SCHOOL OF
ENGINEERING
& APPLIED SCIENCE

NUCLEAR REACTOR FACILITY
Department of Mechanical,
Aerospace & Nuclear Engineering

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March 19, 1996

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 6.7.2 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, 1995 through December 31, 1995. This report has been reviewed and approved by the Reactor Safety Committee.

Sincerely,

J. P. Farrar

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

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

A020 1/1

UNIVERSITY
OF
VIRGINIA

REACTOR FACILITY

1995
ANNUAL REPORT

This report was compiled by the following personnel:

Sections I, II, and III - J.P. Farrar, Administrator
Section IV - D.P. Steva, Health Physicist
Sections V and VI - P.E. Benneche, Reactor Supervisor

We wish to thank the Reactor Safety Committee for their review of this report and their constructive comments on the form and content.

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1995 ANNUAL REPORT

University of Virginia Reactor Facility

I. INTRODUCTION

A. Reactor Facility Reporting Requirements

1. Reporting Period

This report on Reactor Facility activities during 1995 covers the period January 1, 1995 through December 31, 1995.

2. Basis for Reporting

An annual report of reactor operations is required by the UVAR Technical Specifications, section 6.7.2. 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 shut down, awaiting decommissioning). The Facility also has a 3300 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

The UVAR 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. The UVAR was converted to LEU fuel during 1994. Figure 1 shows a layout of the reactor and the various experimental facilities associated with the UVAR.

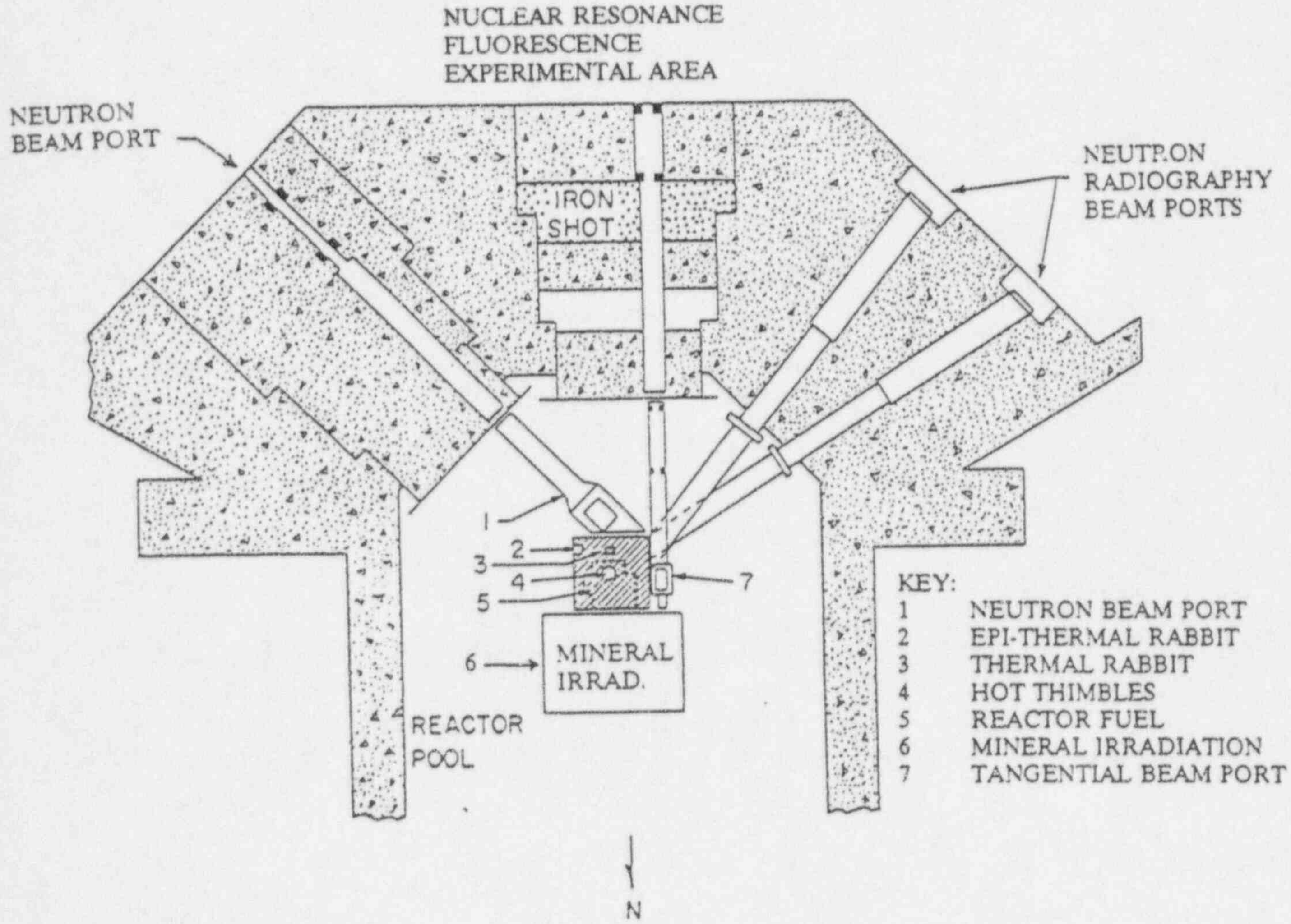


Figure 1. UVAR Experimental Facilities

2. 100 W CAVALIER

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, have been donated to the University of North Texas. Shipment is planned in the near future, as soon as UNT has room to store the components.

