SCHOOL OF
ENGINEERING
& APPLIED SCIENCE

NUCLEAR REACTOR FACILITY
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March 25, 1994

Director, Division of Reactor Licensing
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Document Control Desk
Mail Stop P1-137
Washington, D.C. 20555

Re: Docket No. 50-62
Docket No. 50-396

Dear Sir:

We hereby submit, as required by section 6.6.2 of the Technical Specifications, our annual report of the operations of the University of Virginia Reactor (UVAR), License No. R-66, Docket No. 50-62 and the CAVALIER Reactor, License No. R-123, Docket No. 50-396 during the period January 1, 1993 through December 31, 1993. This report has been reviewed and approved by the Reactor Safety Committee.

Sincerely,

J. P. Farrar

J.P. Farrar, Administrator
U.Va. Reactor Facility

City/County of Albemarle
Commonwealth of Virginia

I hereby certify that the attached document is a true and exact copy of a letter (type of document), presented before me this 25th day of March, 1994 by J.P. Farrar (name of person seeking acknowledgement)

Vickie S Thomas
Notary Public

Commission expires 2/28 1998

cc: USNRC, Mr. A. Adams
USNRC, Region II

IE47

UNIVERSITY OF VIRGINIA

REACTOR FACILITY

1993 ANNUAL REPORT

1993 ANNUAL REPORT
UNIVERSITY OF VIRGINIA REACTOR FACILITY

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1993 ANNUAL REPORT

University of Virginia Reactor Facility

I. INTRODUCTION

A. Reactor Facility Reporting Requirements

1. Reporting Period

This report on Reactor Facility activities during 1993 covers the period January 1, 1993 through December 31, 1993.

2. Basis for Reporting

An annual report of reactor operations is required by the UVAR and CAVALIER Technical Specifications, section 6.6.2. Additionally, it is the desire of the Facility management to document and publicize the most important results derived from reactor operations.

B. Reactor Facility Description

The Reactor Facility is located on the grounds of the University of Virginia (U.Va.) at Charlottesville, Virginia and is operated by the Department of Mechanical, Aerospace and Nuclear Engineering. The Facility houses the UVAR 2 MW pool type research reactor and CAVALIER 100 watt training reactor (now shutdown, awaiting decommissioning in 1994). The Facility also has a 4,200 curie cobalt-60 gamma irradiation facility, a hot cell facility with remote manipulators, several radiochemistry laboratories with fume hoods, radiation detectors, counters and laboratory counting equipment, computerized data acquisition-analysis systems, and fully equipped machine and electronics shops.

1. 2 MW UVAR Reactor

The UVAR reactor is a light water cooled, moderated and shielded type reactor that first went into operation at a licensed power level of one megawatt in June 1960, under license No. R-66. In 1971, the authorized power level was increased to two megawatts. In September 1982 the operating license for the UVAR was extended for 20 years. Figure 1 shows a layout of the reactor and the various experimental facilities associated with it.

UVAR Experimental Facilities

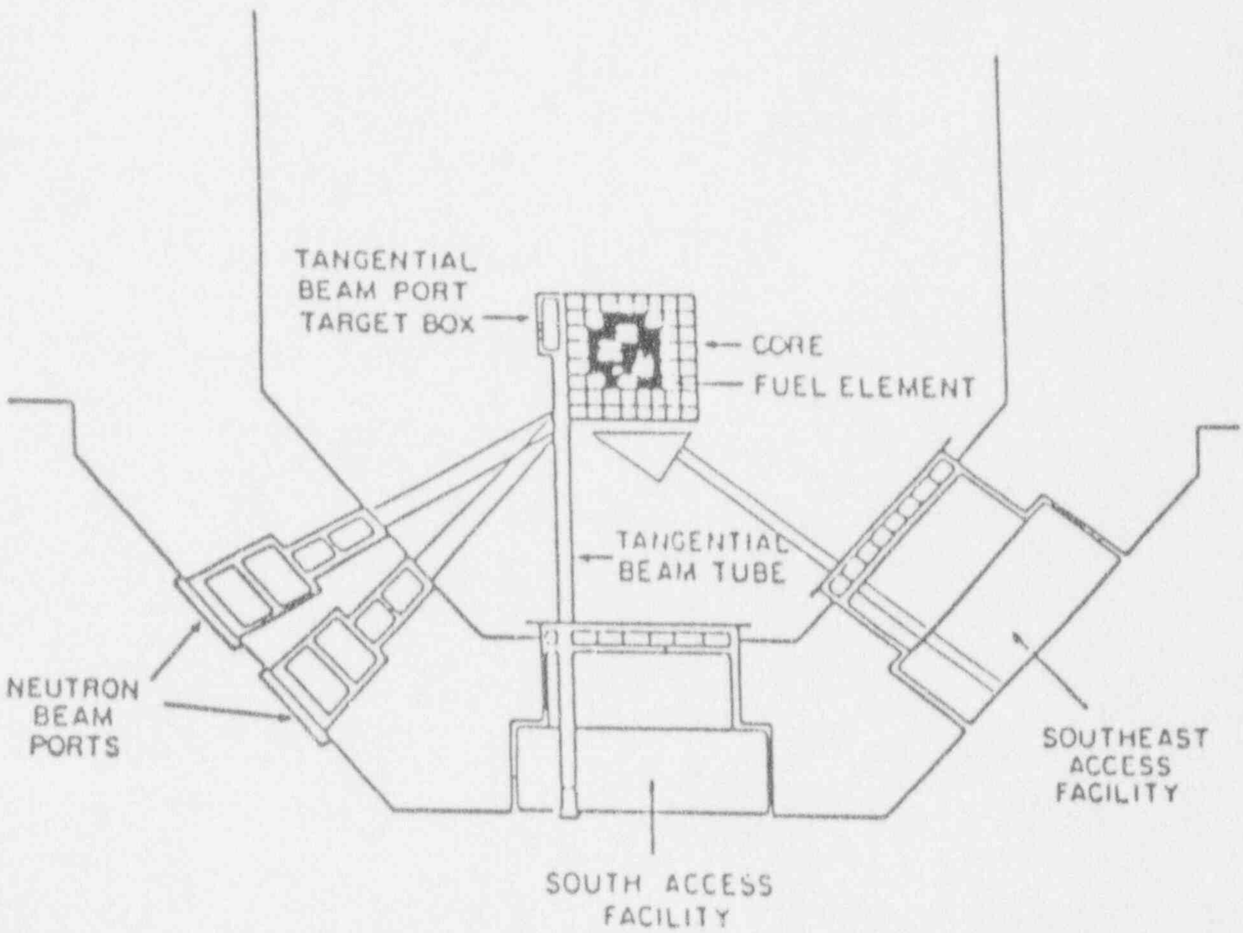


Figure 1

2. <u>100 W CAVALIER Reactor</u>

The CAVALIER (Cooperatively Assembled Virginia Low Intensity Educational Reactor) first went into operation in October 1974, under license R-123, at a licensed maximum power of 100 watts. The reactor was built to accommodate reactor operator training and perform experiments for undergraduate laboratory courses. The operating license was renewed in May 1985, for a period of 20 years. Figure 2 shows a layout of this reactor and its control room. A dismantlement plan was submitted in November, 1987 to the NRC. The NRC requested a decommissioning plan which was submitted early in 1990. An order to decommission was issued on February 3, 1992. The reactor components, less the fuel and tank, are being donated to the University of North Texas and shipment is planned in the near future.

3. <u>Past Operating History</u>

a. <u>UVAR Reactor</u>

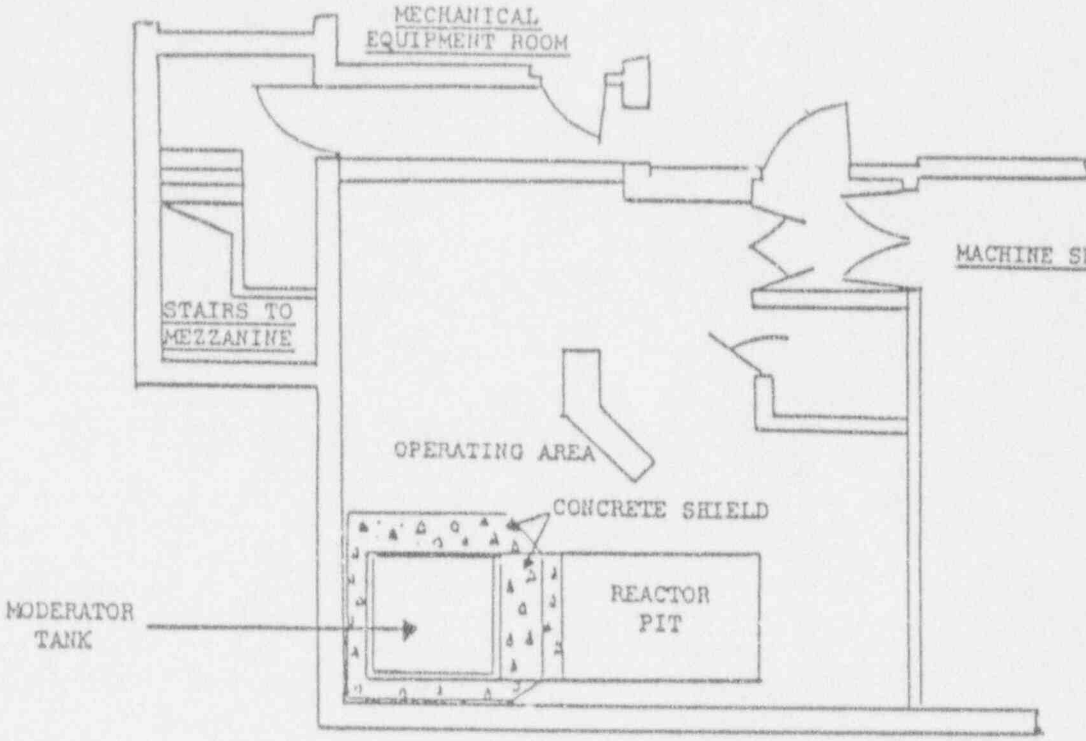
The UVAR reactor operating history is shown in Table 1.

