $-7.7X10^{-7}$ ρ/cm^3 Date 10-30-84

Temperature Coefficient $-1.3X10^{-4}$ ρ/°F Date 11-20-84

Reactivity Addition Rate (max %ΔK/K/sec)

I 0.019 II 0.019 III 0.026 Reg. 0.01

Rod Drop Time (24")

I 495 msec, II 480 msec, III 495 msec, Date 9-7-84

Magnet Separation Time (at I_{max})

I 27 msec, II 31 msec, III 36 msec, Date 9-7-84

VII. Public Relations

The reactor staff continues to put forth considerable effort to help educate the public about the application of nuclear energy. Over 2,077 persons have toured the facility during this report period. Tours included groups representing social, military, civic, industrial, governmental and educational fields. These groups are usually given a brief orientation lecture by a member of the reactor staff. These lectures are augmented by visual aids such as slides and displays. Many high school, junior college and college groups have attended the various lectures and open houses.

Some of the groups have spent an entire day at the facility becoming acquainted with the reactor and performing simple experiments. Usually these groups are from colleges which have no reactor facilities. A guided tour by the reactor staff includes a brief description of the basic nuclear reactions, components of a nuclear reactor, a few specific examples of how nuclear energy is used in the industrial and educational fields and how nuclear energy helps the environmental situation.

One staff member participated in the International Nuclear Education Conference in Rochester, NY, presenting a paper about the facility's training program for Reactor Operators.

The Nuclear Engineering faculty are members of various social, civic, professional, and governmental committees. The faculty and students also are involved in speaking engagements around Missouri concerning the Reactor Facility and in informational programs at high schools and colleges.

VIII. Educational Utilization

Forty-four UMR students, graduates and undergraduates, have participated in classes at the facility, utilizing 52 student-semester hours of allocated time. Also students from several colleges, and high schools have used the facility.

The following is a list of scheduled classes at the facility along with the total hours of reactor use for this reporting period.

NE 2	Introduction to Nuclear Engr. II	9.4
NE 304	Reactor Laboratory I	41.3
NE 306	Reactor Operations	185.5
NE 308	Reactor Laboratory II	62.3
83-1	Glass Optics	4.3

The current enrollment in Nuclear Engineering is 68 students.

A program called Reactor Sharing Program, funded by the Department of Energy, was established for colleges and universities which do not own a nuclear reactor. About 50 students and their instructors participated in this program.

IX. 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. New Health Physics SOP's are being written.

Routine Surveys

Monthly radiation surveys of the facility consist of direct gamma and neutron measurements with the reactor at power. No unusual exposure rates were found. Monthly surface contamination surveys consist of 20 to 30 swipes counted separately for alpha, beta and gamma activity. In 12 monthly surveys, no significant contamination outside of contained work areas was found.

By-Product Material Release Surveys

During the period, 3 shipments of by-product material were surveyed and released from the reactor facility. Total activity released was 0.011 mCi. One shipment was low-level waste transferred to the UMR Hazardous Waste storage building. The second shipment was a radioactive device returned to the originator and the third shipment was by-product material used on campus.

Routine Monitoring

Twenty-seven reactor facility personnel and students frequently involved

with operations in the reactor facility are currently assigned beta-gamma, neutron film badges which are read twice each month. There are 4 beta-gamma, neutron area badges assigned and one test badge to check accuracy of exposure reports. Fourteen 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 13 beta-gamma area and spare badges assigned on campus. In addition, 7 direct-reading dosimeters are used for visitors and high radiation area work. There have been no personnel over exposures during the period.

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

Pool water activity is monitored monthly to insure that no gross pool contamination nor fuel cladding rupture has occurred. Gross counts and spectra of long-lived gamma activity are compared to previous monthly counts. From April through March sample concentrations averaged 8.04×10^{-6} μCi/ml.

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 19.38 millicuries were released into the air. Released isotopes were 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. Radioactive waste released to

the sanitary sewer is primarily from regeneration of the resin exchange column. During this period 10 releases to the sanitary sewer totaling approximately 4650 gallons of concentrated resin regeneration solution and pool water were discharged with a total activity of 0.271 millicuries. No peaks were identified during the analysis.

Instrument Calibrations

During this period, portable instruments were calibrated four times. Remote area monitors were checked for calibration four times.

X. Plans

Now that the license renewal process has been completed, the reactor management plans to spend more time and effort upgrading the facility's research capability. Although extra efforts have been made to inform academic department chairmen and research center directors of the current availability of the reactor and the various associated counting systems, we have not generated very much research activity. We also try to inform the individual faculty members/researchers, who we believe might be doing research that could utilize the UMR Reactor, that we would be pleased to cooperate with them. A six-member Reactor Research Advisory Committee has been established to assist the reactor management with ideas for research. The purpose of the committee is to have a knowledgeable group of faculty/researchers who would advise the reactor staff regarding areas of potential research and regarding equipment needed in order to develop proper research capability. The specific objectives of the committee are as follows:

1. To more fully utilize the present research capabilities of the UMR reactor.

2. To improve communications and interactions between the faculty and graduate students and the reactor staff.

3. To develop new research projects based upon the interaction of nuclear reactor-related radiation (ie. neutrons and/or gamma rays) and matter. Such projects could be either neutron activation analysis (NAA) or radiation damage or effects.

4. To determine the facility modifications or equipment additions needed in order to improve the research capabilities of the UMR Reactor.

A five-year research plan for the Reactor Facility was prepared by the Reactor Director and submitted to the Dean. In order to develop a quality research program at the UMR Reactor over the next five years, financial support in the amounts as shown in Table 9 would be needed.

Table 9. Additional Engineering Research and Equipment Support Needed for the UMR Reactor Facility For the Next Five Years (in '85 dollars)

	Fiscal Year				
Needs	'87	'88	'89	'90	'91
Research Equipment	15,000	15,000	15,000	15,000	15,000
Instructional Equipment	5,000	5,000	5,000	5,000	5,000
Other					
Grad. Res. Asst.	16,400	16,400	24,600	24,600	32,800
Post-Doc. Fellow		22,000	22,000		22,000
Senior Researcher				50,000	50,000
Supplies	3,600	5,800	6,700	9,500	12,500
Total	40,000	64,200	73,300	104,100	137,300

The grand total for the 5-year program would be $418,900. By the end of the five-year period there would be a research staff of four half-time graduate research assistants, one post-doctoral fellow, and one senior researcher in addition to the present number of operational staff. If properly done, some of the funding could be provided by external sources.

The specific research equipment needs of the Reactor Facility are listed in Table 10.

Table 10. Research Equipment Needs
Of the UMR Reactor Facility (in '85 dollars)

Item		Estimated Cost
Intrinsic Germanium Detector		$10,000
Microcomputer-based Multichannel Analyzer		16,500
Isotope Identification Package		3,000
Printer/Plotter		2,000
	Total Total	$31,500

The instructional equipment needs are shown in Table 11.

Table 11. Instructional Equipment Needs
Of the UMR Reactor Facility (in '85 dollars)

Item		Estimated Cost
Intrinsic Germanium Detector		$10,000
Canberra Series 85* Multichannel Analyzer		9,400
Daisey Wheel Printer		1,000
Linear Micromicroammeter		3,000
Digital Pulse Generator		1,800
Curve Tracer		700
X-Y Plotter		1,960
X-Y Plotter Interface		460
Eberline Rascal* Neutron Meter		3,000
Air Sampler		1,200
	Total	$32,520

* or equivalent

The two previous tables do not necessarily total the amount needed in Table 9.

In conclusion, for a reasonable sum of money the UMR Reactor could be developed into a viable research facility which could benefit the mid-west region of the nation. By the end of the 5-year program the research staff would be built up to a level so that they could be self-supporting on research grants and contracts.

In particular, it would enhance the neutron activation analysis capability of the UMR Reactor Facility if the present pneumatic transfer system were to be modified so that samples could be transferred directly from the core to the Ge(Li) detector. Likewise, it would be beneficial to have an automatic sample handling system so that a large number of samples (say at least 24 of them) could be inserted into the Ge(Li) detector and counted. We would also like to develop prompt neutron activation analysis capabilities. The hardware necessary for the suggested improvements would be requested on research proposals prepared by the reactor staff or in cooperation with other researchers.

The U.S. Department of Energy supports the UMR Reactor through the University Reactor Sharing Program. We received $9000 financial support this past year. Several groups from Linn Technical Institute have come or will come to campus for a day each. The University of Arkansas will send a graduate student or two for two days in April. Other schools are expected to use the reactor for education or research before the end of the contract in August. We hope to be selected for an extension of that program.

Reactor management's plan to have at least three licensed senior operators has been accomplished.

In terms of modifications to the facility which are planned, they include several which have been mentioned in prior Progress Reports. We do plan to install the new solid-state magnet power supply, linear power channel and solid-state power range (safety) channels that were purchased several years ago and not installed because we were in the midst of re-licensing. Without a doubt, the solid-state devices should be more reliable than the present vacuum tube ones, which were original equipment.

APPENDIX A

Independent Audits

RECD FEB 27 1985

UNIVERSITY OF MISSOURI

Research Reactor Facility

Research Park
Columbia, Missouri 65211
Telephone (314) 882-4211

February 25, 1985

Dr. Albert Bolon
Reactor Director
University of Missouri-Rolla
Nuclear Engineering, Building C
Rolla, Missouri 65401

Dear Dr. Bolon:

On Monday, February 11, 1985, Nolan Tritschler and I conducted a Reactor Facility Inspection of the UMR-Reactor. This inspection concentrated on several areas given in your independent audit form. The summary comments from the inspection from each of us are attached to the audit form. There may be some duplication between our comments since we discussed several items while we were there.