3. Past Operating History

a. UVAR

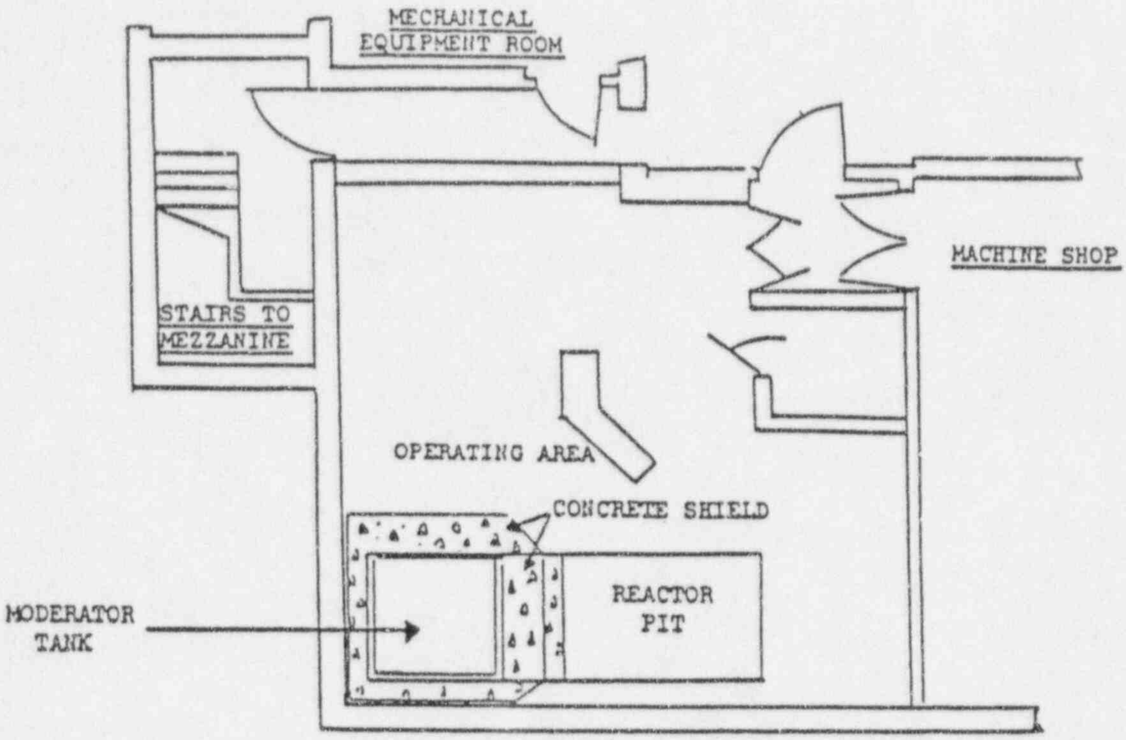
The UVAR operating history is shown in Table 1.

TABLE 1

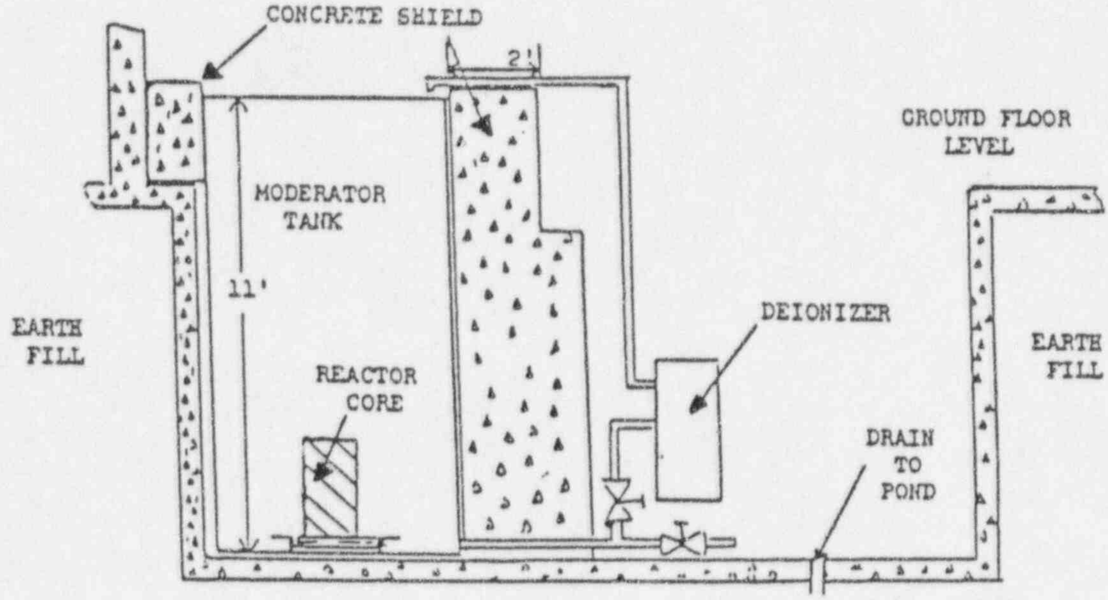
Operating History of University of Virginia Reactor

Year(s)	Megawatt-hours	Hours Operated
1960-1970	3960	4500
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
1994	1594	1016
1995	1703	1079

During the years 1979 through 1984, the UVAR 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 UVAR first operated at full power with LEU fuel on May 12, 1994.



Plan View of CAVALIER Operating Area



Vertical Section Through Reactor Pit

Figure 2

b. CAVALIER

The CAVALIER operating history is shown in Table 2.

TABLE 2		
Operating History of CAVALIER		
Year(s)	Watt-hours	Hours Operated
1974-1980	2128	758
1981-1985	1278	388
1986	147	37
1987	28	29
1988-1995	shutdown	shutdown

The CAVALIER was used primarily for reactor operator training and undergraduate lab experiments, although it has not been operated over the past eight years. The last date of operation was August 4, 1987. The CAVALIER fuel and start-up source was unloaded on March 3, 1988. A decommissioning plan was submitted to the NRC in January, 1990. An order to decommission was issued by the NRC on February 3, 1992. Decommissioning should be completed in the near future once the donated reactor components (less fuel elements) have been received by the University of North Texas at Denton, Texas.

4. Summary of 1995 Reactor Utilization

a. UVAR

During 1995, the UVAR was operated for 1079 hours and a total integrated power of 1703 Megawatt-hours. The following projects were performed utilizing the UVAR:

- 278 neutron activation analysis (NAA) samples were run in the pneumatic rabbit system.
- 6 sets of samples were run in the mineral irradiation facility (MIF).
- 18 separate runs were made in the canister irradiation facility (CIF) for a total of 346 hours.
- 480 hours of reactor operations were dedicated to neutron radiography.
- Hot Thimble experiments were operated for a total of 152 full power hours.
- Student Laboratory Experiments
- Reactor Operator Training

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 neutron fluence during irradiation of a large number of specimens.
- Epithermal neutron irradiation facilities with heaters for sample temperature control.
- Cobalt-60 gamma irradiation facility with 3,300 curies, permitting underwater exposures at rates up to 104,000 R/hr.
- Depleted uranium subcritical facility (donated to U. North Texas, awaiting their shipping instructions.
- Small hot cell, (10 ft x 6 ft x 12.5 ft high) 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 NRC approved Reactor Facility organization chart is shown in Figure 3. Personnel on the reactor staff as of the end of 1995 were:

R.U. Mulder .... Reactor Director
J.P. Farrar .... Administrator
P.E. Benneche .... Reactor Supervisor (SRO)
B. Hosticka .... Research Scientist (SRO)
D.R. Krause .... Senior Reactor Operator (SRO)
T.E. Doyle .... Research Scientist (SRO)
C.A. Bly .... Part time student (SRO)
J.D. Muskopf .... Part time student (RO)
M.J. Crawford .... Electronic Shop Supervisor
J.S. Baber .... Machine Shop Supervisor
V.S. Thomas .... Reactor Facility Secretary