TABLE 1

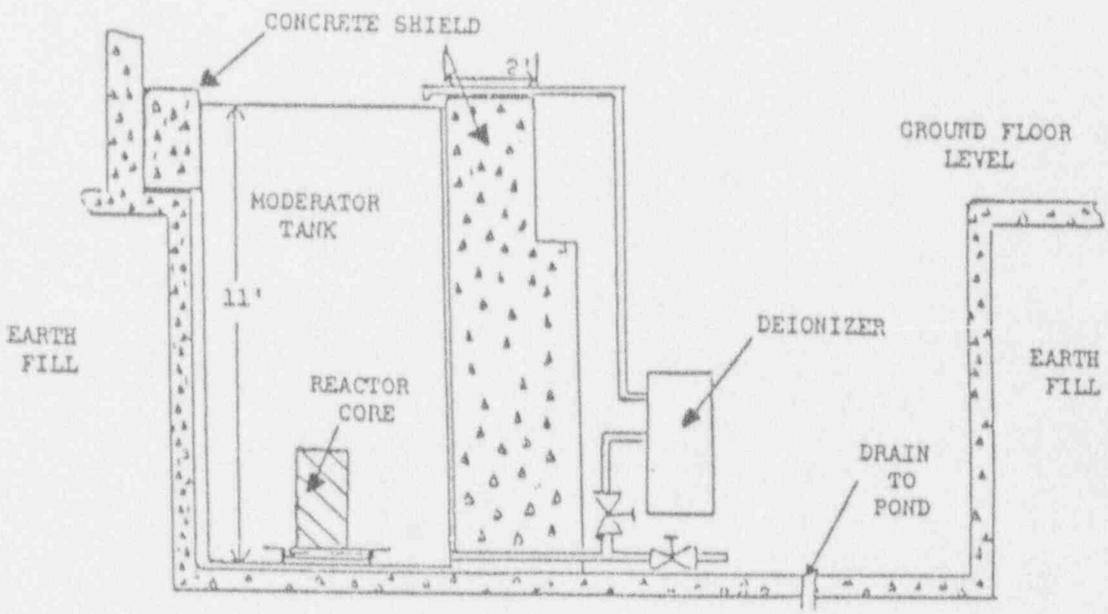
Operating History of University of Virginia Reactor

Years(s)	Megawatt-hours	Hours Operated
1960-1965	1218	1500
1966-1970	2742	3000
1971-1975	1654	1800
1976-1978	1769	1480
1979-1980	9036	5627
1981	4988	3568
1982	5507	3024
1983	6079	3556
1984	5687	3166
1985	927	718
1986	1330	891
1987	1220	801
1988	910	621
1989	1378	869
1990	1837	1087
1991	2360	1365
1992	2428	1450
1993	2663	1533

During the years 1979 through 1984, the UVAR reactor was operated approximately 110 hours per week to irradiate metal specimens for radiation damage studies on pressure vessel steels. Since that time, the reactor has operated on a variable schedule up to 40 hours per week. The intent of the reactor management is to perform various on-going small and diverse irradiation projects, rather than a single large irradiation project.



Plan View of CAVALIER Operating Area



Vertical Section Through Reactor Pit

Figure 2

b. CAVALIER Reactor

The CAVALIER reactor operating history is shown in Table 2.

TABLE 2		
Operating History of CAVALIER reactor		
Years(s)	Watt-hours	Hours Operated
1974-1980	2128	758
1981-1985	1278	388
1986	147	37
1987	28	29
1988-1992	shutdown	shutdown

The CAVALIER reactor has been used primarily for reactor operator training and undergraduate lab experiments, although it has not been operated over the past three years. A dismantlement plan was submitted to the NRC in November, 1987 but the NRC decided the Facility should submit a decommissioning plan. A complete decommissioning plan was submitted in January, 1990. The CAVALIER fuel and start-up source were unloaded on March 3, 1988 and decommissioning should be completed in 1994.

4. Summary of 1993 Reactor Utilization

a. UVAR Reactor

During 1993, the UVAR was operated for 1533 hours and a total integrated power of 2663 Megawatt-hours. The following experiments were performed utilizing the UVAR reactor:

- 619 neutron activation analysis (NAA) samples were run in the pneumatic rabbit system.
- Seven sets of samples were run in the mineral irradiation facility (MIF).
- 23 separate runs were made in the canister irradiation facility (CIF).
- 335 hours of reactor operations were dedicated to neutron radiography.
- Hot Thimble experiments were operated for a total of 1332 full power hours.

b. CAVALIER Reactor

The CAVALIER reactor was permanently shut down in 1988 and will no longer be operated.

5. Special Facilities

The following facilities are operated in connection with UVAR:

- Two neutron beam ports, of eight inch diameter entrance, stepped to 10 inches at the exit, are available. One beam port is currently dedicated to neutron radiography.

- Two access ports (6 ft x 4 ft). One port is currently configured for a high energy photon beam, and the other port for a neutron beam.

- Hydraulic rabbit, for activation analysis, permitting samples with less than 0.69 inch diameter and 6 inch length.

- Pneumatic rabbit, for activation analysis, permitting sample diameters of 1 inch and length not exceeding 2.3 inches, accessing either a thermal or an epithermal irradiation facility.

- Solid gel irradiator for electrophoresis.

- Epithermal neutron mineral irradiation facility.

- A rotating irradiation facility used to equalize the neutron levels seen by a large number of specimens.

- Epithermal neutron irradiation facilities with heaters for sample temperature control.

- Cobalt-60 gamma irradiation facility with 4,200 Ci, permitting exposures at rates up to 90,000 R/hr.

- Depleted uranium subcritical facility.

- Small hot cell, with remote manipulators.

- Machine and electronic shops.

- Several radiochemistry labs with fume hoods, counters and standard lab equipment.

- Low-background counting room with shielded, solid state germanium and silicon detectors and computerized data acquisition/analysis system.

@ C. Reactor Staff Organization

1. Operations Staff

A Reactor Facility organization chart is shown in Figure 3. Personnel on the reactor staff as of the end of 1993 were:

R.U. Mulder . . . Reactor Director
J.P. Farrar . . . Reactor Supervisor (SRO)
P.E. Benneche . Services Supervisor (SRO)
B. Hosticka . Research Scientist (SRO)
D.R. Krause . . . Senior Reactor Operator (SRO)
T.E. Doyle . . . . Research Scientist (RO)
W.N. Wilson . . . Technician
J.S. Baber . . . . Machine Shop Supervisor
V.S. Thomas . . Reactor Facility Secretary
M.J. Combs . . . Research Associate (1/2 time)

During the year the Electronic Shop Supervisor took disability retirement and one Senior Operator resigned to attend Law School.

2. Health Physics Staff at the Facility

D.P. Steva . . . . Reactor Health Physicist
E.B. Easter . . . Radiation Safety Technician
S.M. Garver . . . Radiation Safety Technician

The Health Physicist is assisted by a Reactor staff member paid from reactor services income. Other health physicists and technicians employed by the University are on call with the Office of Environmental Health and Safety.

3. Reactor Safety Committee

The Reactor Safety Committee is composed of the following individuals:

A.B. Reynolds . Professor, Nuclear Engineering - Chairman
W.R. Johnson . . Professor Emeritus, Nuclear Engineering
R.A. Rydin . . . . Associate Professor, Nuclear Engineering
J.S. Brenizer . . Associate Professor, Nuclear Engineering
J.R. Gilchrist . . Assistant Director, Environmental Health & Safety
G.T. Gillies . . . Research Professor, Mech. & Biomedical Eng.
R.U. Mulder . . . Reactor Director & Asst. Professor, Nuclear Engineering
R.G. Piccolo . . . University Radiation Safety Officer