We found no major areas of concern with the UMRR operations and noticed many improvements concerning past audit comments. We think that a new audit form might be in order to reflect the references to the new technical specifications. The current form leaves quite a bit of uncertainty as to what exactly the auditor should be looking for in several categories.

We would appreciate receiving a copy of the most current SOP's so we will be ready next time you need us to come down. We thank Milan Straka and Butch Jones for their help in performing this audit.

Sincerely,

Walt A. Meyer, Jr.
Reactor Operations Engineer

WAM:vs

Attachments

February 11, 1985 AUDIT COMMENTS (WALT MEYER)

SURVEILLANCE REQUIREMENTS

We reviewed the quarterly, semiannual and annual surveillance performed in November and December, 1984. This included RAM calibration (Q), HP Instrument Calibration (Q), Emergency Drill (S), Requalification Review (S), Pool Water H_3 Analysis (S), Void Coefficient Measurement (A), and Temperature Coefficient Measurement (A). All were performed within specified time intervals. The void coefficient and temperature coefficient were done by a student laboratory report reviewed by Dr. Bolon and M. Straka. This provides adequate control by management as long as the reviews are performed. The review of the void coefficient had not yet been performed by management. The process of obtaining these coefficients appears to be valid, however their performance is not specifically tied to the Standard Operating Procedures for these checks (SOP 303, SOP 304).

REQUALIFICATION

We reviewed the requalification records and most recent tests and found no discrepancies. The performance evaluation forms are now filled out completely.

One question we had involved the fact that all three operators took their requalification test on separate dates (Dr. Bolon 8/21/84, M. Straka 8/28/84, C. Barton 7/13/84). This might raise the question of the security of the content of these tests unless all three tests are different (i.e., an operator might know the content of the test in advance).

UMRR HOURLY OPERATING LOGS (SOP-104)

As a follow up item, we reviewed the hourly operating logs for completeness. We found on several occasions that no senior operator had reviewed the logs at the end of the day (8/30/84, 9/5/84, 10/10/84, 11/9/84, 2/8/85).

There also were numerous occasions when no licensed operator was signed in at the beginning of the day. We felt it might be more significant to have a licensed signature, than multiple student signatures.

UMRR PRE-STARTUP CHECKLIST (SOP-102)

This sheet was revised 9/4/84 to incorporate the inclusion of the date on the second page. We found no problems with these checklists.

UMRR SHUTDOWN CHECKLIST (SOP-105)

Our review found no problems with these checklists.

WEEKLY SURVEILLANCE CHECKLIST (SOP-811)

Our review of these checklists found no major problems. On September 5, the test of annunciators has a blank in the space for checking Beam Room High Neutron Flux.

STANDARD OPERATING PROCEDURES

We were somewhat handicapped by the fact that the SOP's with which we had familiarized ourselves, were out of date by four months. The 9/4/84 revision appeared to change about half of the SOP's. In this regard, we would appreciate receiving an up-to-date complete SOP, so we can be better prepared next time.

The proper reviews by licensed personnel for all SOP changes appeared to have been made in a timely fashion. We found it difficult in comparing our out-of-date SOP to the new SOP to determine which SOP's were current. One suggestion might be to include the use of a list of effective pages to show which pages are current after each revision.

We also could not determine how a "controlled" SOP copy could be distinguished from a "non-controlled" copy.

Submitted by:

Walt A. Meyer, Jr.
Reactor Operations Engineer

February 11, 1985 AUDIT COMMENTS (Nolan Tritschler)

1. Recommend implementation of unscheduled shutdown checksheet. This should aid in recovering information for recurring problems, maintenance, monthly reports, etc. Also would allow much fuller explanation of events than is currently exercised in the console log.
2. Suggest some method be formed to test the operability of the power range NI after maintenance or replacement before startup of the reactor. I feel that the detector could be bugged in some manner although the existing neutron source is not strong enough to serve this purpose.
3. Recommend the addition of an overlay or some other method of determining the slope of the trace on the log count rate recorder during startup to assure that the 45° slope limit is not exceeded. At this time, this is being done by eyeball only. One possibility is the placing of 45° lines on the back of the recorder door glass as a reference.
4. Console log entries pertaining to who is on shift, what evolutions are being performed, etc., have been an item of comment on previous audits. It shows that some progress has been made in this area, however, it still needs attention as the improvements are rather spotty. One action in particular is the use of bypass keys; these are to be used only by a senior reactor operator. Due to the spotty log entries, it is, at times, impossible to determine if there is a senior reactor operator in the building much less in control of the bypass key usage. I recommend that when a bypass key is used or removed, this action should be entered in the console log and initialed by the senior reactor operator.

5. On 12-12-84, an evacuation drill was performed and according to the log it took three minutes to carry it out. It would seem that this is an overly long time to clear a facility of this size. Some steps should be taken to expedite this exercise. A time interval of no longer than 1-1/2 to 2 minutes should be a good goal.
6. Another area of concern is the hourly logs. At the top of the form are blanks for the operators to be named and/or signed in. Upon examination, no reactor operator or senior reactor operator had been entered on many occasions, in fact, not one had been entered from 1-25-85 to 2-8-85 even though the reactor had been operated several times. Students had been entered regularly however, this is rather irrelevant. On 1-22-85, PRM readings were taken in error on at least four power level readings by a student. The operators must understand that they are the ones with the licenses, not the students. The students are merely an extention of their own, and they need to monitor such activities very closely as they are ultimately responsible and should review and initial each and every set of readings.
7. On 1-24-85, the reactor was operated up to a power of 190KW. At this time, it was decided that the reactor should be shut down because the detectors were badly misaligned. On the same afternoon, the reactor was again operated at power levels up to 200 KW (full power) without anything having been done about the detectors. On 1-25-85, the detectors were aligned. It would seem that if the misalignment was bad enough to warrant a shutdown, then the reactor should not have been operated at full power until this was corrected.

8. Lastly, it was felt that the S.O.P.'s are very cumbersome and contain a good deal of superfluous instruction, i.e., wash windows, empty trash, etc. They also contain several errors both typographical and genuine. One was the formula for calculating void coefficient - it just won't work as written. (S.O.P. 303, page 2 of 2, revised 7-22-75, says:

$$"3 \times 10^{-6} \frac{\Delta K}{K} = 3 \times 10^{-7} \frac{\Delta K}{K}".$$

This may have been corrected by 9/4/84 revision.)

Survey Instrument	Calibration Done	
E-120 #9755	11-21-84	
Room 14	11-21-84	
GM E-120 #3194	11-21-84	
GM Thyar-389 #24513	005	
PIC 6A 1405	11-21-84	
PIC 6A 1799	11-21-84	
PIC 6A 1851	11-21-84	
H.R. RADEC III	11-21-84	could not calibrate (OOS ?)
NEUT Vic 488A	1-18-85	

All of the above instruments had been calibrated or removed from service as required, "I think". The one exception was the H.R. RADEC III which was noted on 11-21-84 that it could not be calibrated. We could not determine if it had been removed from service or not.

My general impression was that the facility is run by a knowledgable group of people in a rather relaxed manner. So, I don't think that criteria is not being followed as much as the documentation is just sketchy in places. Enjoyed the opportunity to visit.

Submitted by:

Nolan Tritschler
Reactor Shift Supervisor

Independent Audit

REACTOR FACILITY INSPECTION -- Date(s) February 11, 1985
(Phone: 341-4236)

Date(s) of last NRC inspection not checked

Date(s) of last "inhouse" inspection June 18, 1984

Log Book Inspection:

	Log Book Number	Page	Date
From entry:	6	127	May 17, 1984
Through entry:	6	210	Feb 8, 1985

Follow up items from previous inspection (item, follow-up):

Hourly Operating Log Senior Operator Signature
Use of Bypass Keys (Documentation of SO)
Completeness of Requal Performance Evaluations

	OK	Comments
A. Technical specifications-------------- Appendix A -- Jan. 6, 1967	→	current tech specs - Dec, 1984
1. (2.1) Ventilating fans------------	✓	
Automatic closure ---------------	✓	
2. (3.1) Pool water depth (16 ft. min above core)---------------------	✓	
3. (3.1) Inlet water temperature 60°F <t <135°F------------------	not checked	
4. (3.2) Radiation one meter above pool <5 mr/hr ------------------	✓	
5. (3.2) Resistivity >0.5 megohm-cm-	✓	
6. Fuel --------------------------		Type of elements: MTR Other ______ Present loading(s): (not checked)
(4.1.3) ρ ex <1.5% --------------		Dates: (1)______
1.5% <ρex<3.5% five consecutive days twice a year----------------		(2)______
7. Control rod: (9.5) condition-----		Date Inspected: (not checked)
(4.2.3) Reactivity shutdown margin at least 8% --------------		
(4.2.4) Drop time <600 msec-------		(9.3) Dates: (1)______
(4.3.2) Limit lights; shim range lights, magnet contact lights-----		(2)______
8. Neutron source (min. 10^6 n/sec----		