2. Health Physics Staff at the Facility

D.P. Steva .... Reactor Health Physicist
D. Moody ... Radiation Safety Technician

The Health Physicist is assisted by students paid from reactor services income. Other health physicists and technicians employed by the University are on call through 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 & Assoc. Professor, Nuclear Engineering
R.G. Piccolo ... University Radiation Safety Officer

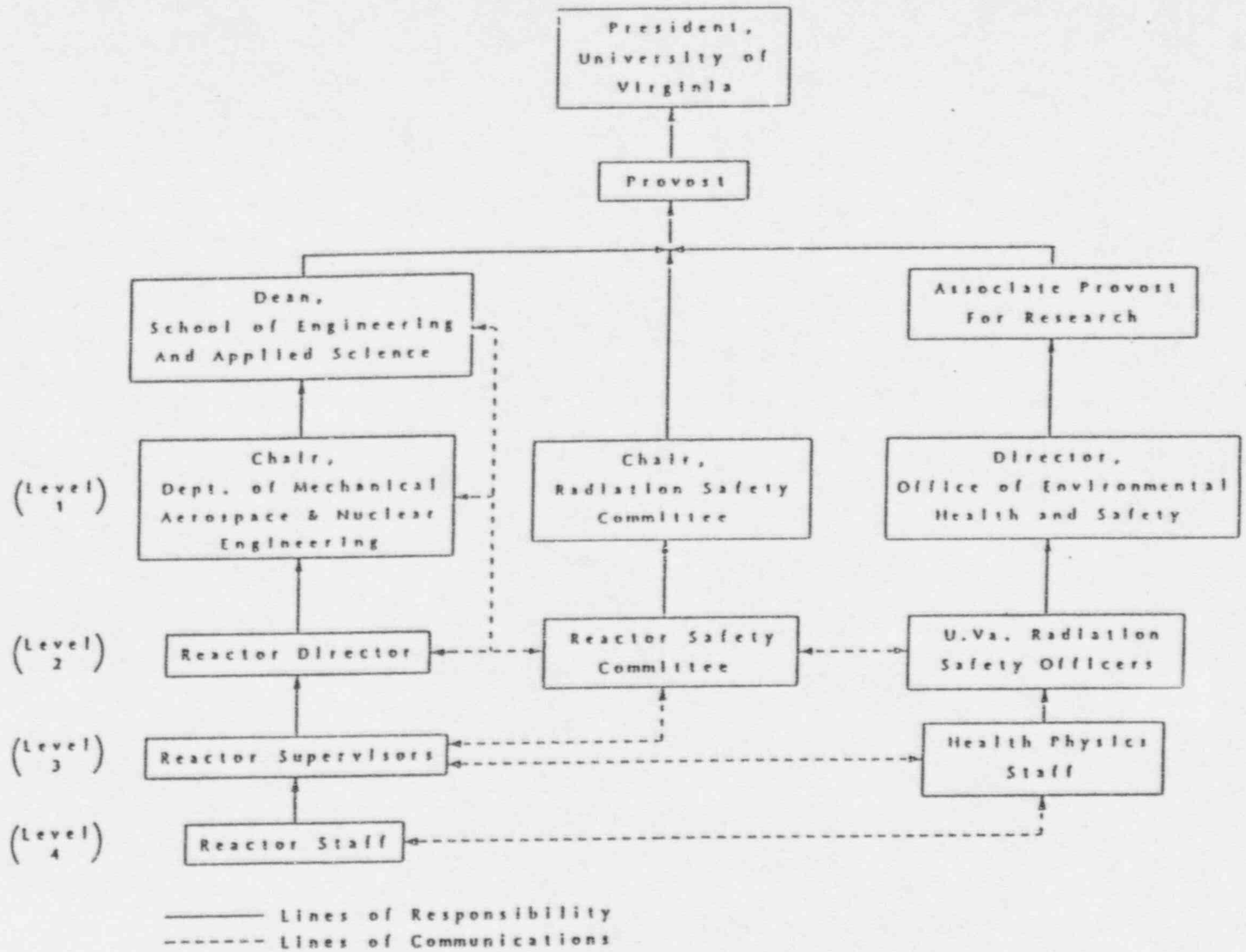


Figure 3: Oganizational Structure of U.VA. Reactor Facility

II. REACTOR OPERATIONS

A. UVAR

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) flat plate-type elements, utilizing U_3Si_2. The fuel is approximately 19.7% enriched in the U-235 isotope. The elements have 22 fuel plates per element, with a loading of approximately 275 grams of U-235 per element. The control rod elements have 11 fuel plates with a loading of approximately 137 grams U-235 per element. A plan view of these elements is shown in Figure 5.

2. Standard Operating Procedures

Section 3, Personnel Responsibilities, of the UVAR standard operating procedures was completely rewritten and expanded during the year. 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 for physical integrity.

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

UNIVERSITY OF VIRGINIA REACTOR CORE LOADING DIAGRAM

CORE LOADING 95-2 SHUTDOWN MARGIN - $ 2.126 (Base)

Date August 11,1995 EXCESS REACTIVITY + $ 4.531 (Base)

U-235 4637 GRAMS (9-30-95) EXPERIMENT WORTH $ 0.82

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 - $ 3.936 #2 - $ 3.784 #3 - $ 2.873 Reg - $ 0.554