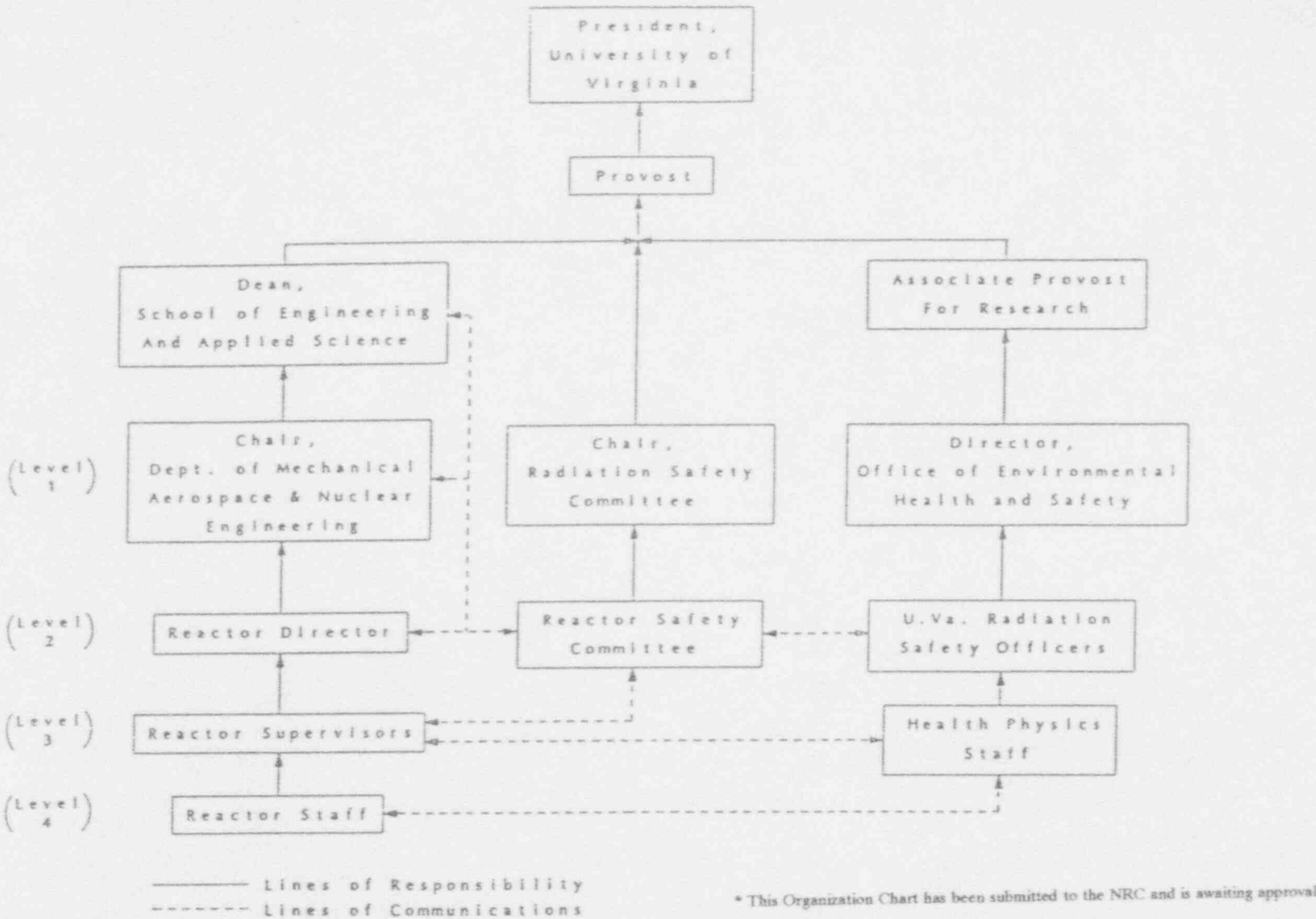


Figure 3 Organizational Structure of the U.Va. Research Reactor Facility

II. REACTOR OPERATIONS

A. UVAR Reactor

1. Core Configurations

A typical UVAR core configuration is shown in Figure 4. The reactor employs three boron-stainless steel safety rods and one stainless steel regulating rod for fine power control. The fuel elements are of the Materials Test Reactor (MTR) curved plate-type elements, utilizing a U-Al alloy. The fuel is approximately 93% enriched in the U-235 isotope. The elements have 18 fuel plates per element, with a loading of approximately 195 grams of U-235 per element. The control rod elements have 9 fuel plates with a loading of approximately 97.5 grams U-235/element. A plan view of these elements is shown in Figure 5. The UVAR reactor made its last operation with HEU fuel on December 22, 1993.

2. Standard Operating Procedures

Five sections of the UVAR standard operating procedures were changed during the year in the areas of: General Regulations, Checklists, Operating Procedures, System Calibration, Waste Release, and Radiation Controls. The Reactor Safety Committee reviewed and approved these changes.

3. Surveillance Requirements

The following surveillance items were completed during the year as required by Section 4.0 of the Technical Specifications:

a. Rod Drop Tests and Visual Inspection

Rod drop times are measured at least semi-annually, or whenever rods are moved or maintenance is performed.

Magnet release time should be less than 50 milliseconds and free drop time less than 700 milliseconds.

Rods are visually inspected at least annually.

Rod drop times were measured on the UVAR reactor and are shown in Table 3.

UNIVERSITY OF VIRGINIA REACTOR CORE LOADING DIAGRAM

CORE LOADING 34-E SHUTDOWN MARGIN 1.31 % delta k/k

Date December 7, 1993 EXCESS REACTIVITY 2.81 % delta k/k

U-235 3717 GRAMS EXPERIMENT WORTH 0.563 % delta k/k

F - Normal Fuel Element
PF - Partial Fuel Element
CR - Control Rod Fuel Element
G - Graphite Element
S - Graphite Source Element
REG - Control Rod Fuel Element with Regulating Rod
P - Grid Plate Plug
HYD RAB - Hydraulic Rabbit
THER RAB - Thermal Pneumatic Rabbit
EPI RAB - Epithermal Pneumatic Rabbit
RB - Radiation Basket

Rod Worths #1 - 1.81 % #2 - 2.98 % #3 - 2.31 % Reg - 0.189 %

MINERAL IRRADIATION FACILITY

G 11	F V-05 12	F V-04 13	F-REG VC-26 14	F V-02 15	F V-01 16	CANISTER IRR. FAC. 17	P 18
G 21	F V-06 22	F V-14 23	V-27 24	F-CR1 VC-21 25	F V-13 26	27	P 28
G 31	F V-08 32	F-CR2 VC-25 33	F V-03 34	F T-10 35	F T-24 36	37	P 38
G 41	F V-09 42	F V-11 43	F-CR3 VC-20 44	F V-10 45	F T-30 46	47	P 48
G 51	F T-18 52	F T-13 53	F T-09 54	F T-14 55	F T-8 56	57	P 58
G 61	G 62	H.T. #1 63	G 64	G 65	S 66	P 67	P 68
G 71	THER RAB 72	G 73	EPI RAB 74	G 75	G 76	HYD RAB 77	P 78
G 81	G 82	G 83	G 84	G 85	G 86	G 87	G 88

Figure 4

HEU FUEL ELEMENTS
(Dimensions in inches)

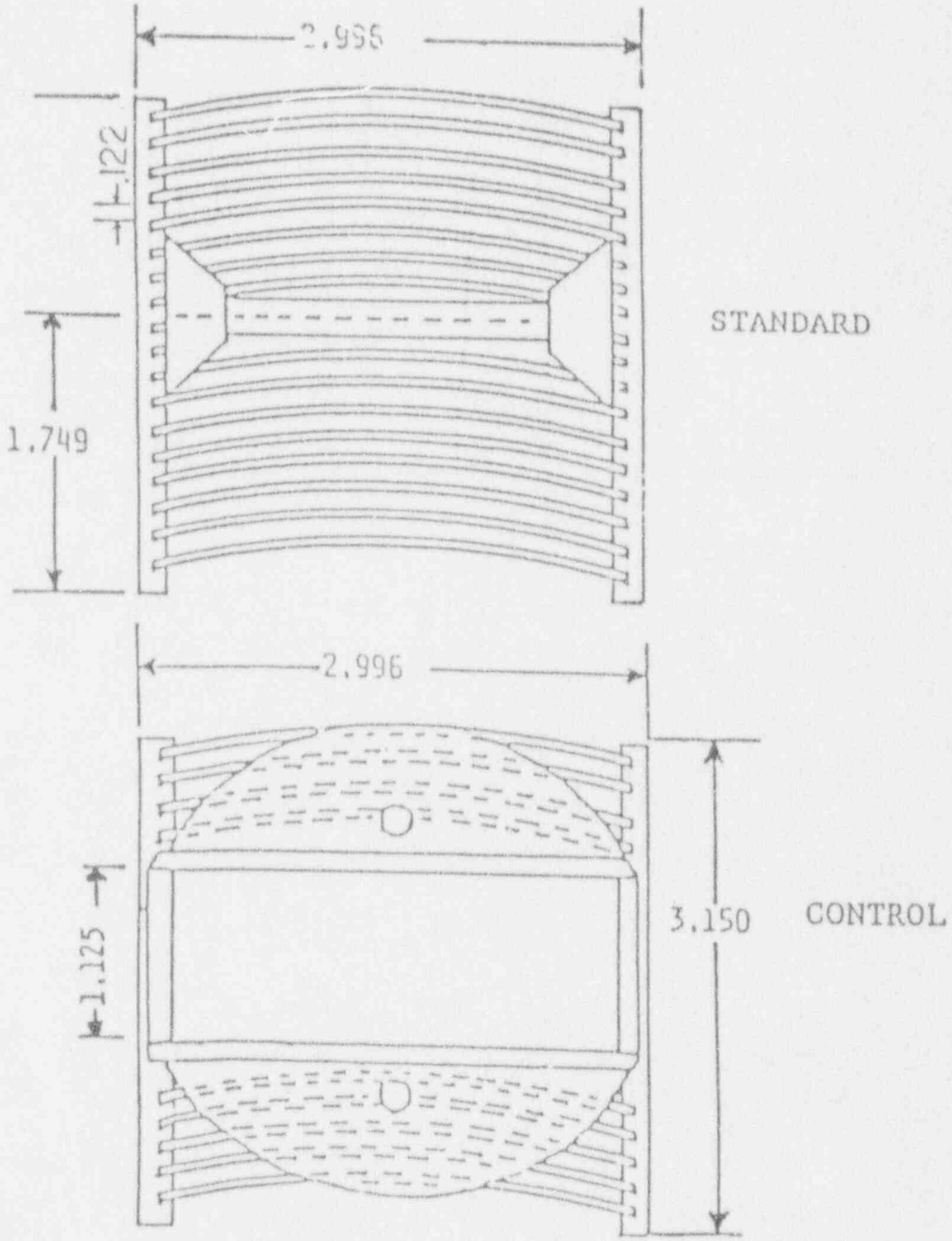


Figure 5

TABLE 3					
Measured Control Rod Drop Times on UVAR Reactor					
Rod Number	Magnet Current (m-amps)	Rod Position (inches)	Magnet Release Time (msec)	Free Drop Time (msec)	Total Drop Time (msec)
4-15-93 Semi-annual Surveillance					
1	165	26	13	478	491
2	165	26	32	455	455
3	75	26	26	595	621
6-15-93 After shutdown for 1.5 months					
1	165	26	11.5	479	490.5
2	165	26	45.5	454	499.5
3	75	26	22.5	457	479.5
7-12-93 After visual inspection of rods					
1	165	26	14	494	508
2	165	26	26	455	481
3	75	26	24	457	481

The rod drop times continue to be within the limits required by the Technical Specifications (700 msec free drop and 50 msec magnet release).