	OK	Comments
9. Safety systems (annunciator)------	✓	
(5.4) Start-up channel------------	✓	
(5.4) Linear channel--------------	✓	
(5.4) Log N - Period channel------	✓	
(5.4) Safety channel #1-----------	✓	
(5.4) Safety channel #2-----------	✓	
10. (5.5) Magnet release time <50 msec	N/A	not in new tech specs.
11. (5.7) Radiation levels <0.1 mr/hr		Location / Reading Pool surface above core Near demineralizer Beam room
12. (5.8) Portable survey instruments List: Neutron Gamma Other		Alpha Beta these instruments and calibration data are included in attached summary.
13. Experimental facilities-----------		Give example as to how it is used.
Hung samples----------------------		not checked
(6.1.1) Core access element-------		
(6.1.1) Isotope prod. element-----		
(6.1.2) Rabbit tube---------------		
(6.1.2) Thermal column------------		
(6.1.2 Beam port-----------------		
(6.2.2) Documentation of exps.----		
(6.2.3) Single independent experiment: ρ_{ex} <0.7% -------------		
(6.2.4) Single movable experiment: ρ_{ex} <0.4% ------------- 0.6% all movable exp.---		
(6.2.5) Experiments having moving parts: ρ_{ex} <0.05%-------------		
(6.2.6) Position of any/all exp.--		
14. General Operating Limitations		
(7.1) Startup: Sr. Oper. plus one (in the control room)	✓	
(7.1) Operation: S.O. plus one--- (in building)	✓	
(7.4) No fuel position vacancies in core; loading (wall chart)-----	✓	

	OK	Comments
15. Fuel Storage & Transfer wall chart ----------------------	✓	
(8.3) Fuel handling tools locked--	✓	separate checklist
(8.4) Fuel transfer--three men (Sr.Oper.; Lic.Oper.; plus one----	✓	
16. (10.1) New loading: approach to critical exp.(reason & date)------		not checked
(10.2) Core configuration change: one grid position. (Reason & date)		
(10.3) Loading change of more than one grid position-unload 50%------		
17. Instruments functioning (Table I)-		(On weekly check list - *)
Scram: Manual-------------------	✓	startup
Period <5 sec.------------	✓	*
150% full power----------	✓	startup
Bridge motion------------	✓	*
Log N- Period non-op------	✓	*startup
Rundown: 120% power (linear)-----	✓	*
Period <15 sec ----------	✓	*
Reg Rod (insert limit-auto rundown)	✓	
120% full power (log N)---	✓	*
Low CIC voltage----------	✓	startup
High radiation-----------	✓	startup
Rod prohibit: Period <30 sec-----	✓	*
Any recorder off----------	✓	*
Low count rate-----------	✓	*
Reg Rod prohibit (rods below shim range)---------	✓	
Inlet temp.> 135°F--------	✓	*
Servo-prohibit on reg. rod--------	✓	
18. Check Lists and records		
Log book checked-----------------	✓	
(9.1) Daily facility check list---	✓	
(9.3) Instrument channels & area monitors-calibrated at 90 day intervals------------------------	✓	Dates: (1)________ (2)________ (3)________ (4)________
UMRR startup check list----------	✓	
Hourly records-note variations----	✓	
Shut-down check list-------------	✓	
Weekly check list----------------	✓	
Work load log--------------------	Not checked	
Six month systems check----------	✓	Dates: (1)________ (2)________

	OK	Comments
B. Records		
1. Log books----------------------	✓	Current book number 6 Other ______ Stored ______
2. Recorder charts-------------- Log N (permanent)-------------	not checked	Stored: where and for how long Located:
3. Evacuation alarms: number and cause------------------------	N/A	1.
4. Evacuation procedures, drills-		2. evacuation drill 12/12/84
5. Use of by-pass keys-----------		1. 7/6/84 <30sec bypassed 9/21/84 <2 counts bypassed
6. Key security------------------ General security-------------- Night use of building---------	not checked	
7. SOP'S - Note any revisions----	✓	many new revisions - see attached list (9/4/84)
8. Film badge, dosimeter---------	✓	
9. Night watchman record---------	not checked	
C. Reactor Bay		
1. General condition of pool-----	✓	
2. General condition of storage--	✓	
3. Use of cable trench-----------	not checked	
4. Nitrogen diffuser-------------	✓	
5. Miscellaneous (List)----------	N/A	
D. Control Room------------------------	✓	
List of current operators----------	✓	Senior operators: Dr. A.E. Bolon C.M. Barton
E. Office (film badge rack, etc.)-----	✓	
F. Counting Room-----------------------	✓	Operators: Milan Straka 1/11/85 SO Butch Jones (trainee)
G. Rooms & Storage upstairs-----------	✓	

	OK	Comments
H. Stairwell & pump area----------------	✓	
1. Demineralizer system----------------	✓	
2. Outside air filters----------------	✓	
I. Stairs and beam room-----------------	✓	
1. Thermal column--------------------	✓	
2. Beam tube------------------------	✓	
3. Fuel storage---------------------	✓	
4. Liquid & solid waste storage-------	✓	appeared that upper waste tank had seepage from connections at bottom
J. Health Physics		
1. Sample removal--------------------		not checked (items J.1 through J.6.f)
2. SOP'S (list)---------------------		
3. Excursion or incident monitor------		
a. Film badge placement-----------		
b. Other-------------------------		
4. Film badge, dosimeter records------		
a. Staff-------------------------		
b. Students----------------------		
c. Guests------------------------		
d. Night watchman----------------		
5. Possible detection of fuel element rupture-------------------		
6. Radiation survey-----------------		Dates:
a. Periodic swipe tests-----------		
b. Pool water--------------------		
c. Inside air--------------------		
d. Outside air-------------------		
e. Neutron level (sub-critical----		
f. Misc. items (list)------------		
7. Emergency box (Physics Bldg.)------		

General comments:

See attached comments.

UNIVERSITY OF MISSOURI

Research Reactor Facility

Research Park
Columbia, Missouri 65211
Telephone (314) 882-4211

July 10, 1984

Dr. Albert Bolon
Reactor Director
University of Missouri-Rolla
Nuclear Engineering, Building C
Rolla, Missouri 65401

Dear Dr. Bolon:

On Monday, June 18, 1984, Charles Anderson and I conducted a Reactor Facility Inspection of the UMR-Reactor. This inspection concentrated on several areas included in your inspection form. Detailed comments from the inspection will primarily be contained in this letter, referenced from your inspection form by an asterisk (*).

A.18 Checklists and Records

1) Weekly Surveillance Checklist (SOP 811)

January 3, 1984. 120% demand rundown entry omitted.

2) Pre-Startup Checksheets (SOP 102)

a) Weeks of January 9 and March 5; drop current rod #1 = 63 ma. Rod current set at 85 ma and 88 ma respectively. SOP 137 defines normal magnet current = drop current + 10 ma, and defines maximum magnet current = normal current + 10 ma, which implies maximum magnet current = drop current + 20 ma. This does not imply that operation is out of compliance with technical specifications (which address rod drop and separation times), it just seems that to be consistent with SOP 137, maximum operating magnet current should be as defined or have rod drops at currents exceeding maximum magnet current documented to not effect drop times significantly.

b) When reviewing the Pre-startup checksheet, several second pages had become detached. The second page has no place for a date to tie it to a specific page one. Suggest adding date to second page.

Dr. Albert Bolon
July 10, 1984
Page 2

3) Material Transfer Form (SOP 604)

Consignee byproduct license blank not filled in for several dates - 3/14, 5/2, 5/3). These may be covered by UMRR byproduct license (?).

4) Semiannual Checklist

a) Start Date - December 19, 1983
Completion Date - January 6, 1984

Several items in checklist dated outside the start to completion dates (specifically January 10, 1984).

b) Possible error in recording data on page 7, step c. Entry for check of 2.0×10^{-7} is 6.8, should be 2.0.

5) Hourly Operating Log (SOP 104)

a) Several Hourly Operating Logs had no senior operator signature at end of day (2/16, 3/13, 5/1, 5/10, 5/11, 5/14, 5/18, 6/12).

b) Several startups did not list purpose of startup. This was not consistent with previous entries (3/14, 3/16. 3/21, 3/22).

B.5 Use of Bypass Keys

Console log has two entries for insertion of same bypass key, with no intervening removal of key logged (4/17).

B.7 Standard Operating Procedures

These items are detailed in section A.18 of this letter.

J. Health Physics

A detailed review of this section showed no major items of concern. The outside air sample listed on audit sheet is not being done. The Health Physics Manager no longer has a Health Physics Technician working with him to cover all campus areas.

General Comments

The operator requalification program is now subject to periodic review by the Reactor Manager which should improve documentation. One area of omission on individual evaluation sheets -- the requalification program states that "evaluator will also discuss or simulate abnormal or emergency conditions during the manipulations and grade operator on response". This does not seem to be done. One suggestion might be to discuss these conditions prior to or directly after manupilation to keep from distracting the operator during startup.

Dr. Albert Bolon
July 10, 1984
Page 3

In regards to the reactor scram due to plugging into an electrical outlet that was connected to reactor control power -- one suggestion might be to label such outlets with some caution or warning tags.

Chuck and I would like to thank you, Milan, and Mr. Barton for your assistance in locating and explaining your records.

We found your operations being conducted in a satisfactory manner with no major problem areas identified. We hope some of the suggestions are helpful.

Sincerely,

Walt Meyer, Jr.
Reactor Operations Engineer

WAM:vs

Attachment: UMRR Audit Forms

REACTOR FACILITY INSPECTION -- Date(s) June 18, 1984
(Phone: 341-4236)

Date(s) of last NRC inspection ____________

Date(s) of last "inhouse" inspection Jan 10, 1984

Log Book Inspection:

	Log Book Number	Page	Date
From entry:	VI	81	Jan 10, 1984
Through entry:	VI	129	Jun 14, 1984

Follow up items from previous inspection (item, follow-up):

S.O.P. Revisions

	OK	Comments
A. Technical specifications--------------- Appendix A -- Jan. 6, 1967	✓	
1. (2.1) Ventilating fans------------	✓	
Automatic closure ---------------	✓	
2. (3.1) Pool water depth (16 ft. min above core)----------------------	✓	
3. (3.1) Inlet water temperature 60°F <t <135°F------------------	✓	
4. (3.2) Radiation one meter above pool <5 mr/hr ------------------	✓	
5. (3.2) Resistivity >0.5 megohm-cm-	✓	
6. Fuel ----------------------------		Type of elements: MTR Other ____
(4.1.3) ρ ex <1.5% ---------------	N/A	Present loading(s): 67W & 6TT
1.5% <ρex<3.5% five consecutive days twice a year----------------	N/A	Dates: (1)____ (2)____
7. Control rod: (9.5) condition-----	✓	
(4.2.3) Reactivity shutdown margin at least 8% --------------		Date Inspected: .
(4.2.4) Drop time <600 msec-------	*✓	(9.3) Dates: (1)____ (2)____
(4.3.2) Limit lights; shim range lights, magnet contact lights-----	✓	one not operative - SOP 305 used
8. Neutron source (min. 10^6 n/sec----	✓	

not checked in detail.