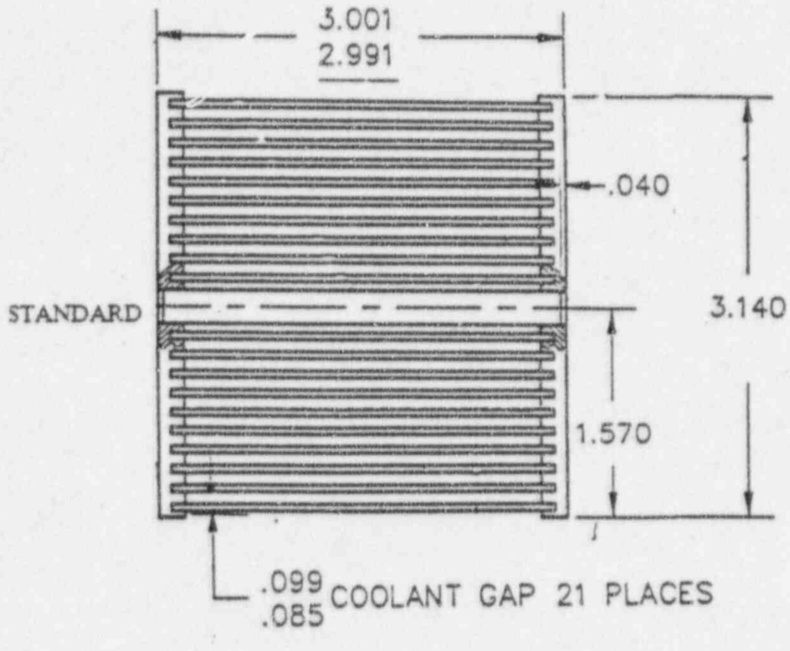
MINERAL IRRADIATION FACILITY

MIF LEAD SHIELD

P 11	F VS-015 12	F VS-009 13	F-REG VC-001 14	F VS-013 15	F VS-004 16	17 CANISTER IRR. FAC.	P 18
G 21	F VS-006 22	F-CR1 VC-002 23	PF VP-001 24	F VS-007 25	F VS-008 26	27	P 28
G 31	F VS-001 32	F VS-010 33	F VS-002 34	F-CR2 VC-003 35	F VS-012 36	37	P 38
G 41	F VS-014 42	F VS-003 43	F-CR3 VC-004 44	F VS-005 45	F VS-011 46	47	P 48
G 51	G 52	G 53	G 54	P 55	S 56	57	P 58
G 61	G 62	G 63	EPI RAB 64	G 65	G 66	G 67	G 68
G 71	G 72	THER RAB 73	G 74	G 75	P 76	G 77	G 78
G 81	G 82	G 83	G 84	G 85	G 86	G 87	G 88

Figure 4

LEU FUEL ELEMENTS
(Dimensions in inches)



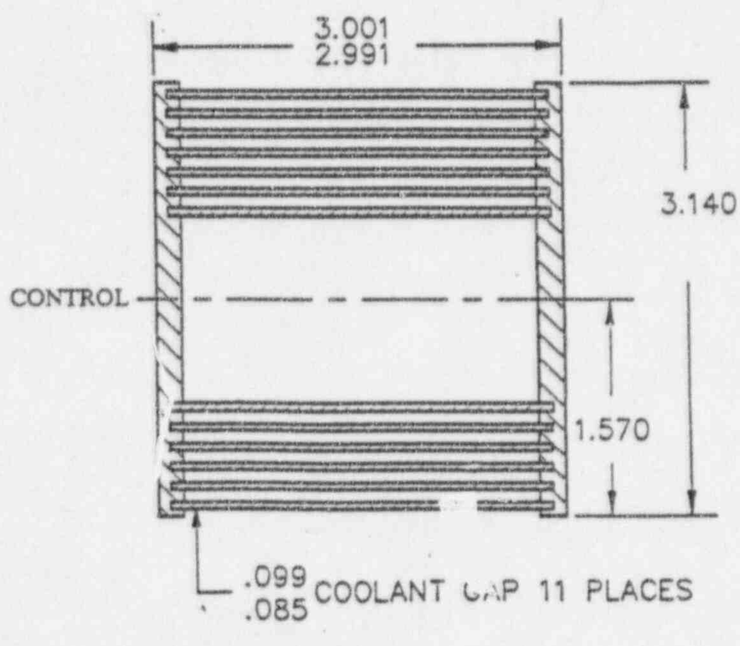


FIGURE 5: LEU FUEL ELEMENTS

TABLE 3					
Measured Control Rod Drop Times on UVAR					
Rod Number	Magnet Current (m-amps)	Rod Position (inches)	Magnet Release Time (msec)	Free Drop Time (msec)	Total Drop Time (msec)
5-19-95 (After visual inspection of rods)					
1	170	26	16	484	500
2	170	26	34	465	499
3	70	26	18	487	505
12-18-95 Semiannual Surveillance					
1	175	26	19	483	502
2	175	26	32	472	504
3	75	26	34	559	593

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 5-18-95 and 5-19-95. The following is abstracted from the reactor log book and the surveillance files:

Rod #1 - Inspected rod under water. Slight deformity in one of ribs near middle on one side and some slight rub marks about 1/3 from bottom on the narrow edge. Rod passed 0.95 inch gauge easily.

Rod #2 - Inspected rod under water. No rub marks or cracks noted. Rod passed 0.95 inch gauge easily.

Rod #3 - Inspected rod under water. Rub mark on thin side of rod at 1/2 of rod height. No evidence of cracking. Passes 0.95 inch gauge easily.

All of the rods appear essentially the same as in previous inspections.

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 on November 13, 1995. The results are as follows:

	S.E. Tank (gal/min)	S.W. Tank (gal/min)
minimum required flow	11.0	11.5
11-13-95 actual flow	12.0	12.3
last five year range	11.9-12.3	12.1-12.5

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

The UVAR core configuration was changed on February 15, 1995. Although no new fuel was added to the core, fuel elements were shuffled to give a more even burnup. The control rods were recalibrated and the experimental worth was remeasured. The rods were calibrated again on August 11, 1995 when the integrated power had reached 1050 Mwhrs.

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. These checks confirmed the availability of systems and communication equipment.

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

4. Maintenance

The maintenance performed on the UVAR systems during the calendar year 1995 is shown in Table 4.

TABLE 4			
Reactor System Maintenance Performed in 1995			
Date	System	Problem	Corrective Action
1-04-95	Scram Logic Drawer	Pool Level #1 scrams when manipulating rods even though pool level is normal.	Found suspect terminal (TM-16) resoldered wires and buffed terminal board.
3-22-95	Primary Console	Drop-out relay stays engaged when power removed.	Found "stuck" contact. Cleaned and repaired contact.
3-22-95	Source Range	Erratic readings.	Found and cleaned dirty contacts.
4-20-95	Primary Pump	Pump will not start.	Found and replaced 2 blown fuses.
4-24-95	Demineralizer System	City H_2O float valve does not cut off upon high level in anti-syphon tank.	Replaced rubber seat and extended float shaft 3 inches. Replaced seals & "O" rings.
5-03-95	Demineralizer System	Valve #4 leaking during regeneration.	Found and replaced ruptured diaphram.
5-04-95	Power Range #2	Lags Power Range #1 when approaching 2Mw, then rises to appropriate level.	Replaced detector with used one. Will check out on next startup.
5-05-95	Power Range #2	Erratic signal when at power.	Replaced detector. Checks out O.K.
5-08-95	Source Range	No problems. Removed detector for spectral analysis.	Reinstalled detector.
5-17-95	Scram Logic Drawer	SSR failure light comes on and stays on. Scrams can be reset O.K.	Problem found with 2 resistors (R1 and R2). Replaced resistors.
5-18-95	Source Range	Signal erratic during checklist.	Found and replaced bad pre-amp.
6-28-95	Source Range	Erratic signal while reactor shut down.	Found H_2O in detector well. Replaced connectors, bottom 10 feet of cable and "O" ring. Polished "O" ring seat.
7-31-95	Demineralizer System	Upon starting system, had difficulty with automatic valve latching.	Found and tightened loose tension screw.
10-12-95	Servo Rod Control	Servo does not move rod.	Found and replaced blown fuse.
10-19-95	Primary Console	Alarm on common alarm panel for conductivity irratic.	Found time constant too short. Added timing circuit to delay 1 sec.
10-24-95	N. Neutron Beamport Blockhouse.	Removed portion of concrete shielding for rewiring of equipment.	Rewiring completed, shielding replaced, and radiation survey performed with reactor at power.
10-24-95	Primary Cooling System	Pressure gauges on Heat Exchanger not functioning.	Replaced gauges with stainless steel gauges.
10-24-95	Heat Exchanger Tubes	Leak in Heat Exchanger tubes.	Plugged 8 tubes, tested O.K.
11-13-95	Criticality Alarm	Alarm not audible throughout building.	Connected alarm to building evacuation alarm.