The UVAR control rods were visually inspected on 7-12-93. The following is abstracted from the reactor log book and the surveillance files:

Rod #1 - Inspected rod under ~3 feet of water. Dose rate at surface of water was ~25 mr/hr. No sign of cracking or rub marks. Rod passed 0.95 inch gauge easily.

Rod #2 - Inspected rod under ~3 feet of water. Dose rate at surface of water was ~30 mr/hr. Small rub mark at top. No evidence of cracking. Rod passed 0.95 inch gauge easily.

Rod #3 - Inspected rod under ~3 feet of water. Dose rate at surface of water was ~30 mr/hr. Small rub mark at top. No evidence of cracking. Passes 0.95 inch gauge easily.

b. Tests and Calibrations

Data on these tests and calibrations are on file at the Facility.

1) Monthly

Operational checks of the ventilation duct, personnel door, truck door and emergency exit cover were performed as required.

2) Semi-Annually

Visual inspection of gaskets on personnel door, ventilation duct and truck door was completed.

Calibration checks of source range channel, linear power channel, core gamma monitor, bridge radiation monitor, reactor face monitor, duct argon monitor, constant air monitor, pool level monitors, pool temperature monitor, core differential temperature monitor, and primary flow instrument were done.

3) Annually

The emergency cooling system was tested during the month of September, 1993. The results are as follows:

	S.E. Tank (gal/min)	S.W. Tank (gal/min)
minimum required flow	11.0	11.5
9-13-93 actual flow	12.1	12.1
last five year range	11.8-12.2	12.1-12.9

No pattern was observed in the variation of the test results for the last five years.

4) Daily Checklist

The daily checklist, which is completed when the reactor is to be operated, provides for checks on all the significant automatic shutdown systems associated with the reactor.

5) Reactor Pool Water Quality

The Technical Specifications require that the pH and conductivity of the pool water be measured at least once every two weeks. These measurements were actually made on a daily basis when the reactor was operating and at least once each week. These measurements have indicated that the water quality was maintained well within the Technical Specification limits of pH between 5.0 and 7.5 with conductivity < 5 micromhos/cm.

6) Core Configuration Changes

a) In April, 1993, the control rods were due for calibration. In order to gain more excess reactivity, a high burnup element was replaced with a fresh element. The rods were then recalibrated and the worth of all experimental facilities was remeasured.

b) In July 1993, a Hot Thimble experiment was removed from the core and replaced with a new Hot Thimble. The difference in reactivity worth for these changes was 0.024% $\Delta k/k$ and did not require recalibration of the rods.

c) In September, 1993, Hot Thimbles were again exchanged in the reactor. The reactivity change was 0.014 % $\Delta k/k$ and did not require recalibration of the rods.

d) In October, 1993, the integrated power since the last rod calibration was approaching the limit of 1200 MW-hr. The rods were again recalibrated and the worth of all experimental facilities was measured.

e) In December, 1993, a Hot Thimble was removed from the core, requiring recalibration of the rods and measurement of experiments.

7) Communication Checks

The security system and emergency communications with the University Police and Fire Department were checked on a weekly basis throughout the year.

Data on all of these tests and calibrations are on file at the Facility.

4. Maintenance

The maintenance performed on the UVAR reactor systems during the calendar year 1993 is shown in Table 4.

TABLE 4			
Reactor System Maintenance Performed in 1993			
Date	System	Problem	Corrective Action
1-08-93	Intermediate Detector	Detector appears saturated. Not responsive to power change	Replaced detector and checked out O.K.
2-01-93	Holdup Station Monitor	Monitor not functioning properly	High Voltage lead not making connection. Fixed, checked out.
2-01-93	Delta T Monitor	Won't zero in operate mode	Found loose ground wire and fixed.
2-23-93	Intermediate Range	Spurious scrams	Found corroded connections and cleaned and re-soldered.
3-21-93	Scram Logic System	Pool Level #1 and pump-off scrams do not reset	Found broken wire on TB-12 for 10 V power supply.
4-21-93	Linear Power	Unstable signal while at power	Replaced malfunctioning Keithley.
4-22-93	Linear Power	Signal unstable	Cable at detector brittle. Replaced connectors and 2 ft of cable.
5-11-93	Waste Tanks	Broken PVC pipe	Repaired pipe and installed needle valve for better control
5-21-93	Scram Logic System	MD #22 takes a few seconds to reset	Found connection R6 to be loose. Re-soldered connection
5-28-93	Wind sock for wind speed and direction	Wind sock torn	Replaced wind sock
6-09-93	Power Range #2	HV loaded down by detector during calibration check	Removed detector, cleaned connectors, replaced cable connectors
7-19-93	Cooling Tower		Drained and cleaned cooling tower as part of yearly preventative maintenance
7-30-93	Scram Logic System	Modification to MIF system	
8-04-93	Constant Air Monitor	Indicator light in control room flickering	Found and replaced blown fuse and bulb
8-09-93	Core Gamma Monitor	Alarm not functioning	Found and replaced broken wire
8-23-93	Bridge Radiation Monitor	Meter oscillating	Replaced detector
9-07-93	Constant Air Monitor	Recorder not reading same as meter	Found zero out of adjustment. Adjusted and checked out
10-07-93	Reactor Bridge Monitor	Scram with no apparent reason	Checked and cleaned all connectors
10-11-93	Delta T system		Installed new probe to test out new Delta T System
10-19-93	Reg Rod Control	Movement of rod very sluggish	Replaced bad stator
10-19-93	Pool Temperature System	Instrument reading freezes at unreasonable temperature	Found transistor Q3 opens after warming up. Replaced and checked out
10-20-93	Waste Tanks	Tank #2 limit switch stuck	Cleaned contacts and replaced
10-22-93	Reg Rod Position Indication	Reg Rod position does not update automatically	Found transistor QA4 bad. Replaced and checked out

TABLE 4 (continued)			
Reactor System Maintenance Performed in 1993			
Date	System	Problem	Corrective Action
11-03-93	Source Range	Test position "A" not within specs.Period and level unstable	Signal connector found to be oxidized. Replaced connector and two feet of cable.
11-10-93	Conductivity Meter	Erratic readings	Found corroded connectors. Cleaned all connections
11-12-93	Power Range #2	Reading 106% in 100% test position	Performed complete calibration of system

No significant trends were noted in the maintenance.

5. Unplanned Shutdowns

The 34 unplanned shutdowns which occurred on the UVAR reactor during the calendar year 1993 are shown in Table 5.

6. Unplanned Reactor Downtime

On April 28, 1993, while investigating the cause of spurious scrams, a Senior Operator switched two Mixer Driver units in the scram logic drawer to try to isolate the problem, thinking the units were identical. The reactor was started up and run at power for about five hours. When the reactor was shut down it was determined that five scram functions had been bypassed during the run. A thorough investigation revealed that the Mixer Drivers were not identical. The NRC was notified and inspectors came to the facility to investigate the incident. The entire scram logic system was checked out and extensive changes to the operating procedures were made to prevent this from happening again. A Safety System Checklist was established so that any time there is an unplanned shutdown or maintenance performed on the console every scram must be checked prior to operating the reactor. The reactor resumed operations on June 16, 1993. An enforcement conference was held at Atlanta, Georgia on June 29, 1993. A civil penalty of $2000 was imposed on the facility.

TABLE 5		
Unplanned Reactor Shutdowns in 1993		
Date	#	Shutdown Mechanism
01-07-93	1	Manual scram to dislodge air bubbles
01-08-93	1	Building power failure
01-28-93	2	Noise from rod switches; secondary console bumped
02-17-93	1	Operator forgot to flip range switch when increasing power
02-18-93	1	Turned off primary pump to remove air bubbles
02-22-93	3	Noise in Intermediate Period while reactor was subcritical
02-23-93	1	Noise in Intermediate Period, reactor critical at low power
02-26-93	2	Noise in Intermediate Period while reactor was subcritical
04-02-93	1	Building power failure
04-15-93	3	Power failure on one, no indication on others, reactor subcritical
04-16-93	3	Power failure on one, no indication on others, reactor subcritical
04-27-93	1	Manual scram, operator mistakenly thought MIF compressor was off
04-28-93	1	Reactor scram with no indication of cause
06-16-93	1	Building power failure
06-25-93	1	Building power failure
06-28-93	1	Building power failure
07-06-93	1	Beamport spurious trip, possible power failure
07-14-93	1	Momentary loss of building power
07-15-93	1	Power Range #1 while adjusting detector position
07-30-93	1	Operator moved switch on Reactor Bridge monitor, causing scram
08-05-93	1	Lost power to secondary console
09-23-93	1	Lost power to secondary console
10-07-93	1	Noise in Reactor Bridge Monitor - survey showed no problem
10-20-93	1	Noise in NNBP intrusion alarm - no one was in area
11-17-93	1	noise in NNBP intrusion alarm - no one was in area
11-18-93	1	MIF compressor cut off by automatic timer - reactor was operating late past timer setting.

7. Pool Water Make-up

During the first half of 1993, make-up water to the UVAR pool averaged approximately 28 gallons per day, which is normal. In the early fall the makeup increased and a small leak was discovered at the S.E. Access Facility. Makeup averaged about 150 gal/day. The observed leakage was routed to the liquid waste tanks, but did not account for all of the makeup. It was felt that some of the water was finding its way into the ground under the pool. Daily water samples have been taken of the pond behind the building and the reactor pool and analyzed for gross Beta activity, H-3, and Gamma spectrum. An outside contractor has made several attempts to seal the leak, with partial success, and efforts continue to find the source of the leakage. Weekly reports have been made to the NRC concerning the leakage.