~~* see cover letter~~

	OK	Comments
9. Safety systems (annunciator)------	✓	
(5.4) Start-up channel------------	✓	experiencing problems with C&C
(5.4) Linear channel--------------	✓	
(5.4) Log N - Period channel------	✓	
(5.4) Safety channel #1-----------	✓	
(5.4) Safety channel #2-----------	✓	
10. (5.5) Magnet release time <50 msec	X ✓	
11. (5.7) Radiation levels <0.1 mr/hr	✓	**Location** / **Reading**
		Pool surface above core
		Near demineralizer
		Beam room
12. (5.8) Portable survey instruments List:		Checked calibration dates of all instruments; all within last month except Eberline 1405, cal. 3/27/84
Neutron		Alpha
Gamma		Beta
Other		
13. Experimental facilities----------		Give example as to how it is used.
Hung samples---------------------		not covered
(6.1.1) Core access element-------		
(6.1.1) Isotope prod. element-----		
(6.1.2) Rabbit tube---------------		
(6.1.2) Thermal column------------		
(6.1.2 Beam port-----------------		
(6.2.?) Documentation of exps.----		
(6.2.3) Single independent experiment: ρ_{ex} <0.7% -------------		
(6.2.4) Single movable experiment: ρ_{ex} <0.4% -------------		
0.6% all movable exp.---		
(6.2.5) Experiments having moving parts: ρ_{ex} <0.05%-------------		
(6.2.6) Position of any/all exp.--		
14. General Operating Limitations		
(7.1) Startup: Sr. Oper. plus one (in the control room)		
(7.1) Operation: S.O. plus one--- (in building)		
(7.4) No fuel position vacancies in core; loading (wall chart)-----		

~~*see cover letter~~

	OK	Comments
15. Fuel Storage & Transfer wall chart ----------------------	✓	
(8.3) Fuel handling tools locked--	✓	
(8.4) Fuel transfer--three men (Sr.Oper.; Lic.Oper.; plus one----	✓	
16. (10.1) New loading: approach to critical exp.(reason & date)------		not checked
(10.2) Core configuration change: one grid position. (Reason & date)		
(10.3) Loading change of more than one grid position-unload 50%------		
17. Instruments functioning (Table I)-		(On weekly check list - *)
Scram: Manual--------------------	✓	startup electrical load cycle - Apr 11
Period <5 sec.------------	✓	* suggest - may want to
150% full power-----------	✓	startup ~~[illegible]~~ label electrical
Bridge motion-------------	✓	* outlets as Rx control
Log N- Period non-op------	✓	*startup power outlets
Rundown: 120% power (linear)-----	✓	*
Period <15 sec -----------	✓	*
Reg Rod (insert limit-auto rundown)		
120% full power (log N)---	✓	*
Low CIC voltage-----------	✓	startup
High radiation------------	✓	startup high rod area ≈ 8mr/hr - Apr 12
Rod prohibit: Period <30 sec-----	✓	*
Any recorder off----------	✓	*
Low count rate------------	✓	*
Reg Rod prohibit (rods below shim range)---------	✓	
Inlet temp.> 135°F--------	✓	*
Servo-prohibit on reg. rod--------	✓	
18. Check Lists and records		
Log book checked-----------------	✓	
(9.1) Daily facility check list---	✓	
(9.3) Instrument channels & area monitors-calibrated at 90 day intervals-------------------------	N/A	Dates: (1)________ (2)________ (3)________ (4)________
UMRR startup check list----------	✓*	
Hourly records-note variations----	✓*	
Shut-down check list-------------	✓	
Weekly check list----------------	✓*	
Work load log--------------------	N/A	
Six month systems check----------	N/A	Dates: (1)________ (2)________

* see cover letter

	OK	Comments
B. Records	*✓	
1. Log books--------------------	✓	Current book number VI
	✓	Other ____ Stored ____
2. Recorder charts---------------	✓	Stored: where and for how long
Log N (permanent)-------------	✓	Located:
3. Evacuation alarms: number and cause----------------------	#	1.
		2.
4. Evacuation procedures, drills-	✓	1. May 2, 1984 evac. drill
5. Use of by-pass keys-----------	✓	Console log has entry for two bypass key inserted w/no intervening removal logged - Apr 17
6. Key security------------------	✓	
General security--------------	✓	
Night use of building---------	✓	
7. SOP'S - Note any revisions----	*✓	Several revisions made, notably 100 series (reactor log) 600 series (rad. protection;
8. Film badge, dosimeter---------	✓	SOP 501 updated to include M. STRAKA for notification
9. Night watchman record---------	✓	SOP 604 - material Transfer Form - consignee byproduct license # blank - 3/14, 5/2, 5/3
C. Reactor Bay		
1. General condition of pool-----	✓	
2. General condition of storage--	✓	
3. Use of cable trench-----------	✓	
4. Nitrogen diffuser-------------	✓	
5. Miscellaneous (List)----------		
D. Control Room------------------------	✓	
List of current operators----------		Senior operators: DR. ALBERT BOLON Apr 6, 1982; C.M. BARTON Sept 9, 1983
E. Office (film badge rack, etc.)-----	✓	
F. Counting Room-----------------------	✓	Operators: M. STRAKA Sept 22, 1983
G. Rooms & Storage upstairs-----------	✓	
	*	Requal program documentation being updated (M. STRAKA is instituting review of requal documentation)

* see cover letter

	OK	Comments
H. Stairwell & pump area------------------		
1. Demineralizer system----------------	NA	
2. Outside air filters----------------		
I. Stairs and beam room------------------		not checked
1. Thermal column---------------------		
2. Beam tube--------------------------		
3. Fuel storage-----------------------		
4. Liquid & solid waste storage-------		
J. Health Physics		
1. Sample removal---------------------	✓	
2. SOP'S (list)-----------------------	✓	Recently revised, May 1984
3. Excursion or incident monitor------	✓	Badges placed throughout building
a. Film badge placement-----------	✓	at RAMS - processed every two weeks
b. Other--------------------------		
4. Film badge, dosimeter records------	✓	LANDAUER BADGE SYSTEM
a. Staff--------------------------	✓	dosimeter - logged in guest book
b. Students-----------------------	✓	
c. Guests-------------------------	✓	
d. Night watchman-----------------	✓	dosimeter - self logged in Night Watchman's Log
5. Possible detection of fuel element rupture-----------------------	✓	Room above pool - pool water sample
6. Radiation survey-------------------		Dates:
a. Periodic swipe tests-----------	✓	
b. Pool water---------------------	✓	
c. Inside air---------------------	✓	continuous particulate monitor and grab samples
d. Outside air--------------------	✗	outside not performed
e. Neutron level (sub-critical----		
f. Misc. items (list)-------------		
7. Emergency box (Physics Bldg.)------	✓	inventory yearly

General comments:

See cover letter

[signature]

APPENDIX B

Semi-Annual Checks (SOP-800)

Semi Annual Check List

Date Commenced DEC [illegible]
Date Completed JAN [illegible] 1985
Total Hours on Hour Meter 09054.0

1. Log N and Period Channel — Initial

JAN 1984

a. Nog N Power Supply
   (1) Cleaned chassis — CWB
   (2) Tested all vacuum tubes — CWB

   Replaced:

tube #	tube type
None	

b. Log N Recorder — Date JAN 1984
   (1) Cleaned chassis — CWB
   (2) Tested all vacuum tubes — CWB

   Replaced:

tube #	tube type
None	

c. Neutron Detector Check

	Resistance (ohms)	Capacitance (pf)	JAN 1 [illegible]
(1) Signal to ground	6.7×10^{11}	1129pf	CWB
(2) Positive to ground	6.8×10^{11}	1214pf	CWB
(3) Negative to ground	6.8×10^{11}	1194pf	CWB

d. Log N Calibration Date JAN 7 1984 Initial

1. Meter	Recorder	Keithley	Initial
100	100	5×10^{-5}	[illegible]
10	8	3.5×10^{-6}	[illegible]
1	1	4.5×10^{-7}	[illegible]
0.1	0.1	5×10^{-8}	[illegible]
.01	0.012	5×10^{-9}	[illegible]
.001	0.0012	5×10^{-10}	[illegible]
.0001	0.0002	5×10^{-11}	[illegible]

Reconnection of Cables Verified [illegible]

Note: The ratio of true-to-observed readings should be between 0.7 and 1.4

e. Period Recorder Date JAN 7 1984

(1) Cleaned chassis [illegible]

(2) Tested all vacuum tubes [illegible]

Replaced:

tube #	tube type
None	

2. Linear Power Channel

a. Linear Power Supply Date JAN [illegible] 1985

(1) Cleaned chassis [illegible]

(2) Tested all vacuum tubes [illegible]

Replaced:

tube #	tube type
None	

b. Linear Recorder Date JAN 1985

(1) Cleaned chassis CWB

(2) Tested all vacuum tubes CWB

Replaced: tube # tube type

None

c. Micro-Micro Ammeter (Spare) Date JAN 1 1984

(1) Cleaned chassis CWB

(2) Tested all vacuum tubes CWB

Replaced: tube # tube type

*

* V_1 and V_2 Tube assembly (Preamp) was used in SN 18650.