Table 4, Reactor System Maintenance, continued			
12-04-95	Yellow Springs Temperature Probe	Probe #2, pool temperature, not functioning.	Replaced probe and checked out. Reading O.K.
12-04-95	Rabbit System Holdup Monitor	Need to replace monitor, which is current facility standard.	Replaced with in-house pico-ammeter. Calibrated.
12-22-95	Source Range Instrument	Source Range reading high, ~100 cps, with reactor shutdown.	Replaced pre-amp and 2 power supplies. Calibrated.

No significant trends were noted in the maintenance.

5. Unplanned Shutdowns

The 26 unplanned shutdowns which occurred on the UVAR during the calendar year 1995 are shown in Table 5.

6. Unplanned Reactor Downtime

During the week of August 7, 1995 the secondary side of the heat exchanger was cleaned. It was noted that some of the tubes had scaling and pitting, although there was no evidence of a leak. The tubes were cleaned, the heat exchanger was reassembled and the reactor was operated at 2 MW on August 17^{th}, 18^{th} and 22^{nd}. On the afternoon of the 22^{nd} low levels of Na-24 were detected in the secondary water, indicating a possible primary to secondary leak. The secondary side of the heat exchanger was reexamined and four tubes were found to have small leaks. The isolation valves were closed between the primary and secondary systems and reactor operation was restricted to natural convection (up to 200 kW) operation until the problem could be evaluated and corrected. The NRC was notified of the problem and they requested that the facility do a complete safety analysis of potential heat exchanger leaks and submit this analysis to the NRC as an ammendment to the LEU SAR. The analysis was completed and submitted to the NRC on October 10, 1995 with additional submittals on October 19, 1995. Further testing revealed slight moisture leaks in four other tubes. The eight tubes were plugged on October 25 and a static pressure test revealed no other leaks. A new surveillance requirement for weekly monitoring of the secondary water for radioisotopes was added to the Technical Specifications on November 9, 1995. Weekly analysis since that time has shown no isotopes above minimum detectable levels.

TABLE 5		
Unplanned Reactor Shutdowns in 1995		
Date	#	Shutdown Mechanism
1-04-95	2	Scram - Ground floor manual indication. Noise in system.
		Scram - Pool level #1 indication. Makeup was just started. Caused by turbulence.
1-06-95	3	Scram - Switch noise from moving fission chamber, indicated Pool level #1.
		Scram - Noise while moving fission chamber, indicated as pump off.
		Scram - Noise while moving Reg Rod, indicated as pump off.
1-24-95	1	Scram - Switch noise while repositioning rods. Indication was pump off.
2-15-95	1	Scram - False Beamport entry, due to bubble in nosepiece sightglass exhaust tube.
2-16-95	1	Scram - Noise while moving Rod #3. Indication was Pool Level #1.
2-20-95	2	Scram - No indication of cause.
		Scram - Noise in Period instrument while pulling rods. Reactor sub-critical.
3-10-95	1	Scram - Operator's chair bumped secondary console, giving pump off scram.
3-16-95	1	Scram - Electrical breaker for MIF pump tripped. Cause unknown.
5-04-95	1	Scram - Noise in Power Range #2 detector.
5-09-95	1	Scram - Noise in Power Range #2 detector.
6-06-95	1	Scram - Noise while moving Rod #2. Indication was period.
6-26-95	1	Scram - Noise during startup. Indication was pump off.
7-07-95	1	Scram - Momentary building power failure.
7-14-95	1	Manual shutdown by operator to remove small air bubble from top of core.
8-04-95	1	Scram - Momentary power failure - Rods 1 & 2 dropped, dropped rod 3 with key switch.
8-22-95	1	Scram - Building power failure.
10-31-95	2	Scram - Noise in Intermediate Period while manipulating rods.
		Scram - Rod switch noise. Pool Level #1 indication. Level @ 19' 3 1/2".
11-01-95	1	Scram - Neutron Beamport Entry - Student entered Blockhouse to perform survey when beamport was drained and reactor @ 200 kW. Student was not in front of beam.
11-09-95	1	Scram - Pool level #1 indication, although pool level was 1" above set-point. Switch was cycled and tested O.K.
11-09-95	1	Scram - Momentary building power failure.
11-20-95	1	Scram - Momentary building power failure.

7. Pool Water Make-up

During the year makeup water to the reactor pool averaged 52 gallons per day through the middle of October. Most of this is attributed to pool water surface evaporation during operation of the reactor. From the middle of October until the end of December the makeup averaged 104 gallons per day due to a suspected pool leak around the center buttress. The leak appears to be self-sealing, with makeup levels dropping to 70-80 gal/day during the first two months of 1996. The staff is pursuing leak repair options with contract firms.

8. Fuel Shipments

a. Fresh Fuel

No fresh fuel was received at the facility during 1995.

b. Spent Fuel

No spent fuel was shipped from the facility during 1995.

9. Personnel Training and Instruction

a. Reactor Facility Staff

At the end of 1995 the staff had five senior reactor operators and one reactor operator. A NRC senior operator exam was held at the Facility during the week of August 28, 1995. One individual received a senior operators license. All licensed operators participated in the Facility's operator requalification program, which was carried out during the year. The program consists of periodic lectures, participation in the daily operation of the Facility, performing checklists and start-ups of the reactor and a biennial written examination. The written exam was given during the month of July and all operators passed with high marks.

b. Summer Course for High School Teachers

During the month of June, 1995, 28 high school teachers from within the state of Virginia attended a one week special course at the Reactor Facility entitled: "Science of Nuclear Energy and Radiation". The course consisted of formal lectures, laboratory experiments with the UVAR reactor in the areas of sub-critical multiplication, basic radiation counting, and gamma-ray analysis. During the week the teachers also visited the North Anna Nuclear Power Station.

10. Reactor Tours

During the calendar year 1995, the staff guided 44 groups on tours of the Facility, for a total of 747.