8. Fuel Shipments

a. Fresh Fuel

No fresh fuel was received at the facility during the calendar year 1993.

b. Spent Fuel

Twelve spent HEU fuel elements were shipped to Savannah River on 7-28-93.

9. Personnel Training and Instruction

a. Reactor Facility Staff

At the end of 1993 the staff had four senior reactor operators and one reactor operator. All licensed operators participated in the Facility's operator requalification program, which was carried out during the year. The program consisted of periodic lectures, participation in the daily operation of the Facility, performing checklists and start-ups of the reactor and an annual written examination.

b. Summer Course for High School Teachers

During the month of June, 1993, 23 high school teachers from within the state of Virginia attended a one week special course at the Reactor Facility entitled: "Science of Nuclear Energy: Environmental and Safety Issues". The course consisted of formal lectures, laboratory experiments with the UVAR reactor in the areas of sub-critical multiplication, rod calibration, measurement of temperature coefficient and power calibration. During the week the teachers also visited the North Anna Nuclear Power Station.

10. Reactor Tours

During the calendar year 1993, the staff guided 60 groups on tours of the Facility, for a total of 829 visitors.

B. CAVALIER Reactor

1. Core Configuration

The reactor was completely and permanently unloaded during the first week of March, 1988. A decommissioning order was issued by the NRC on February 3, 1992. The decommissioning should be completed in 1994.

III. REGULATORY COMPLIANCE

A. Reactor Safety Committee

1. Meetings

During 1993, the Reactor Safety Committee met fourteen times, on the following dates:

March 9, 1993	May 20, 1993
March 22, 1993	May 27, 1993
April 14, 1993	July 8, 1993
April 30, 1993	October 18, 1993
May 6, 1993	November 1, 1993
May 10, 1993	November 22, 1993
May 12, 1993	December 20, 1993

2. Audits

During the year sub-committees of the Reactor Safety Committee performed two audits of the Facility in the areas of: reactor operations records, the QA/QC program, Irradiation Procedures, and the Operator Requalification Program.

3. Approvals

The Reactor Safety Committee approved changes to the UVAR Standard Operating Procedures during the year in the areas of: General Regulations, Checklists, Operating Procedures, System Calibration, Waste Releases, and Radiation Controls.

4. 10 CFR 50.59 Reviews

The following 10 CFR 50.59 analyses were performed during the year and were reviewed by the Reactor Safety Committee:

a. Modifications to reactor room pool water makeup system, including a timer controlled valve, flow regulator, and flow controlled lamp.

b. Install switch to allow MIF Lead scram to be active while MIF gas scrams are bypassed (when MIF is out of core but lead is not).

c. Labeling of nuclear instrument modules.

d. Remove jumpers in Mixer Drivers which are not part of the scram logic system.

e. Install and seal two inch conduit through wall of UVAR room to run wires for new instrumentation.

f. Install tubing for flow through duct argon monitor to duct ventilating beamports and access facilities.

g. Installation of RTD probe in primary piping for new ΔT system.

B. Changes to the Reactor Facility

1. Low Enriched Uranium Conversion Plans

The NRC mandated in 1986 a change from high enriched uranium (HEU) fuel to low enriched uranium (LEU) fuel, with the date of conversion to depend on several factors. The U.Va. Facility will be among the initial group of research reactor facilities to convert to LEU fuel. A study funded by DOE was begun in the spring of 1986 to accomplish this. A management decision has been made to shut down the CAVALIER reactor and a dismantlement plan was submitted to the NRC, however, the NRC has requested that a complete decommissioning plan be submitted. This was accomplished in early 1990 and a decommissioning order was issued by the NRC in February, 1992. The CAVALIER will be decommissioned in 1994. The present plans call for the conversion of the UVAR reactor in the spring of 1994. The NRC issued an order to convert the UVAR reactor to Low Enriched Uranium in April, 1993. The UVAR made its final run with HEU fuel on December 22, 1993 and the facility will be receiving LEU fuel in early January, 1994. The LEU fuel will be loaded in the UVAR in early spring 1994 for testing.

C. Inspections

During 1993 the Facility underwent three NRC compliance inspections, at the following times and in the areas of:

8-26-93	Reactor Operations
11-01-93	Health Physics
12-16-93	Emergency Preparedness

NRC inspectors also visited the facility for the incident of April, 1993, concerning the scram logic system, in November to observe pool leak repairs, and in December to observe an Emergency Drill.

D. Licensing Action

a) On April 29, 1993, the NRC issued amendment 20 to License R-66 to convert from High-to-Low Enriched Uranium.

b) As the result of an incident at the facility on April 28, 1993, concerning the switching of mixer driver units in the scram logic drawer that resulted in the UVAR being operated for about five hours with five scrams being bypassed. The incident was reported to the NRC. Several reports were sent to the NRC. A Peer review was held at the facility by TRTR personnel. An NRC Enforcement Conference was held in Atlanta on June 29, 1993, and a civil penalty of $2000 was imposed on the facility.

c) A new Operator Requalification Program for the facility was approved by the NRC on October 25, 1993.

E. Emergency Preparedness

1. On January 29, 1993, a practice evacuation of the Facility was initiated by actuating the criticality alarm system located at the fuel storage room. All personnel evacuated in an orderly manner. Verification was made of alarms sounding in the CAVALIER room, first floor hallway and mezzanine hallway.

2. On May 28, 1993 at 11:40 A.M ., a building evacuation drill was initiated by actuating the evacuation alarm. There were 15 individuals in the building at the time and everyone evacuated and were accounted for in about two minutes. During the drill a recently installed battery - backed system for the evacuation alarm was tested and was still functioning properly at the completion of the drill, which lasted about 15 minutes. The two-way radios and the cellular phone was also checked during the drill.

3. Three classroom sessions were held during the months of March, April, and December covering: The Emergency Plan and Implementing Procedures, Health Physics training for emergencies, and table-top scenarios involving several different emergency situations.

4. On December 16, 1993, an emergency drill involving the University Police and the Rescue Squad was held at the facility. The drill was observed by two NRC inspectors, three people from the Va. Office of Emergency Services, and senior personnel from the U.Va. Police.

The scenario involved a forced entry into the building with the lock on the side door taped open. The intruder encounters a student in the building who is rendered unconscious. The student is placed under a table in a lab on the mezzanine level. While moving the student the intruder turns over a container of radioactive liquid which contaminates the students clothing. Subsequently a bomb threat is phoned in to the University Police.

The drill began at 0603 A.M. when the University Police, on a routine patrol around the outside of the facility, found the mezzanine door ajar with the lock taped open. An alternate emergency support center was set up at the Office of Environmental Health and Safety. Several entries were made into the building by police and staff members over the next two hours using bomb search procedures. The "injured" student was found at 0826 and transported to a rescue squad vehicle. The drill was terminated at 0912. It was noted that the police could have called in a professional bomb squad team with dogs, but they were two hours away and was felt they were not necessary for the drill. If it had been a real bomb threat they would have been called.

5. On December 17, 1993, a practice evacuation was held at the facility. The building evacuation alarm was activated at 1334. The UVAR reactor was operating at 2 MW at the time and automatically shutdown. There were 19 individuals in the building at the time and everyone evacuated in an orderly manner to an area near the front gate and everyone was accounted for. It was determined that the staff retrieved 4 portable survey instruments, 8 pocket dosimeters, 3 portable radios, 1 walkie-talkie, 3 personnel dosimetry racks, the reactor log book, 1 visitors log, a copy of the UVAR SOP's, and 2 copies of the EPIP's. The evacuation alarm system was placed on a battery backup system prior to the drill (at 1326). The alarm was still operating loudly at the end of the drill. The cellular phone and fire radio were also checked satisfactorily. The drill was terminated at 1345.

IV. HEALTH PHYSICS

A. Personnel Dosimetry

1. Visitor Exposure Data For 1993

Visitors to the UVAR primarily consist of students, tour groups, maintenance personnel and vendors. Visitor exposure at the UVAR is monitored through the use of gamma-X-ray sensitive direct reading electronic pocket dosimeters. During 1993, there were 2,528 visitor entries into the Reactor Facility. Of these entries, 1699 were individual visitor entries and 829 were visitors as part of 60 tour groups. Only two visitors received any measurable dose. No visitor received an exposure greater than five milli-roentgens in any one visit.

2. Reactor Facility Personnel Dosimetry Data For 1993

a. Monthly Whole Body Badge Data

Radiation doses received by Reactor Facility personnel were measured using Landauer personnel dosimeters. Film badge dosimeters measured exposure from beta, X, gamma and thermal neutron radiation. In 1993, all personnel working with the neutron beamports at the Facility were issued neutron dosimeters in addition to their whole body film badges. The neutron dosimeters used were Landauer Neutrak ER badges which allowed detection of an extended range of neutron energies. All dosimeters were changed out on a monthly basis.

The dose distribution for personnel badged at the Reactor Facility during the period January 1 through December 31, 1993 is shown in Table 6.

TABLE 6	
Personnel Radiation Does Received at Reactor Facility	
Measured Cumulative Total Dose* (mrem)	Number of Occurrences in 1993
Less than 10	98
10 - 20	10
21 - 30	2
31 - 40	0
41 - 50	2
51 - 60	1
61 - 70	1
71 - 80	0
81 - 90	0
Greater than 90	2

Number of badged personnel: 116 persons

Total population dose for this group: 0.86 person-rem

* whole body deep dose only as measured by film badge dosimeters

NOTE: The dosimeters used by the Reactor Facility had a detection minimum of 10 mrem for gamma, X-rays and thermal neutrons and 40 mrem for energetic beta particles.

The individual who received the highest dose (280 mrem), was a Reactor Facility staff member routinely involved in unloading the mineral irradiation facility and preparing iridium-192 seeds for shipment.

b. Neutron Exposures

Thirteen Facility personnel were issued Neutrak ER neutron badges in 1993. The neutron dose distribution for this group is shown in Table 7.