d. Linear Neutron Detector Check JAN 1 1985

	Resistance (ohms)	Capacitance (pf)	
(1) Signal to ground	2.2×10^{10}	1222 pf	CWB
(2) Positive to ground	3.5×10^{11}	1226 pf	CWB
(3) Negative to ground	4×10^{11}	1100 pf	CWB

e. Micro-Micro Ammeter replacement

(1) Remove Micro-Micro Ammeter from console and replace with spare CWB

(2) Reconnection of cables verified JW

Note: Any instrument found to be out of calibration should be realigned in accordance with procedures.

f. (Linear Cont.) Record after step e. (1) has been performed

(1)

Keithley	Meter	Recorder	Initial
$6.66x10^{-5}$	6.6	100	CWB
$2.0x10^{-5}$	2.0	100	CWB
$6.66x10^{-6}$	6.8	101	CWB
$2.0x10^{-6}$	2.0	100	CWB
$6.66x10^{-7}$	6.8	101	CWB
$2.0x10^{-7}$	2.0	101	CWB
$6.66x10^{-8}$	6.65	100	CWB
$2.0x10^{-8}$	1.99	100	CWB
$6.66x10^{-9}$	6.6	100	CWB
$2.0x10^{-9}$	2.0	100	CWB
$6.66x10^{-10}$	6.5	99	CWB
$2.0x10^{-10}$	1.9	99	CWB

g. Reconnect all cables CWB

Reconnection of cables verified Jw

Note: From 10^{-5} to 10^{-8}, the overall accuracy should be better than 2% of full scale. From $3x10^{-9}$ to $3x10^{-10}$ the overall accuracy should be better than 4%.

3. Log Count Rate Channel Initial

a. Log Count Rate Recorder Date JAN 1985

(1) Cleaned chassis CWB

(2) Tested all vacuum tubes CWB

Replaced:

tube #	tube type
None	

b. Fission Preamp Date JAN . 1985

(1) Cleaned chassis and inspected CWB

b. Fission Preamp (cont.)

(2) Additional Comments

c. Log Count Rate Channel Date JAN 11 1985

(1) Pulse Generator*	Meter	Recorder	Initial
10	10	10	CWMB
100	80	80	CWMB
1,000	1050	10^3	CWMB
10,000	10100	10^4	CWMB

Reconnection of cables verified Jaw

Note: All readings should give .7 to 1.4 ratio of true-to-observed readings

4. Safety Channels

a. Safety Preamp Date DEC 20 1984

(1) Cleaned chassis CWMB

(2) Tested all vacuum tubes CWMB

Replaced:

tube #	tube type
NONE	

b. Neutron Detector #1 JAN 10 1985

	Resistance	
(1) Signal to ground	6.8×10^{11}	CWMB
(2) Positive to ground	2.5×10^{11}	CWMB
(3) Additional Comments		

c. Neutron Detector # 2 JAN 10 1985

	Resistance	
(1) Signal to ground	$7 \times 10^{+11}$	CWMB
(2) Positive to ground	$2.5 \times 10^{+11}$	CWMB
(3) Additional Comments		

4. Safety Channels (cont.) — Initial

d. Safety Amplifier — Date DEC 20 1984 ~~DEC~~ CMB

(1) Cleaned chassis — CMB

(2) Tested all vacuum tubes — CMB

Replaced:

tube #	tube type
NONE	

e. Safety Amplifier Adjustments — CMB

f. Replace all cables to safety amplifier — CMB

Reconnection of cables verified — [illegible]

5. PAT 60 Controller

a. PAT 60 — Date JAN [illegible] 1985

(1) Cleaned chassis — CMB

(2) Tested all vacuum tubes — CMB

b. Check dial settings and record the following

(1) Approach — — CMB

(2) Proportional Bond 70 — CMB

(3) Rate Time 0.03 — CMB

(4) Reset 6 — CMB

(5) Gain (if applicable) 1.5 — CMB

6. Temperature Recorder — Date JAN 1[illegible] 1985

a.

Reading #	Thermometer	Recorder	Initial
1	80°F	81	CMB
2	80°F	81	CMB
3	80°F	80	CMB
1	~~140~~ 120°F CMB	120	CMB
2	~~140~~ 120°F CMB	120	CMB
3	~~140~~ 120°F CMB	120	CMB

Note: All readings should be ± 1°F

6. Temperature Recorder (cont.) Date JAN 2 1 1985 Initial

b. 135°F Interlock Trip Point 135 CWB

7. Regulated Power Supply Date JAN 1985

a. Cleaned chassis CWB
b. Additional comments

8. Conductivity Bridge Date JAN 1 1985

a. Cleaned chassis CWB
b. Additional comments

9. Relay Test Date JAN 2 1 1985

a. Console relays tested and replaced as per SOP 815 CWB
b. Relays Replaced None CWB

10. Rod Indicator Calibration Date JAN 1 1984 CWB

Actual Height	I.	II.	III.	Reg.
1"	1	1	1	1
6"	6	6	6	6
12"	12	12	12	12
18"	18	18	18	18
24"	24	24	24	24

11.	Fire Alarm Check	Date JAN 1 1985	Initial
	a. Cleaned system containers		CMB
	b. Changed batteries		CMB
	c. Checked pull stations		CMB
	d. Checked heat detectors		CMB
	e. Checked smoke detectors		CMB
	f. All indicator lamps operate		CMB
12.	Security System Check	Date 1985	
	a. Door Sensors		CMB
	b. Motion Detectors		CMB
	c. Duress Alarm		CMB
	d. Control Modules (at UMR Police office)	Date 1985	
	(1) Power Supply		CMB
	(2) Control Module		CMB
13.	Public Address System	Date 1985	
	(1) Cleaned chassis		CMB
	(2) Additional Comments		
14.	Area Radiation Monitor	Date JAN 18 1985	
	(1) Cleaned chassis		CMB
	(2) Additional Comments		
	Calibration checked Sat.		

Date 22 Jan 1985

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 ______________________ or Reactor Manager ______________________

Semi Annual Check List

Date Commenced AUG 9 1984

Date Completed AUG 2? 1984

Total Hours on Hour Meter 8845.25

1. Log N and Period Channel — Initial

a. Nog N Power Supply

(1) Cleaned chassis — C-MB

(2) Tested all vacuum tubes — C-MB

Replaced:

tube #	tube type
V4	5651
V5	5651
V6	5651

b. Log N Recorder — Date AUG 9 1984

(1) Cleaned chassis — C-MB

(2) Tested all vacuum tubes — C-MB

Replaced:

tube #	tube type
None	

c. Neutron Detector Check

	Resistance (ohms)	Capacitance (pf)	Initial
(1) Signal to ground	1.2×10^{12}	$1.162 \times 10^{+3}$ pf	C-MB
(2) Positive to ground	6.7×10^{12}	1.248×10^{3} pf	C-MB
(3) Negative to ground	5×10^{12}	$1.226 \times 10^{+3}$ pf	C-MB

d. Log N Calibration Date AUG . . 1984 Initial

1. Meter	Recorder	Keithley	Initial
100	100	5x10^-5	CMB
10	10	5x10^-6	CMB
1	1	4x10^-7	CMB
0.1	0.1	5x10^-8	CMB
.01	0.01	6.4x10^-9	CMB
.001	0.001	5 ~~4~~ x10^-10	CMB
.0001	0.0002	5x10^-11	CMB

Reconnection of Cables Verified MS

Note: The ratio of true-to-observed readings should be between 0.7 and 1.4

e. Period Recorder Date AUG 10 1984

(1) Cleaned chassis CMB

(2) Tested all vacuum tubes CMB

Replaced:

tube #	tube type
None	

2. Linear Power Channel

a. Linear Power Supply Date AUG 9 1984

(1) Cleaned chassis CMB

(2) Tested all vacuum tubes CMB

Replaced:

tube #	tube type
V10	5651
V7	5651

b. Linear Recorder Date AUG 1984

(1) Cleaned chassis CMB
(2) Tested all vacuum tubes CMB

Replaced:

tube #	tube type
None	

c. Micro-Micro Ammeter (Spare) Date AUG 1 1984

(1) Cleaned chassis CMB
(2) Tested all vacuum tubes CMB

Replaced:

tube #	tube type
None	

d. Linear Neutron Detector Check

	Resistance (ohms)	Capacitance (pf)	
(1) Signal to ground	1×10^9	1.262×10^3 pf	CMB
(2) Positive to ground	1×10^9	1.257×10^3 pf	CMB
(3) Negative to ground	1×10^9	580 pf	CMB

e. Micro-Micro Ammeter replacement

(1) Remove Micro-Micro Ammeter from console and replace with spare *CMB
(2) Reconnection of cables verified [illegible]

* Unit was Replaced on Jun 14, 1984

Note: Any instrument found to be out of calibration should be realigned in accordance with procedures.

f. (Linear Cont.) Record after step e. (1) has been performed

(1)

Keithley	Meter	Recorder	Initial
6.66×10^{-5}	6.60	100	CWB
2.0×10^{-5}	1.98	100	CWB
6.66×10^{-6}	6.60	101	CWB
2.0×10^{-6}	1.99	101	CWB
6.66×10^{-7}	6.66	102	CWB
2.0×10^{-7}	2.00	102	CWB
6.66×10^{-8}	6.60	100	CWB
2.0×10^{-8}	2.00	101	CWB
6.66×10^{-9}	6.62	101	CWB
2.0×10^{-9}	2.00	101	CWB
6.66×10^{-10}	6.60	98	CWB
2.0×10^{-10}	1.95	98	CWB

g. Reconnect all cables CWB

Reconnection of cables verified JLS

Note: From 10^{-5} to 10^{-8}, the overall accuracy should be better than 2% of full scale. From 3×10^{-9} to 3×10^{-10} the overall accuracy should be better than 4%.