B. CAVALIER Reactor

1. Reactor Shut Down

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 the near future pending availability of shipping funds and storage room at U. of North Texas at Denton for reactor components (excluding fuel).

III. REGULATORY COMPLIANCE

A. Reactor Safety Committee

1. Meetings

During 1995, the Reactor Safety Committee met four times, on the following dates:

March 6, 1995	October 9, 1995
July 25, 1995	November 28, 1995

The Technical Specifications require the committee to meet at least twice each year.

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, experimental procedures, QA program and operator training.

3. Approvals

The Reactor Safety Committee approved changes to the UVAR Standard Operating Procedures during the year in the area of Personnel Responsibilities.

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:

1) Replaced low voltage power supply on Power Range #2 system.

2) Modify common alarm panel so that alarms from demineralizer conductivity monitor are processed only if they persist for more than 1/2 - 1 second.

3) Replace pressure gauges on inlet and outlet of Heat Exchanger.

4) Plug Heat Exchanger tubes that have small leaks.

B. Inspections

During 1995 the Facility had two NRC compliance inspections, at the following times and in the area of:

6-05-95 Reactor Operations
11-08-95 Emergency Preparedness

There were no violations uncovered during these inspections.

D. Licensing Action

1. On July 21, 1995, the NRC issued Amendment No. 21 to the UVAR License, R-66, which consisted of a complete new set of Technical Specifications.

2. On August 18, 1995, the NRC approved a revised version of the Quality Assurance Program for Radioactive Material Packages.

3. On November 9, 1995, the NRC issued Amendment No. 22 to the UVAR License R-66 to add a surveillance requirement for monitoring the secondary system water. The NRC also reviewed and approved a safety analysis concerning Heat Exchanger leaks and repairs.

D. Emergency Preparedness

1. On April 12, 1995 a classroom training session was held to discuss recent changes to the Emergency Plan and Implementing Procedures.

2. On May 22, 1995, at 2:03 P.M. the reactor supervisor initiated a practice evacuation of the facility by activating the Criticality Alarm System. This system is designed to evacuate that section of the building where the fuel storage room is located. When personnel gathered outside the facility a personnel accountability procedure showed that one staff member was still in the building. He was found in the electronics shop, where the alarm was inaudible. The alarm has since been connected to the evacuation alarm system which is audible throughout the entire facility. 15 people were accounted for at the assembly area. The following equipment was also retrieved by the staff: 3 portable radiation instruments, 9 pocket dosimeters, 2 copies of the EPIP's, 3 personnel dosimetry racks, 2 portable police radios, 1 portable fire radio, 1 cellular phone, and 1 visitor's log. The drill lasted about 10 minutes.

3. On November 8, 1995, at 08:45, an annual emergency drill was initiated at the facility. An NRC inspector was present at the facility to observe the drill. The drill scenario involved an earthquake in the local vicinity and a subsequent minor pool leak contaminating a person with a broken leg. The drill was initiated over the loud speaker system by informing personnel that the building was vibrating violently and loose objects were falling off shelves, etc. The reactor supervisor set off the evacuation alarm and assumed command as Emergency Director. A command post was set up outside the building. Personnel accountability procedures were initiated and it was discovered that one student was missing. The Emergency Director had a staff member search the building and the student was discovered at the south access facility (a movable shield at the reactor face) with a broken leg and pinned under an instrument rack (simulated). A small stream of water from the pool was leaking onto the student, contaminating him slightly. The student was administered first aid and the rescue squad was called (simulated). Makeup water was started to the pool to maintain pool level. Health Physics personnel were called to assist monitoring of the area and determine the extent of the contamination. The Emergency Director declared an "unusual event" at 08:59 and notified the Virginia Office of Emergency Services and the NRC at Washington and Atlanta. The drill went very well and was terminated at 09:37.

IV. HEALTH PHYSICS

A. Personnel Dosimetry

1. Visitor Exposure Data For 1995

Any individual who accesses the Reactor Facility but is not permanently badged is logged into the visitor log and issued a gamma-X-ray sensitive direct reading electronic pocket dosimeter. During 1995, there were 1724 visitor entries into the Reactor Facility. Of these entries, 977 were individual visitor entries and 747 were visitors in tour groups. The highest dose received in any one visit was 7 mrem. This exposure was received by a staff member of the Office of Environmental Health and Safety who was assisting in the packaging of low level waste. Most visitors received no measurable dose.

2. Reactor Facility Personnel Dosimetry Data For 1995

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. 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 that 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, 1995 through December 31, 1995 is shown in Table 6.

TABLE 6	
1995 Personnel Radiation Doses Received at Reactor Facility	
Measured Accumulated Deep Dose Equivalent* (mrem)	Number of Individuals in Dose Range
Less than 10 (M)	59
10 - 20	32
21 - 30	2
31 - 40	0
41 - 50	2
51 - 100	1
100 - 124	0
125 - 500	2
Greater than 500	0
Number of badged personnel:	98 persons
Collective dose for this group:	1.13 rem

* Deep dose equivalent as measured by film badge dosimeters. These dosimeters have 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 annual dose (330 mrem), was a Reactor Facility staff member routinely involved in unloading the mineral irradiation facility and preparing iridium - 192 seeds for shipment. All facility personnel doses were less than the University of Virginia ALARA Investigational Level 1 of 125 mrem/qtr.

b. Neutron Exposures

Thirteen Facility personnel were issued Neutrak ER neutron badges in 1995. The neutron dose distribution for this group is shown in Table 7.

TABLE 7	
1995 Personnel Neutron Doses at the Reactor Facility	
Measured Accumulated Deep Dose Equivalent(mrem)	Number of Individuals in Dose Range
Less than 20 (M)	15
20 - 30	1
Greater than 30	0
NOTE: These dosimeters have a minimum reporting dose of 20 mrem.	

c. Extremity Exposures

During 1995, 16 Facility personnel were issued 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, 1995 through December 31, 1995.

TABLE 8	
1995 Personnel Extremity Doses at the Reactor Facility	
Measured Extremity Dose (mrem)	Number of Individuals in Dose Range
Less than 30	12
30 - 500	8
501 - 1250	2
Greater than 5000	0
NOTE: These dosimeters have a minimum reporting dose of 30 mrem for X and gamma-rays and 40 mrem for energetic beta particles.	

The individual who received the highest extremity dose (1160 mrem), was a Reactor Facility staff member routinely involved in unloading the mineral irradiation facility and preparing Iridium seeds for shipment. All facility personnel doses (extremity) were less than the University of Virginia ALARA Investigative Level 1 of 1250 mrem/qtr.

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 that 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 recorded in 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 1995 was 122.8 mR. The highest individual exposure was 68.1 mR. This exposure was received by an individual packaging radioactive waste.