TABLE 7	
Personnel Neutron Doses at the Reactor Facility	
Measured Cumulative Neutron Dose (mrem)	Number of Occurrences in 1993
Less than 20	12
20 - 30	1
Greater than 30	0
NOTE: These dosimeters have a minimum reporting dose of 20 mrem.	

c. Extremity Exposures

During 1993, 23 Facility personnel wore TLD ring badges in addition to their whole body badges. The following is a summary of the extremity doses received by Reactor Facility personnel who wore ring badges during the period January 1, 1993 through December 31, 1993.

TABLE 8	
Personnel Extremity Doses at the Reactor Facility	
Measured Extremity Dose (mrem)	Number of Occurrences in 1993
Less than 100	19
101 - 500	4
501 - 1000	0
Greater than 1000	0

The individual who received the highest extremity dose (630 mrem), was a Reactor Facility staff member routinely involved in unloading the mineral irradiation facility and handling radioactive materials for neutron activation analysis.

d. Direct-reading Dosimeter Exposures

Direct-reading dosimeters (in addition to whole body film badges) are worn by UVAR personnel when they are handling irradiated material which has a calculated or measured exposure rate of greater than 100 mR per hour, measured at one foot from the source. If the exposure totals more than 5 mR in one day, the exposure is logged into an exposure log kept in the control room. This information is helpful in assessing the amount of exposure received during specific operations. The total of all exposures recorded in the log book during 1993 was 134.3 mR. The highest individual exposure was 18 mR. This exposure was received by an individual preparing iridium seeds for shipment.

B. Effluents Released During 1993

1. Airborne Effluents

Argon-41 gaseous release concentrations are calculated using a methodology described in a June, 1977 memorandum entitled: Memo to Senior Operators - argon 41 production in UVAR." The methodology described in this memorandum assumes:

a. a maximum production rate for Ar-41 (with present UVAR core loading)

b. immediate evolution of Ar-41 from the pool water into the UVAR confinement atmosphere

c. no decay

d. air saturating the UVAR pool water at 68°F.

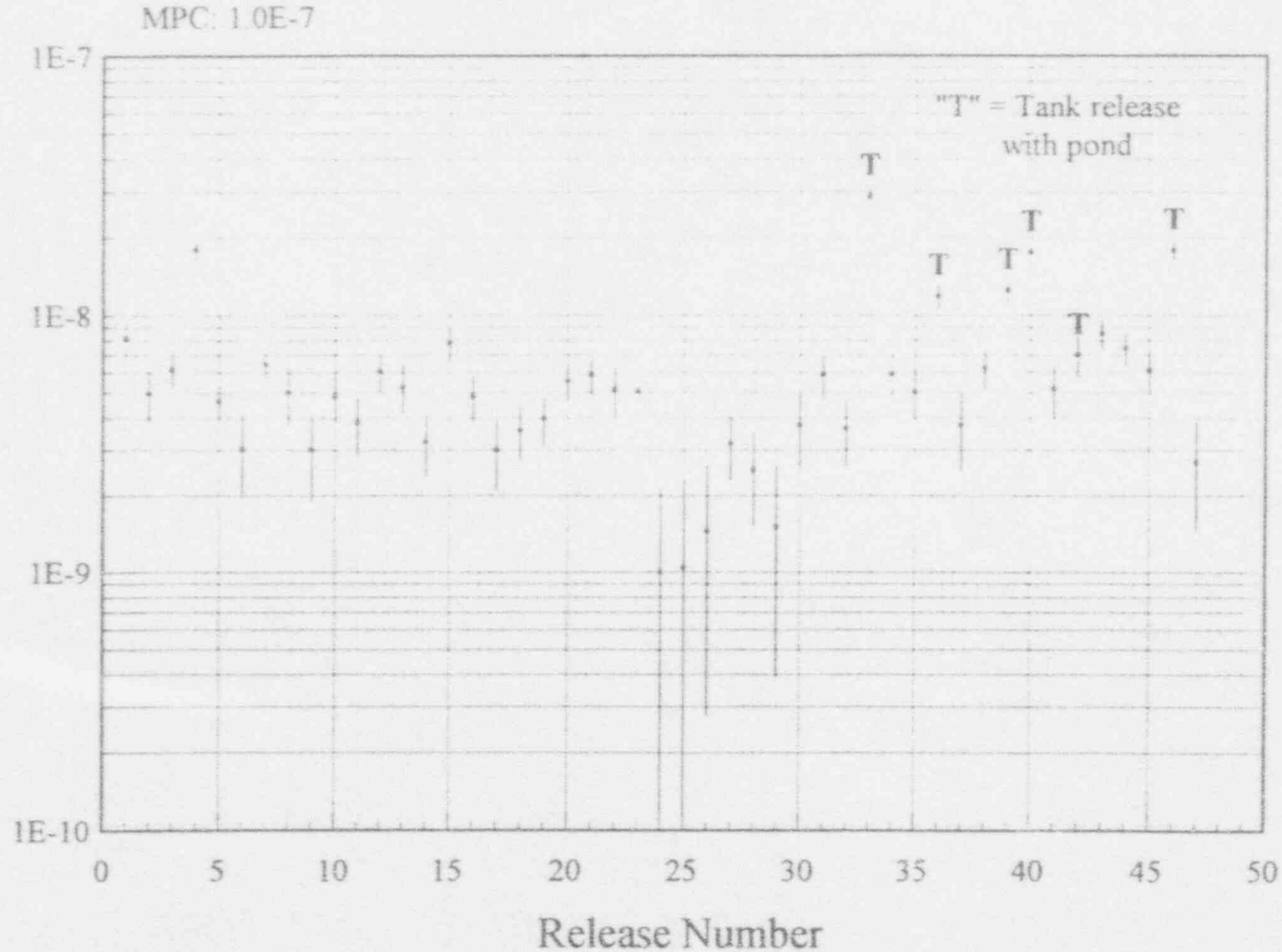
Based on this method, and using the known amount of time the reactor was at power during 1993 (2 MW for 1332 hours), the calculated total activity of Ar-41 released was 3.8 Curies.

2. Liquid Effluents

Liquid radioactive waste generated at the UVAR is disposed of by one of two means. Liquid waste generated in the student laboratories is poured into approved containers which are collected and disposed of by the Environmental Health and Safety Office. Other liquid wastes generated by the UVAR operation are released off-site in accordance with 10 CFR 20 release limits. The majority of liquid released off-site is from an on-site pond. This pond receives surface runoff and water from a creek which flows into it. In unusual situations, it may receive a direct discharge from the facility (e.g. draining of the reactor pool). Regeneration of the UVAR demineralizer system is the major source of radioactivity in the liquid effluent released from the Facility.

Prior to release, the regeneration liquid is stored in two 5,000 gallon underground tanks where it is circulated through Cuno filters. The liquid in these tanks is analyzed for radioactivity content and then released through the pond spillway where it is diluted with pond water. Prior to, and during all liquid releases, water samples are collected and analyzed for radioactivity content. During 1993 there were 47 releases of liquid effluent to the environment (See Fig. 6).
In 1991 it was verified that leakage was occurring through the pond spillway to the release standpipe at an average rate of 3 gallons per minute. As this is

Liquid Effluent Releases
Gross Beta Analysis Results (µCi/ml +/- 2 σ)
January-December 1993



Apriori LLD: 3.0 E-9 uCi/ml

Figure 6

considered release of pond water, it is sampled on a montl / basis and analyzed for gross beta particle activity. Consequently, the volume and activity released via this pathway is included in the 1993 liquid release totals. The total volume of liquid released off-site in 1993 was 48,400,000 liters (12,800,000 gallons).

The average concentration of radioactive material (as measured by gross beta particle activity analysis) released in effluent from the UVAR site was 6.3×10^{-9} μCi/ml. This concentration was 6.3% of the applicable MPC. The average concentration of radioactive material in the water leaking through the spillway was 4.3×10^{-9} μCi/ml. The total activity (excluding tritium activity) released in effluent was 293 μCi. This activity includes naturally occurring radionuclides contributed to the pond from the runoff and feeder creek mentioned above.

The average tritium concentration in effluent from the site was 1.0×10^{-7} μCi/ml. This concentration was 0.003% of the applicable MPC. The total tritium activity released during 1993 was 4327 μCi.

3. Solid Waste Shipments

There were no transfers of radioactive waste from the reactor to EHS in 1993. No shipments of radioactive waste were made to an off-site waste disposal facility in 1993.

C. Environmental Surveillance

1. Water Sampling

Environmental water samples are collected on a monthly basis from the locations indicated in Table 9. Gross beta particle activity analysis was performed on all water samples collected. The results of the analyses are provided in Table 10. The average gross beta concentration measured at each location was less than the applicable MPC.