3. Log Count Rate Channel — Initial

a. Log Count Rate Recorder — Date AUG 1984

(1) Cleaned chassis — CWB

(2) Tested all vacuum tubes — CWB

Replaced:

tube #	tube type
None	

b. Fission Preamp — Date AUG 2 1984

(1) Cleaned chassis and inspected — CWB

b. Fission Preamp (cont.)

(2) Additional Comments

c. Log Count Rate Channel Date________________

(1)

Pulse Generator*	Meter	Recorder	Initial
10	10	10	[illegible]
100	100	100	[illegible]
1,000	1000	1000	[illegible]
10,000	10000	10000	[illegible]

Reconnection of cables verified [illegible]

Note: All readings should give .7 to 1.4 ratio of true-to-observed readings

4. Safety Channels

a. Safety Preamp Date AUG . 1984

(1) Cleaned chassis [illegible]

(2) Tested all vacuum tubes [illegible]

Replaced:

tube #	tube type
None	

b. Neutron Detector #1

	Resistance	Initial
(1) Signal to ground	9.5×10^{12}	[illegible]
(2) Positive to ground	1.2×10^{10}	[illegible]

(3) Additional Comments

c. Neutron Detector # 2

	Resistance	Initial
(1) Signal to ground	9×10^{12}	[illegible]
(2) Positive to ground	1.2×10^{10}	[illegible]

(3) Additional Comments

4. Safety Channels (cont.) Initial

d. Safety Amplifier Date AUG 9

(1) Cleaned chassis [initials]

(2) Tested all vacuum tubes [initials]

Replaced:

tube #	tube type
None	

e. Safety Amplifier Adjustments [initials]

f. Replace all cables to safety amplifier [initials]

Reconnection of cables verified [initials]

5. PAT 60 Controller

a. PAT 60 Date ______

(1) Cleaned chassis [initials]

(2) Tested all vacuum tubes [initials]

b. Check dial settings and record the following

(1) Approach [illegible] [initials]

(2) Proportional Bond 70 [initials]

(3) Rate Time [illegible] [initials]

(4) Reset 6 [initials]

(5) Gain (if applicable) 1.5 [initials]

6. Temperature Recorder Date AUG 1984

a.

Reading #	Thermometer	Recorder	Initial
1	80°F	80	[initials]
2	80°F	80	[initials]
3	80°F	80	[initials]
1	140°F	140	[initials]
2	140°F	139	[initials]
3	140°F	139	[initials]

Note: All readings should be ± 1°F

6. Temperature Recorder (cont.) Date AUG 1984 **Initial**

b. 135°F Interlock — Trip Point: 135 — CWB

7. Regulated Power Supply Date AUG 1984

a. Cleaned chassis — CWB

b. Additional comments

8. Conductivity Bridge Date AUG

a. Cleaned chassis — CWB

b. Additional comments

9. Relay Test Date AUG 1984

a. Console relays tested and replaced as per SOP 815 — CWB

b. Relays Replaced None — CWB

10. Rod Indicator Calibration Date AUG — CWB

Actual Height	I.	II.	III.	Reg.
1"	1	1	1	1
6"	6	6	6	6
12"	12	12	12	12
18"	18	18	18	18
24"	24	24	24	24

11. Fire Alarm Check Date AUG 1984 Initial

a. Cleaned system containers [illegible]
b. Changed batteries [illegible]
c. Checked pull stations [illegible]
d. Checked heat detectors [illegible]
e. Checked smoke detectors [illegible]
f. All indicator lamps operate [illegible]

12. Security System Check Date AUG 1984

a. Door Sensors [illegible]
b. Motion Detectors [illegible]
c. Duress Alarm [illegible]
d. Control Modules (at UMR Police office) Date AUG 1984
(1) Power Supply [illegible]
(2) Control Module [illegible]

13. Public Address System Date [illegible]

(1) Cleaned chassis [illegible]
(2) Additional Comments

14. Area Radiation Monitor Date AUG 1984

(1) Cleaned chassis [illegible]
(2) Additional Comments

Date 27 August 84

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 or Reactor Manager

APPENDIX C

Revised SOP's

UNIVERSITY OF MISSOURI-ROLLA - NUCLEAR REACTOR

STANDARD OPERATING PROCEDURES

S.O.P.: 101	REVISED: 09-04-84	PAGE 1 OF 3

TITLE: General Operational Procedures

1. No one except a licensed operator may manipulate the reactor controls. The only exception will be persons who operate the reactor for educational purposes, when a licensed Operator or Senior Operator is present at the console. Changes in power level will be under the direct supervision of a Senior Operator.
2. Loading or unloading of the fuel elements in the core will be done only under the direct supervision of a Senior Operator, with a minimum of another licensed Operator, and one other person present. This will be enforced by keeping the fuel element handling tools locked in place with the only keys in the possession of the Senior Operator on Duty.
3. In loading any configuration change of more than one element, or following any significant change of ($\Delta\rho \geq 0.2\%$) in nearby experimental equipment or experiments, the reactor will be brought to criticality by means of a critical experiment under the direct supervision of a Senior Operator.
4. No individual experiment worth more than 0.7% in reactivity will be installed in the reactor, no single moveable experiment worth more than 0.4% will be installed in the reactor, and the worth of all moveable experiments shall be no greater than 0.5% reactivity. Rev.
5. Following the loading of a core configuration previously logged, the approach to critical will be made under the direction of a Senior Operator but need not be done by means of a critical experiment.
6. The system for designating a loading will be as follows: any change in fuel of a critical mass will be designated by a number. Any change in reflector will be designated by a letter following the number of a particular core loading. Loading diagrams of each core shall be inserted in the proper log book of core loadings, and a core data sheet filled out for each core. A loading will not be designated by a new number or letter unless the reactor is taken

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critical.

7. The reactor will be operated with the minimum amount of excess reactivity necessary to fulfill operational requirements, and those requirements will be at the discretion of the Senior Operator on Duty.
8. Personnel in the Reactor Building will be informed over the public address system about changes made to the reactor status. This includes startups, power changes and shutdowns.
9. All reactor operational personnel are responsible for entering in the appropriate log book any work on or around the reactor or reactor components important enough to justify a record for future reference.
10. All personnel are responsible for notifying the Senior Operator on Duty of any work being done.
11. Radioactive samples or sources will be removed from the core or thermal column only under the direction of a Senior Operator. He will in turn seek Health Physics assistance if he deems it necessary. The bridge monitor may be switched to by pass the alarm system when samples are removed under careful survey, at the discretion of the Senior Operator on Duty.
12. Log books will be kept in the control room safe, except the one currently in use, which may be kept on the console. If the books are removed from the control room, permission must be granted by the Reactor Manager. Any books removed shall be returned as soon as possible.
13. Completed recorder chart paper will be dated and filed in designated areas, and kept on file for at least the minimum required time. Log N charts are to be kept as a p[illegible]nent record.
14. All changes in Core Mode (T or [illegible]) will be noted in the permanent log book, including date and time.
15. The use of any interlock by pass key requires a permanent log entry

UNIVERSITY OF MISSOURI-ROLLA - NUCLEAR REACTOR		
STANDARD OPERATING PROCEDURES		
S.O.P.: 101	REVISED: 09-04-84	PAGE 3 OF 3
TITLE: General Operational Procedures		

for insertion and removal. This log entry shall include date and time.

16. A temporary change to the SOP's may be made with the consent of two licensed Operators, one being a licensed Senior Operator. This change shall be submitted in writing within ten working days to the Reactor Director for Approval or Revision. Rev.

17. If at any time during reactor startup or operation the Reactor Operator notices any abnormal behavior of the instrumentation (meters and recorders), he/she should immediately bring it to the attention of the Senior Operator on Duty. If there is any doubt as to whether the equipment is functioning properly, the reactor shall be shut down. Then the cause should be determined and corrective action taken. Rev.

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UNIVERSITY OF MISSOURI-ROLLA - NUCLEAR REACTOR		
STANDARD OPERATING PROCEDURES		
S.O.P.: 103	REVISED: 9-4-84	PAGE 1 OF 5
TITLE: Reactor Start Up Procedure		

A. Purpose To ensure a safe and consistent method for starting up the reactor from a clean or high residual condition. The reactor will be considered clean if shutdown for more than 52 hours. The reactor will also be considered clean if power levels within the past 52 hours have not exceeded 20kW for 1.0 hour or it's equivalence.

B. Precautions, Prerequisites, Limitations

1. SOP 102 shall have been completed and approved by the SRO on Duty prior to commencing reactor startup.
2. The SRO on Duty shall remain in the control room (in audible and visual contact with console operator) during startup, power-change and shutdown of the reactor. | Rev. REB
3. There will be at least two, but no more than nine people in the control room during reactor startup, power change or shutdown.
4. When the reactor is in a stable condition there shall be no more than nine people in the control room at any time. One of these individuals shall hold a valid Operators license or Senior license.
5. The console operator (licensed RO or student under supervision of SRO) shall control all reactivity changes to the reactor by direct manipulation of the controls or by directing the manipulation of experiments being conducted at the facility.
6. Only a licensed Senior Reactor Operator may terminate the action of automatic reactor controls. If a scram, rundown or rod withdrawal prohibit occurs with a licensed Operator or student at the control, the permission to terminate the automatic control or a restart of the reactor can only be authorized by a licensed Senior Reactor Operator.
7. Nitrogen diffuser operation is required for reactor power greater than 20 kilowatts. This requirement is at the

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discretion of the Senior Operator on Duty and may be suspended for special tests, experiments or equipment checks. The reactor bridge radiation levels shall not be allowed to equal or exceed 30 mr/hr.