B. Effluents Released During 1995

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 Argon-41 activity is calculated from a known amount of activity released into the reactor room during a leak rate test of the room and readings obtained on the room argon monitor. These readings were then correlated to the normal readings on the argon monitor during 2 MW operation. Using this method, and the known amount of time the reactor was at power during 1995 (1703 MW-hours), the calculated maximum activity of Ar-41 released was 2.45 curies.

Calculations were performed to determine compliance with 10 CFR 61, Subpart I, entitled: National Emissions Standards For Radioactive Emissions From Facilities Licensed by the NRC and Federal Facilities Not Operated by the DOE. The calculated Total Effective Dose Equivalent (using the USEPA's COMPLY Code: V1.5d), from Ar-41 release was 2.8×10^{-2} mrem. On the basis of this calculation and the totals for the University as a whole, the University is exempt from reporting to the EPA on the annual emissions of radioactive material in 1995.

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 that 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 that 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. The release of effluents from the regeneration of the demineralizer system has been reduced considerably. This is due to better management of pool water makeup and pool water surface skimming that increases the time between regeneration of the demineralizer.

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 1995 there were 26 releases of liquid effluent to the environment (See Table 9), of which 16 were of pond water only.

In 1991 it was verified that pond water was leaking through the pond spillway to the release standpipe at an average rate of 3 gallons per minute. As this is considered release of pond water, it is sampled on a routine basis and analyzed for gross beta particle activity. Consequently, the volume and activity released via this pathway is included in the 1995 liquid release totals. The total volume of liquid released off-site in 1995 was 29,280,000 liters (7,700,000 gallons).

The average concentration of radioactive material (as measured by gross beta particle activity analysis) released in effluent from the UVAR site was 9.5×10^{-9} µCi/ml. This concentration was 32% of the UVAR administrative release limit. The average concentration of radioactive material in the water leaking through the spillway was 3.7×10^{-9} µCi/ml. The total activity (excluding tritium activity) released in effluent was 268 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 3.2×10^{-7} µCi/ml. This concentration was 0.03% of the applicable Effluent Concentration (EC) limit. The total tritium activity released during 1995 was 7300 µCi.

3. <u>Solid Waste Shipments</u>

In 1995, two hundred and sixteen (216) cubic feet of low level radioactive waste was transferred from the reactor to the Office of Environmental Health and Safety (EHS) for disposal. This waste was included in 2 EHS shipments of radioactive waste made to an off-site waste disposal facility in 1995.

Table 9

Liquid Effluent Release Sample Results			
Release No.	Avg. Gross Beta Activity (excluding Tritium) (x 10^{-8} μCi/ml ± 2 s.d.)	Release No.	Avg. Gross Beta Activity (excluding Tritium) (x10^{-8} μCi/ml ± 2 s.d.)
1	0.7 ± 0.2	14	0.4 ± 0.2
2	0.5 ± 0.1	15	0.5 ± 0.3
3	0.7 ± 0.3	16	0.5 ± 0.5
4	0.4 ± 0.1	17	0.4 ± 0.3
5	0.6 ± 0.2	18	0.5 ± 0.2
6	2.3 ± 0.2	19	0.3 ± 0.4
7	1.5 ± 0.9	20	0.4 ± 0.2
8	0.4 ± 0.2	21	1.3 ± 1.4
9	0.2 ± 0.2	22	0.5 ± 0.3
10	1.2 ± 1.1	23	0.8 ± 1.3
11	1.9 ± 0.1	24	2.1 ± 0.3
12	1.7 ± 0.5	25	2.0 ± 0.8
13	1.7 ± 0.5	26	1.1 ± 1.5
A priori LLD: 0.3 x 10^{-8}			

C. Environmental Surveillance

1. Water Sampling

Environmental water samples were collected on a monthly basis from various locations outside the facility. Gross beta particle activity analysis was performed on all water samples collected. The location of these samples and the results of the analyses are provided in table 10. The average gross beta concentration measured at each location was less than the applicable Effluent Concentration Limits.

Table 10

Environmental Water Sampling Results Gross Beta Particle Activity (x 10^{-8} μCi/ml ± 2 sigma)			
	Upstream of on-site pond	Water filtration plant 0.26 mi. southeast	Meadow Creek near Barracks Road, 1.8 mi. northeast (2 samples collected short distance apart on creek, results are averaged)
January	0.3 ± 0.2	0.3 ± 0.2	0.8 ± 0.3
February	0.2 ± 0.2	0.1 ± 0.2	0.3 ± 0.2
March	0.9 ± 0.2	0.4 ± 0.2	0.7 ± 0.1
April	0.6 ± 0.2	0.03 ± 0.1	0.5 ± 0.2
May	0.3 ± 0.2	< 0.3	0.4 ± 0.02
June	0.7 ± 0.2	0.1 ± 0.2	1.0 ± 0.02
July	0.5 ± 0.2	0.3 ± 0.2	0.4 ± 0.2
August	1.0 ± 0.2	0.3 ± 0.1	0.8 ± 0.7
September	0.9 ± 0.2	0.3 ± 0.2	0.6 ± 0.3
October	0.8 ± 0.3	0.1 ± 0.2	0.4 ± 0.5
November	1.2 ± 0.3	< 0.3	0.5 ± 0.3
December	0.8 ± 0.2	0.2 ± 0.1	0.6 ± 0.1
Avg + 2 s.d.	0.7 ± 0.6	0.2 ± 0.2	0.6 ± 0.4
A priori LLD: 0.3 x 10^{-8}			

2. Air Sampling

Environmental air samples were 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 that 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 in Air Particles (x 10^{-13} μCi/ml ± 2 sigma)

	Roof of UVAR Facility	0.13 miles east of UVAR Facility	3.1 miles northwest of UVAR Facility
January	0.9 ± 0.7	0.4 ± 0.1	0.4 ± 0.1
February	3.3 ± 0.8	0.7 ± 0.1	0.6 ± 0.1
March	1.5 ± 0.6	0.8 ± 0.1	9.0 ± 0.1
April	7.2 ± 1.0	2.3 ± 0.1	3.9 ± 0.1
May	3.4 ± 0.6	1.1 ± 0.1	1.5 ± 0.1
June	1.8 ± 0.6	0.7 ± 0.1	0.9 ± 0.1
July	5.8 ± 0.9	1.2 ± 0.1	2.5 ± 0.1
August	11.0 ± 0.9[a]	2.3 ± 0.1	3.3 ± 0.1
September	4.1 ± 0.9	1.8 ± 0.1	2.0 ± 0.1
October	12.0 ± 1.3[b]	2.3 ± 0.1	2.7 ± 0.1
November	5.8 ± 0.8	1.3 ± 0.1	2.1 ± 0.1
December	4.2 ± 0.9	1.5 ± 0.1	1.0 ± 0.1
Avg. + 2 s.d.	5.1 ± 7.1	1.4 ± 1.4	2.5 ± 4.6

a) Decay of activity on filter exhibited effective half-life of 11 hours (thoron daughters). Performed follow-up. Counted filter by gamma spec., nothing significant detected.

b) Decay of activity on filter exhibited effective half-life of 11 hours (thoron daughters). Results of additional sampling: 4.2 ± 1.0 μCi/ml gross beta particle activity.