TABLE 9 ENVIRONMENTAL WATER SAMPLE LOCATIONS		
Locale	Description	Distance/Direction from UVAR
W-1	Creek upstream of on-site pond	on-site
W-2	Water filtration plant	0.26 mi. southeast
W-3	Meadow Creek near Barracks Road, downstream of main University water discharge point (2 samples taken short distance apart on creek, results are averaged)	1.8 mi. northeast

TABLE 10 ENVIRONMENTAL WATER SAMPLING RESULTS			
Gross Beta Particle Activity (μCi/ml ± 1 sigma)			
	Upstream of Reactor Facility Pond W-1 (x 10^{-9})	At Water Filtration Plant W-2 (x 10^{-9})	Meadow Creek W-3 (10^{-9})
JAN	5.9 ± 1.0	1.8 ± 0.8	3.5 ± 0.7
FEB	6.3 ± 0.9	1.0 ± 0.6	4.7 ± 0.6
MAR	5.0 ± 0.9	0.6 ± 0.6	4.3 ± 0.7
APR	8.2 ± 1.1	*-0.6 ± 0.7	3.1 ± 0.7
MAY	3.9 ± 1.0	*-1.2 ± 0.7	4.8 ± 0.7
JUN	5.7 ± 1.0	*-0.1 ± 0.6	4.2 ± 0.7
JUL	3.4 ± 1.1	*-1.8 ± 0.8	1.2 ± 0.7
AUG	14.0 ± 1.4	0.1 ± 0.8	3.5 ± 0.7
SEP	11.0 ± 1.2	0.8 ± 0.7	6.9 ± 0.8
OCT	6.2 ± 1.1	0.8 ± 0.8	4.4 ± 0.7
NOV	6.3 ± 1.1	0.5 ± 0.8	8.3 ± 0.7
DEC	4.3 ± 1.2	0.5 ± 1.0	3.2 ± 0.8
Averages	6.7	0.2	4.3

* A priori LLD: 3.0 x 10^{-9} μCi/ml

2. Air Sampling

Environmental air samples are collected on a monthly basis at the following locations:

A-1 Roof of reactor building
A-2 Indicator - approximately 0.13 mi. E of UVAR
A-3 Control - approximately 3.1 mi. NW of UVAR

Fixed sampling locations are utilized to collect air samples at locations A-2 and A-3. Sampling time for these off-site samples is approximately 96 hours. Air samples are collected at location A-1 using a portable air sampler which is run for approximately two hours. All air samples collected at these locations were particulate air samples and were analyzed for gross beta particle activity. Results are provided in Table 11.

TABLE 11
ENVIRONMENTAL AIR SAMPLING RESULTS

Gross Beta Particle Activity Analyses Results (10^{-13} μCi/ml ± 2 sigma error)

	Roof of UVAR Facility	0.13 miles east of UVAR Facility	3.1 miles northwest of UVAR Facility
JAN	4.5 ± 0.87	1.0 ± 0.08	0.7 ± 0.03
FEB	0.2 ± 1.8	1.4 ± 0.09	0.4 ± 0.05
MAR	1.8 ± 7.9	0.5 ± 0.06	0.5 ± 0.06
APR	4.1 ± 1.7	6.3 ± 0.31*	0.8 ± 0.06
MAY	6.1 ± 3.3	1.6 ± 1.1	2.5 ± 0.67
JUN	6.1 ± 3.4	3.7 ± 0.14	NO DATA**
JUL	8.9 ± 1.7	3.8 ± 0.10	5.8 ± 0.17
AUG	0.4 ± 3.9	1.3 ± 0.05	2.7 ± 0.09
SEP	4.8 ± 1.3	3.8 ± 0.15	11.0 ± 4.0*
OCT	2.4 ± 1.8	3.9 ± 0.13	4.1 ± 0.11
NOV	8.9 ± 0.70***	4.4 ± 0.10***	5.2 ± 0.07***
DEC	1.7 ± 2.1	1.2 ± 0.08	2.1 ± 0.10
Average ± 2 s.d.	4.2 ± 6.0	2.7 ± 3.6	3.3 ± 6.4

* Low sample volume collected, pump malfunction.

** Sampler out of service due to construction at site.

*** Filter paper counted before 24 hour waiting period.

Roof Sampler LLD = 2.8 E-13 μCi/ml
Environmental Samplers LLD = 6.2 E-15 μCi/ml

D. UVAR Facility Health Physics Surveys

1. Radiation and Contamination Surveys

Daily, weekly and monthly surveys are performed throughout the Facility to monitor radiation and contamination levels. All required area radiation and contamination surveys were performed during 1993.

The levels of contamination detected in the Facility during 1993 were generally very low (typically less than 100 dpm/100 cm^2). Although the procedural definition of "contamination" is an activity of 2200 dpm per 100 cm^2 or greater, most areas are decontaminated if found to have greater than 50 dpm/100 cm^2. This is in keeping with the philosophy of ALARA. The area radiation level surveys revealed no overall increase in background or systems-related radiation levels.

In January of 1993, several routine surveys indicated the presence of contamination in the range of 50-100 dpm/100cm^2 on the reactor room floor. A number of air samples were collected in an effort to determine if the source of contamination was airborne radioactivity resulting from the use of the rabbit. No airborne activity was detected in any of the air samples. The reactor room was cleaned and subsequent surveys showed the areas to be clean.

2. Airborne Radioactivity

A particulate air sample is collected in the reactor room as part of the weekly survey of the Reactor Facility. The average concentration of radioactive material detected in the air in the reactor room (as measured by gross beta particle activity analysis of the particulate samples) was 4.1×10^{-12} μCi/ml. The airborne radioactivity detected was primarily due to radon and thoron daughters. None of the measured concentrations exceeded the applicable MPC. (See Fig. 7).

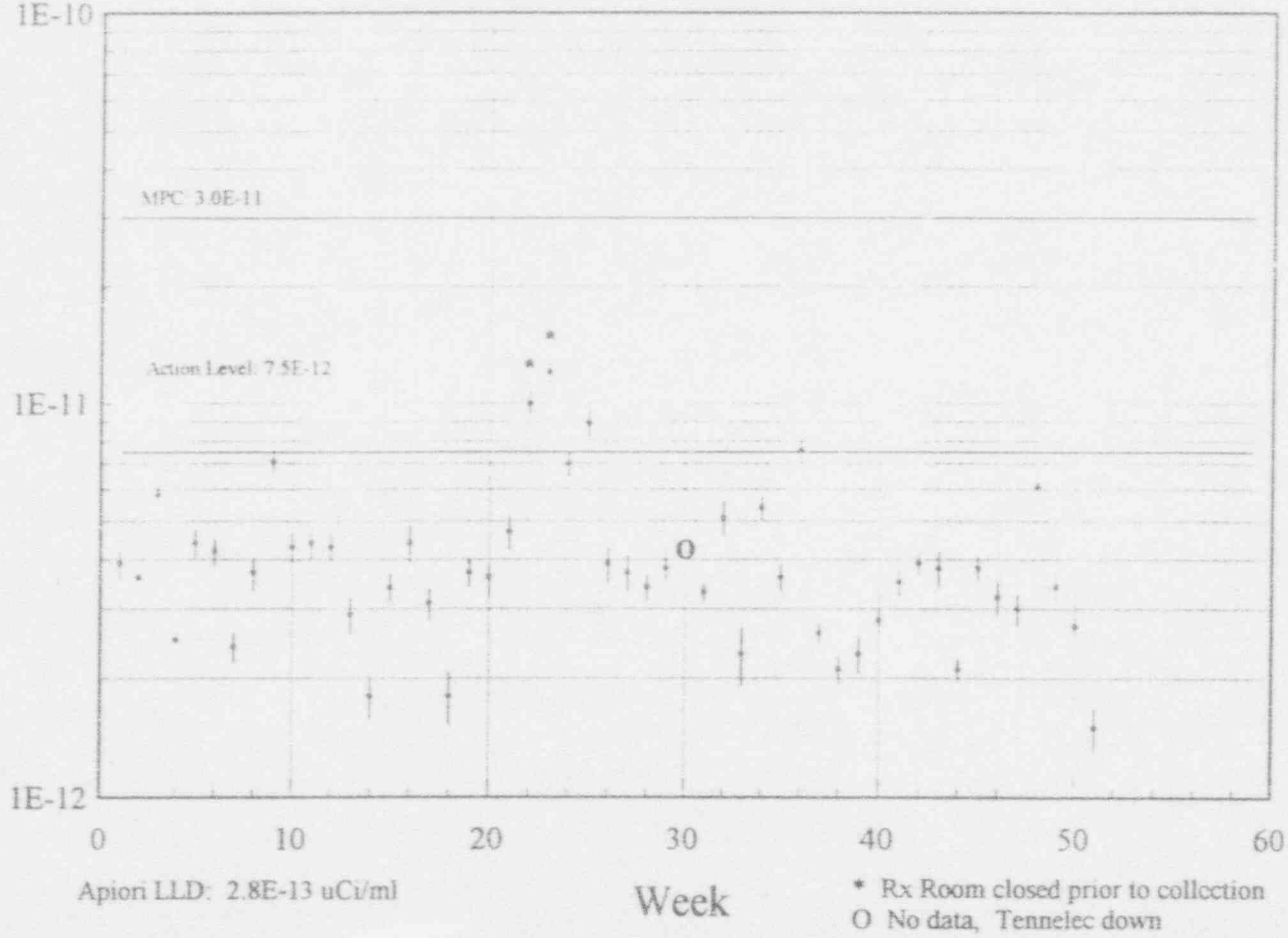
E. Quality Assurance

The UVAR Facility participates in the U.S. Environmental Protection Agency (EPA) Laboratory Intercomparison Studies Program as part of its quality control program for radiation measurement of air and water samples. The UVAR Facility participates in the following studies:

Gamma In Water on a triennial basis
Gross Alpha, Gross Beta in Water on a triennial basis
Tritium in Water on a semiannual basis
Gross Beta on Air Filter on a semiannual basis

Figure 7

Reactor Room Particulate Air Samples
Gross Beta Analysis Results (μCi/ml +/- 2 σ)
January-December 1993



Three independent determinations for each radionuclide included in a study are made and analysis results are reported to the EPA. A tabulation of all results reported by all participating laboratories is generated by the EPA. This tabulation report contains analytical precision values which are used as a basis for judging a laboratory's performance. Table 12 contains the results of the UVAR's performance in the above mentioned studies. A new counting standard will be prepared to be used to establish a new counting efficiency for the EPA filter samples. It is beleived that the different source to detector distances for the currently used planchet source and the EPA filters is responsible for the error causing our results to be outside of the accepted control limits for filter samples.