8. Building exhaust fan operation is required for reactor power level of 200 kilowatts or when the constant air monitor recorder reaches a value of 500 counts/minute. Exhaust fan operation should continue after the reactor is shutdown until a less than 500 counts/minute reading is obtained or until the reactor building is secured at the end of the day. See SOP 505 for securing the reactor building.
9. The safety channel meters should begin to give a definite positive indication when the reactor power is at about 5 kW.
10. If the desired reactor power is greater than 20 W, the reactor shall first be taken to 20 W, (or some similar low power as specified by the Senior Operator on Duty), put in automatic control, and the hourly logs taken. The Reactor Operator shall check that all instrumentation is functioning properly.
11. If the desired reactor power is greater than 20 kW, the reactor shall be taken to 20 kW (or some similar intermediate power between 6 kW and 60 KW as specified by the Senior Operator on Duty), put in automatic control, and the hourly logs taken. The Reactor Operator shall check that all instrumentation is functioning properly, especially the safety (power) channels.

Rev. AEB

C. Procedures

1. Clean core, shim rods at 6 inches and neutron source installed.
   1. While observing the log count rate recorder for any unexpected increase, withdraw all shim rods to shim range. Do not exceed an rod position indicator value of 12.5 inches. The shim range indication lights (yellow-below rod position indicator for each shim rods) will come on

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TITLE: Reactor Start Up Procedure		

between 12.0 and 12.5 inches.

2. While observing the log count rate recorder for any unexpected increase, withdraw the regulating rod to 15.0 inches. Note the increase in counts per second on the log count rate recorder. (The count rate will have approximately doubled if all the shim/safety rods have been withdrawn.)
3. While observing the log count rate recorder withdraw the shim rods an additional 1.0 inch. The console operator should not obtain a slope of less than 1.0 (angle of less than 45° from horizontal) during or after rod withdrawal.
4. Monitor the value on the linear recorder. If the reading reaches 80% of selected scale, change the range selector switch one position counter clockwise (up scale).
5. Continue steps 3 and 4 until a shim rod height of 18.0 inches is obtained. Pause for a short amount of time between each 1.0 inch withdrawal, (approximately 5 seconds).
6. While observing the log count rate recorder withdraw the shim rod an additional 0.25 inches. The console operator should not obtain a slope of less than 1.0 (angle of less than 45° from horizontal) during or after rod withdrawal.
7. Continue steps 4 and (5) until the reactor goes critical. Pause for a short amount of time between each 0.25 inch withdrawal. When the log count rate recorder shows a steady constant increase in value without shim rod withdrawal is an indication that the reactor is critical.
8. Observe the log n recorder and the period recorder for indication that they are within their operating range. The period recorder will indicate a period of less than

ASB Rev.

6, not 5

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UNIVERSITY OF MISSOURI-ROLLA - NUCLEAR REACTOR		
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infinity (∞) and there will be an increasing power level indication on the log N recorder (vertical line). Typically the period and log N meters and recorders will begin to provide positive indications when the log count rate recorder is at approximately $3x10^3$. Rev.

9. When the log count rate recorder reaches full scale (10^4) withdraw the fission chamber until a log count rate recorder reading of 10^2 is obtained. Prior to withdrawal of the fission chamber the operator shall have indication of reactor power on the linear and log n recorders.

10. Establish a reactor period as requested by the Senior Operator on Duty, (or approximately 50 seconds) and continue the reactor power increase to the desired power level on the linear range selector.

11. When the linear power is on the 6 watt scale ask someone to withdraw the startup source. Rev.

12.* When the linear recorder reaches approximately 98% a "green" Auto Permit light will come on. This will allow the regulating rod to be placed in Automatic Control (signal from linear recorder). When the auto permit light occurs, insert the shim rods in "bumps" until the period recorder indicates a reactor period of approximately 400 seconds.

13.* Allow reactor power to increase to 101% on the linear recorder and place the regulating rod in automatic control. This is done by placing the "Manual Auto" switch (below the

*Note: This step assumes an auto setpoint at 100% of linear recorder, for values other than 100% the shim rod insertion should occur at -2% of setpoint and "auto" selected at +1% of setpoint.

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auto permit light) in the auto position. When the "Auto" light comes on release the switch (return to neutral).

14. Ensure that the regulating rod momentarily inserts (white light) and is satisfactorily controlling reactor power at the intended setpoint (red pointer on linear recorder).
15. Reset the Manual Operations Annunciator.
16. Record the time from the console clock in the Hourly Log (time at power).
17. Inform personnel of the reactor power level on the building public address system. "The reactor is at a power level of ________ watts or kilowatts".
18. Position the fission chamber to achieve a log count rate recorder indication of 10^2 (mid scale).
19. Complete Hourly Logs in accordance with SOP 104.

2. High-residual activity (hot) core, shim rods at 6 inches and neutron source installed.
   1. Perform actual startup steps similar to those of C.1 for a clean core, except pause slightly longer between rod withdrawals and be prepared for the reactor to behave differently than usual and for the critical rod height to be different than for a cold, clean core. Rev.

WRITTEN BY: Milan Straka	APPROVED BY: Albert Bolon

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Semi Annual Check List

Date Commenced________________

Date Completed________________

Total Hours on Hour Meter__________

1. Log N and Period Channel — Initial

a. Nog N Power Supply

		Initial
(1) Cleaned chassis		______
(2) Tested all vacuum tubes		______

Replaced:

tube #	tube type
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

b. Log N Recorder — Date__________

	Initial
(1) Cleaned chassis	______
(2) Tested all vacuum tubes	______

Replaced:

tube #	tube type
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

c. Neutron Detector Check	Resistance (ohms)	Capacitance (pf)	
(1) Signal to ground	____________	____________	______
(2) Positive to ground	____________	____________	______
(3) Negative to ground	____________	____________	______

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d. Log N Calibration Date________________ Initial

1. Meter	Recorder	Keithley	
100	______	______	______
10	______	______	______
1	______	______	______
0.1	______	______	______
.01	______	______	______
.001	______	______	______
.0001	______	______	______

Reconnection of Cables Verified ______

Note: The ratio of true-to-observed readings should be between 0.7 and 1.4

e. Period Recorder Date________________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced:	tube #	tube type
	______	______
	______	______
	______	______
	______	______
	______	______

2. Linear Power Channel

a. Linear Power Supply Date________________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced:	tube #	tube type
	______	______
	______	______
	______	______
	______	______
	______	______

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b. Linear Recorder Date________________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced: tube # tube type

tube #	tube type

c. Micro-Micro Ammeter (Spare) Date________________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced: tube # tube type

tube #	tube type

d. Linear Neutron Detector Check

	Resistance (ohms)	Capacitance (pf)	
(1) Signal to ground			
(2) Positive to ground			
(3) Negative to ground			

e. Micro-Micro Ammeter replacement

(1) Remove Micro-Micro Ammeter from console and replace with spare ______

(2) Reconnection of cables verified ______

Note: Any instrument found to be out of calibration should be realigned in accordance with procedures.

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f. (Linear Cont.) Record after step e. (1) has been performed

(1) Keithley	Meter	Recorder	Initial
6.66×10^{-5}			
2.0×10^{-5}			
6.66×10^{-6}			
2.0×10^{-6}			
6.66×10^{-7}			
2.0×10^{-7}			
6.66×10^{-8}			
2.0×10^{-8}			
6.66×10^{-9}			
2.0×10^{-9}			
6.66×10^{-10}			
2.0×10^{-10}			

g. Reconnect all cables ______
Reconnection of cables verified ______

Note: From 10^{-5} to 10^{-8}, the overall accuracy should be better than 2% of full scale. From 3×10^{-9} to 3×10^{-10} the overall accuracy should be better than 4%.

3. Log Count Rate Channel — Initial

a. Log Count Rate Recorder — Date____________
(1) Cleaned chassis ______
(2) Tested all vacuum tubes ______
Replaced:

tube #	tube type

b. Fission Preamp — Date____________
(1) Cleaned chassis and inspected ______

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b. Fission Preamp (cont.)

(2) Additional Comments

c. Log Count Rate Channel Date________________

(1)

Pulse Generator*	Meter	Recorder	Initial
10	______	______	______
100	______	______	______
1,000	______	______	______
10,000	______	______	______

Reconnection of cables verified ______

Note: All readings should give .7 to 1.4 ratio of true-to-observed readings

4. Safety Channels

a. Safety Preamp Date________________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced:

tube #	tube type
______	______
______	______
______	______
______	______
______	______

b. Neutron Detector #1

	Resistance	
(1) Signal to ground	______	______
(2) Positive to ground	______	______

(3) Additional Comments

c. Neutron Detector # 2

	Resistance	
(1) Signal to ground	______	______
(2) Positive to ground	______	______

(3) Additional Comments

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4. Safety Channels (cont.) Initial

d. Safety Amplifier Date ________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

Replaced:

tube #	tube type
______	______
______	______
______	______
______	______
______	______

e. Safety Amplifier Adjustments ______

f. Replace all cables to safety amplifier ______

Reconnection of cables verified ______

5. PAT 60 Controller

a. PAT 60 Date ________

(1) Cleaned chassis ______

(2) Tested all vacuum tubes ______

b. Check dial settings and record the following

(1) Approach ________ ______

(2) Proportional Bond ________ ______

(3) Rate Time ________ ______

(4) Reset ________ ______

(5) Gain (if applicable) ________ ______

6. Temperature Recorder Date ________

a.

Reading #	Thermometer	Recorder	Initial
1	80°F	______	______
2	80°F	______	______
3	80°F	______	______
1	140°F	______	______
2	140°F	______	______
3	140°F	______	______

Note: All readings should be ± 1°F

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6. Temperature Recorder (cont.) Date________________ Initial

   b. 135°F Interlock Trip Point ______

   ____

7. Regulated Power Supply Date________________

   a. Cleaned chassis ______
   b. Additional comments

8. Conductivity Bridge Date________________

   a. Cleaned chassis ______
   b. Additional comments

9. Relay Test Date________________

   a. Console relays tested and replaced as per SOP 815 ______
   b. Relays Replaced ________________ ______
   ____
   ____

10. Rod Indicator Calibration Date________________ ______

Actual Height	I.	II.	III.	Reg.
1"	______	______	______	______
6"	______	______	______	______
12"	______	______	______	______
18"	______	______	______	______
24"	______	______	______	______

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Albert Bolon

Approved By: Albert Bolon

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11. Fire Alarm Check Date________________ Initial

a. Cleaned system containers ______
b. Changed batteries ______
c. Checked pull stations ______
d. Checked heat detectors ______
e. Checked smoke detectors ______
f. All indicator lamps operate ______

12. Security System Check Date________________

a. Door Sensors ______
b. Motion Detectors ______
c. Duress Alarm ______
d. Control Modules (at UMR Police office) Date____________
(1) Power Supply ______
(2) Control Module ______

13. Public Address System Date________________

(1) Cleaned chassis ______
(2) Additional Comments

14. Area Radiation Monitor Date________________

(1) Cleaned chassis ______
(2) Additional Comments

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Date____________________

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

______________________ or ______________________
Director Reactor Manager

The following Standard Operating Procedures were slightly changed in the accounting period. Thus the entire pages were not included in this report because the changes were not considered to be substantive.

SOP	Page(s)	Revision Date
101	1,2,3	9-4-84
102	1,2,3,4,5,6,7	9-4-84
103	1,2,3,4,5	9-4-84
104	1,2,3,4,5,6	3-28-85
105	1,2,3,4	9-4-84
107	1,2,3	9-4-84
108	1	9-4-84
109	1	9-4-84
112	1	9-4-84
115	1,2,3,4	9-4-84
201	1,2	9-4-84
204	1,2,3,4,5,6,7	9-4-84
206	1,2	9-4-84
208	1,2,3	9-4-84
301	1,2	9-4-84
302	1,2	9-4-84
303	1,2	9-4-84
304	1,2	9-4-84
305	1	9-4-84
307	1,2,3,4	7-17-84
308	1,2,3	2-28-85

SOP	Page(s)	Revision Date
401	1,2,3,4	9-4-84
402	1,2	9-4-84
501	1,2,3,4,5,6,7	9-4-84
507	1	1-14-85
507	2,3,4,5,6,7	7-11-84
600	1,2	9-4-84
600	3	1-18-85
601	1,2,3	9-4-84
602	1,2	9-4-84
603	1,2,3,4	5-9-84
604	1,2,3	5-9-84
605	1,2	5-9-84
606	1,2	5-9-84
703	1,2	9-4-84
704	1,2	9-4-84
800	1,2,3,4,5,6,7,8,9	3-26-85
816	1,2,3,4	2-7-85

APPENDIX D

Changes Authorized by 10 CFR 50.59

1. Change in the Core Access Element Drawing

During the review for an experiment using the core access element it was discovered that the element's graphite filling had been omitted in the sketch and the element description given on pages 3-17 and 3-18 in the UMRR Safety Analysis Report (SAR). However, the proper reactivity upon the accidental flooding based on the data provided by Curtiss & Wright was taken into account in the accident analysis performed in Section 9.2 of SAR. Subsequent evaluations and calculations performed in conjunction with the planned experiment confirmed the results given in SAR. For the purpose of determining the reactivity worth of the core access element a subcritical experiment was performed on 3 April 1985. Experimental data have shown that its reactivity worth at the core periphery is about 0.02% $\Delta k/k$. A revised sketch of the core access element is shown on the next page.

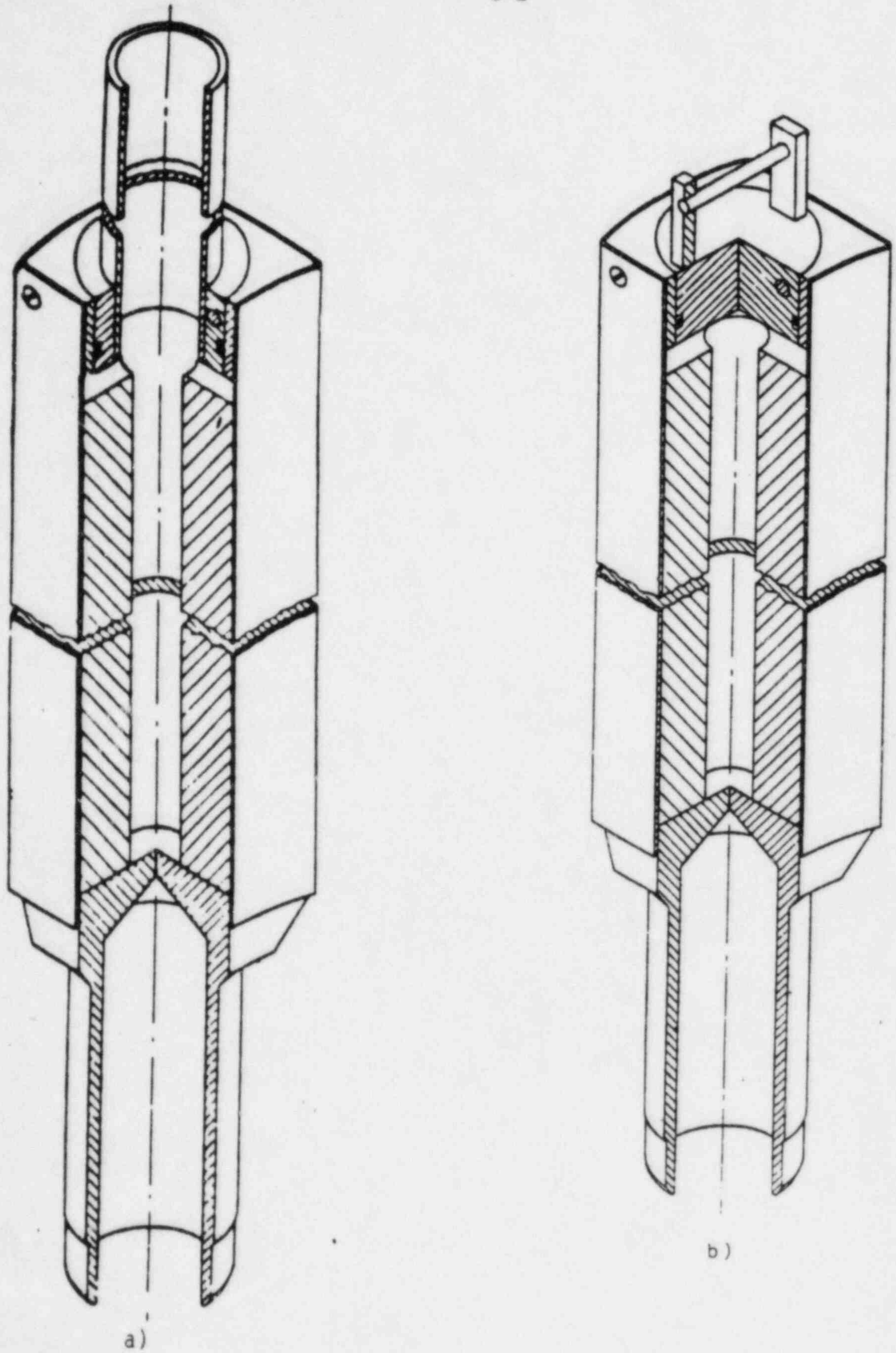

Figure 15. (a) Core access element

(b) Isotope production element.

Rev.4-10-85

2. Change in the Preparation of the Annual Examination for Licensed Operators

The UMRR Operator Requalification Program specifies on page 4 (third paragraph) that "The exam with answer sheet will then be reviewed by the Head of the Safety Committee for his approval." This has been changed in that this statement now reads as follows "The exam with answer sheet will then be reviewed by a faculty member from the Nuclear Engineering Department of the University of Missouri-Rolla or other knowledgeable person." The revised page of the Operator Requalification Program is included on the next page.

a. Lectures or review seminars to present or discuss in a preplanned manner the information relative to each of the areas listed above. Personnel assigned to prepare questions or sections of the annual exam may be exempt for those specific questions or sections.

b. Worksheet questions and problems which the operator can answer in his spare time.

The training coordinator will be assigned responsibility to prepare the ten sections of the annual exam. The exam with answer sheet will then be reviewed by a faculty member from the Nuclear Engineering Department of the University of Missouri-Rolla or other knowledgeable person. The training coordinator will assign to various staff members topics for which they must write, in outline form, and present to the rest of the staff in a formal lecture. The lectures will be on topics, that will comply with 10 CFR 55 Appendix A. The evaluation of each operator will be facilitated by completing an examination record form as shown in Appendix A to this document.

1 Rev. 4-15-85

An operator will be considered to be deficient in any area of the exam if he scores a grade of less than 80% in that area. If the average grade for an operator in all sections is less than 80%, the operator shall be relieved of all licensed activities until he has been retrained and satisfactorily passes re-examination with an average grade greater than 80%.

After all of the examinations have been graded, the Training Coordinator will prepare the retraining schedule for those operators who were deficient in any area. The TC will use Retraining Schedule sheets as shown in Appendix A to facilitate the scheduling.