Table 12
Results of EPA Radioactivity Measurement Laboratory Inter-Comparison Program

Date	Study	Known Value	UVAR reported average value	Normalized Deviation*
8-27-93	Air filter (Beta)	47 pCi/Filter	57	3.46
1-29-93 7-23-93 10-29-93	Gross α/β in H_2O	44 pCi/l 43 pCi/l 15 pCi/l	47.0 40.0 17.3	0.58 2.19
6-4-93 11-05-93	H-3 in water	9,844 pCi/l 7,398 pCi/l	8,416 6,348	-2.51 -2.46
6-11-93	Gamma in water	Co-60 15 pCi/l Zn-65 103 pCi/l Ru-106 119 pCi/l Cs-134 5 pCi/l Cs-137 5 pCi/l Ba-133 99 pCi/l	18.0 88.3 120.3 7.0 9.7 124.7	1.04 -3.06 0.19 1.62 4.45
11-12-93	Gamma in water	Co-60 30 pCi/l Zn-65 150 pCi/l Ru-106 201 pCi/l Cs-134 59 pCi/l Cs-137 40 pCi/l Ba-133 79 pCi/l	NRP NRP NRP NRP NRP NRP	

NRP - No results reported by UVAR Facility

* If this value is between 2.00 and 3.00 the analytical process precision is in the warning zone; if it exceeds 3.00 it is outside of the control limits specified by the EPA.

F. Spills

In September, 1993, a hose on the pool skimmer pump disconnected allowing pool water to spill onto the reactor room floor and down to the mezzanine level below. Areas affected were cleaned and surveyed. Follow-up surveys showed no significant residual contamination.

In late August, slightly contaminated water was discovered leaking from the southeast access facility. Further investigation led to the conclusion that the reactor pool was leaking. Actions were taken to collect and divert this water and address the pool leak.

G. Summary

During 1993, no State or Federal limit for exposure to personnel or the general public was exceeded.

V. RESEARCH, EDUCATION AND SERVICE ACTIVITIES

A. Irradiation and Other Research Facilities Available

An overall description of the experimental facilities available at the UVAR Facility is listed in section I.B.5. During 1993, no substantial changes were made to any existing experimental facilities nor were any new facilities added.

B. Research Activities

1. A continuing program of research was pursued on behalf of the Philip Morris Company. This work was supervised by Dr. Jack Brenizer and conducted primarily by graduate students with Reactor Facility staff assistance. The major projects were neutron radiographic examinations of burning cigarettes, neutron activation analysis of various tobacco products and other substances used in the tobacco industry and the analysis of the distribution of smoke from a smoked cigarette through spiking of tobacco with radioactive isotopes.

2. Staff assistance was provided for one major project and several minor projects utilizing the cobalt-60 irradiation facility. The major project is on behalf of sponsors related to the nuclear power industry. It involves the gamma irradiation of radiation sensitive components from nuclear power plants. Dr. Albert Reynolds is the principal investigator for this project which could last a couple more years.

   One of the other projects was sponsored by the Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, Virginia. The researchers there are investigating the possible radiation degradation of fiber-optic type radiation scintillation detectors that are scheduled for use with the accelerator.

   Several researchers at both U.Va., other universities and some high schools provided a number of different kinds of samples to be sterilized in the cobalt facility.

3. Other researchers from CEBAF contracted with the Reactor Facility to neutron irradiate a mineral loaded tar/puddy material to test its radiation resistance. This material, if found to be acceptable, would be used in target rooms at the new accelerator.

4. Neutron activation analysis services to measure trace amounts of osmium in aqueous DNA solutions were provided by the Reactor Staff to U.Va. chemistry professor M.G. Finn and his graduate students.

5. The Ciba-Geigy pharmaceutical company continued sponsoring work involving neutron activation analysis and production of samarium and erbium radioactive tracers. The interest is to develop methods to measure and control drug delivery and release mechanisms which employ hydrogel bead technology.

6. Preliminary research trials of a cancer treatment technique called Neutron Boron Capture Therapy were completed utilizing mice exposed to a neutron beam from the reactor. This work is being done by several researchers at UVA and it is hoped that the trials will help obtain additional funding for more extensive studies.

7. Neutron activation analyses for zinc, mercury or molybdenum were performed on a number of protein samples for the Mayo Clinic.

8. Neutron activation analyses for manganese were performed on a number of protein samples for Dr. Joseph Larner, a UVA professor of pharmacology.

9. Irradiations of Charpy type steel enbrittlement test specimens in heated epithermal neutron irradiation facilities were continued on behalf of Professor Arvind Kumar of the University of Missouri - Rolla. This research is sponsored by both the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. Irradiations will continue through 1994.

C. Service Projects

1. Iodine determination by epithermal neutron activation analysis (ENAA) was performed on behalf of several sponsors, including Ross Laboratories, Woodson-Tenent Laboratories and Biomineral Sciences International, Inc. The substances analyzed were infant formula, liquid diet supplements, pet foods and various chemical compounds.

2. The project involving the color enhancement of various gemstone grade minerals by fast neutron irradiation was pursued by the reactor staff on behalf on several sponsors involved in the commercial gem trade.

3. The Protechnics International Company, which supplies various radioactive sources to industry, had the Reactor Facility irradiate and ship several sources for use by companies performing oil well drilling.

4. A number of small radioactive sources were produced for use in graduate and undergraduate nuclear engineering laboratories.

5. Co-60 sterilization was completed on a large number of micro-pipettes used for manipulation and fertilization of human eggs prior to their implantation in a woman's uterus. This is a continuing project for a local company that manufactures and distributes these pipettes.

6. A manufacturer of commercial boron products had the Reactor Facility (a professor, staff and students were involved) perform neutron radiography on a large number of aluminum-boron plates as part of a quality assurance program. These plates were designed to be part of a nuclear power plant spent fuel storage container.

D. Reactor Sharing Program

The Department of Energy has for the past fourteen years funded a program at the University entitled Reactor Sharing. The purpose of this program is to make available the UVAR facilities to faculty and students at universities and other educational institutions which do not have nuclear science facilities. Over the years, hundreds of students and dozens of professors have used this arrangement to enhance both their educational and research opportunities. This past year a number of tours, laboratories and research projects were conducted under this program.

The following is a list of both the directly and indirectly funded activities completed in 1993.

School tours:

Seventeen tours from high schools, middle schools and elementary schools involving 336 students and teachers.

Five tours by special groups of high school, middle school and elementary school aged students involving 70 students.

College tours:

Fourteen tours from colleges involving 156 students and professors.

Special tours in conjunction with U.Va. programs:

Eighteen tours involving 232 individuals.

College labs:

Two of the college student tours involved laboratories which were participated in by 19 individuals.

Research projects:

Several research projects utilizing neutron activation analysis or cobalt-60 gamma ray irradiation were conducted by students and faculty from other schools during the year. One of these projects, sponsored by Dr. Lee Banton of Longwood College, involved the neutron activation analysis of hair samples from elementary school children, both "normal" and some with certified learning disabilities, in order to try and ascertain if there are any significant differences in the presence of certain elements which are known to assist with brain functions.

E. Reactor Facility Supported Courses and Laboratories

1. Academic Courses and Laboratories

The following courses and laboratories were taught by professors of Nuclear Engineering during 1993 utilizing in part services provided by the Reactor Facility.

NE 488 - Nuclear Power Plant Operations
NE 382 - Nuclear Engineering Laboratory

During June 1993, 23 high school teachers from the state of Virginia attended a one week special course at the Reactor Facility. The title of the course was "Science of Nuclear Energy and Radiation: Environmental Issues and Safety." It consisted of lectures by University of Virginia nuclear engineering faculty, laboratory experiments using the reactor and a tour of the North Anna Nuclear Power Station.

F. Degrees Granted by U.Va. in Nuclear Engineering

The following number of degrees were awarded during 1993 by the University of Virginia in the discipline of Nuclear Engineering:

Bachelors of Science, Nuclear Engineering	5
Masters, Nuclear Engineering	8
Doctor of Philosophy, Nuclear Engineering	1
TOTAL	14

The following theses by students majoring Nuclear Engineering were completed during 1993 in part using services or facilities provided at the U.Va. Reactor Facility.

Photodegradation of Iron (III) Ethylenediaminetetraacetic Acid: Application to Treatment of Nuclear Steam Generator Chemical Cleaning Waste Solutions, PhD thesis in Nuclear Engineering by Eric J. Karell.

The research work for several other theses is in progress utilizing Reactor Facility support.

VI. FINANCES

A. Expenditures

Expenditures for 1993 were as follows:

	State Support	Locally Generated Monies
Salaries + Fringes:	$222,400	$164,700
Operations:	52,300	33,800
Subtotals:	$274,700	$198,500

TOTAL EXPENDITURES: **$473,200**

B. Income

Income, both the actual amounts received and billed for work done in 1993 and previous years and the projected income for work completed in 1993 but that was not billed in the calender year are shown below:

Va. State support in 1993:	$274,700
Local income received in 1993:	165,700
TOTAL INCOME:	**$440,400**
Total billed in 1993:	120,250
Approximate amount remaining to be billed for work completed in 1993:	100,000
Total from all years that has been billed but not received as of Dec 31, 1993:	97,600
Approximate total receivables as of 12/31/93	197,600

C. State Support / Research and Service Income

The University of Virginia is supported by allocations from the State of Virginia. Of these monies, a portion is allocated for the operation of the Nuclear Reactor Facility. These funds cover many of the expenses directly related to the operation of the reactor but additional monies are necessary to provide for remaining services provided to the university community by the Facility. Additional income is in the form of fees received for research and service work support. This income is "not business related income" because it is primarily used to pay the salaries of extra professional staff members at the Facility who are not state supported. In 1993 there were four (currently three) staff members receiving the majority of their salaries from local funds and one other individual receiving 50% support. Several students who were training to become reactor operators received partial support over the summer.

Many staff members take courses and receive degrees at the University while their salaries are paid from monies generated by service work. In effect, this is another method by which the Reactor Facility supports science education in the University of Virginia School of Engineering and Applied Science. Currently, two staff members are taking courses toward the completion of advanced degrees.