Roof Sampler a priori LLD: 2.8 x 10^{-13} μCi/ml
Environmental samplers a priori LLD: 6.2 x 10^{-15} μCi/ml

3. Outside Area TLD Network

In the vicinity of the UVAR, TLD's are mounted at 8 fixed field sites. All of the sites are outside the UVAR facility but within the area surrounding the facility that is bounded by the exclusion fence. The dosimeters are changed out and read on a quarterly basis. Table 12 shows the doses recorded by these dosimeters.

Table 12 - 1995 Environmental Surveillance - Outside Area TLD Network

Deep Dose Equivalent (mrem) For Periods Shown Below

Location	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Total	Annual Net *
280	M	M	M	M	M	M
281	20	M	M	M	20	20
282	10	M	M	M	10	10
283	10	M	M	M	10	10
284	10	M	M	M	10	10
285	M	M	M	M	M	M
286	M	M	M	M	M	M
287	M	M	M	M	M	M
Control	M	M	M	M	M	Control
Control	M	M	M	M	M	Control

M = minimum detection limits: 10 mrem for gamma and x-rays, 40 mrem for energetic betas.

* Annual Net = Annual Total - Control Annual Total

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.

The levels of contamination detected in the Facility during 1995 were generally very low (typically less than 50 dpm/100 cm^2). In keeping with the ALARA policy, most areas are decontaminated if found to have greater than 50 dpm/100 cm^2. The area radiation level surveys revealed no overall increase in background or systems-related radiation levels.

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 3.5×10^{-12} μCi/ml. The airborne radioactivity detected was primarily due to radon and thoron daughters. None of the measured concentrations exceeded the applicable Derived Air Concentration (DAC) [3×10^{-11} μci/cc].

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 activity in water, on a triennial basis

Gross alpha, gross beta activity in water, on a triennial basis

Tritium in water, on a semiannual basis

Gross beta activity on air filter, on a semiannual basis

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 that are used as a basis for judging a laboratory's performance. Table 13 contains the results of the UVAR's performance in the above mentioned studies.

The normalized deviation of the mean from the known value is calculated from the deviation of the mean from the known value and the standard error of the mean values. The deviation of the mean from the known value is calculated by subtracting the known value from the average of the laboratory's three results. The standard error of the mean is calculated by dividing the expected precision by the square root of 3 (the number of results). The normalized deviation of the mean from the known value is calculated by dividing the deviation of the mean from the known value by the standard error of the mean.

Table 13
Results of EPA Radioactivity Measurement Laboratory Inter-Comparison Program

Date	Study	Known Value	UVAR reported average value	Normalized Deviation*
8-25-95	Air filter (Beta)	86.6 pCi/Filter	92.27	0.98
1-27-95 7-21-95 10-27-95	Gross α/β in H_2O	5.0 pCi/l 19.4 pCi/l 24.8 pCi/l	5.7 24.03 29.7	0.24 1.61 1.70
3-10-95 8-04-95	H-3 in water	7435.0 pCi/l 4872.0 pCi/l	7139.67 4796.33	-0.69 -0.27
6-09-95	Gamma in water	Co-60 40.0 pCi/l Zn-65 76.0 pCi/l Cs-134 50.0 pCi/l Cs-137 35.0 pCi/l Ba-133 79.0 pCi/l	39.67 74.67 46.67 34.33 73.0	-0.12 -0.29 -1.15 -0.23 -1.30
11-03-95	Gamma in water	Co-60 60.0 pCi/l Zn-65 125.0 pCi/l Cs-134 40.0 pCi/l Cs-137 49.0 pCi/l Ba-133 99.0 pCi/l	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. Abnormal Occurrences

In August 1995, the UVAR staff performed maintenance on the non-radioactive secondary side (tube side) of the UVAR heat exchanger which is used to cool the reactor pool. This maintenance involved cleaning tube fouling and removing accumulated scale noted on the ends of the tubes and the tube sheet. Following this maintenance it was discovered that a leak had developed between the primary and secondary side of the cooling system. When the primary pump was on, reactor pool water was leaked into the secondary system. With the pump off, secondary water leaked to the primary side. Calculations were performed to estimate the concentrations of radionuclides which may have been released to the air and sanitary sewer as a result of the

leak. Regulatory limits for off-site releases of radionuclides were not exceeded as a result of this leak.

In October 1995, water was discovered leaking from a crack in the reactor face on the ground floor above the south access facility. It was determined that the water was pool water based on the tritium content of the water. The drip leak was very small in flow rate and was easily collected. The leak stopped on its own after several weeks.

In November 1995, an increase in pool water loss was noted. The pool water loss occurred subsequent to the pool divider gate fit test. Pool water loss was monitored on a daily basis. The highest recorded loss rate was 300 gal/day with a weekly average of 100-180 gal/day. The leak rate (difference between the loss rate, or makeup rate, and the expected average evaporation rate of 40-50 gal/day) slowly dropped off to near traditional levels over the next two months and continues to be monitored. Calculations were performed to estimate an off-site dose as a result of this leak. It was concluded that the off-site impact was negligible and of no regulatory concern.

G. Summary

During 1995, 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 1995, no substantial changes were made to any existing experimental facilities and no new experimental facilities were added.

B. Research Activities

1. A continuing (but reduced) 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. A continuing research program in neutron radiography under the direction of Dr. Jack Brenizer.

3. Continuing research in collaboration with the Pacific Sierra Research Corporation in the development of monitoring systems for airborne radionuclides for use in support of the Comprehensive Nuclear Test Ban Treaty. This work is being performed by Dr. Albert Reynolds, Dr. Jack Brenizer, and Mr. Bouvard Hosticka.

4. Staff assistance was provided to a number of small projects utilizing a cobalt-60 irradiation facility. Several researchers at both U.Va., other universities and some high schools provided a number of different kinds of samples to be irradiated for either sterilization or to attempt to create genetic mutations.

5. Two indium-114 sources were created and shipped to a researcher at the University of Alabama at Huntsville for use in a project sponsored by NASA.

6. Several uranium-235 foils were irradiated in the reactor to produce small quantities of fission products to be used to test counting equipment being assembled and tested for PSR Corporation which is working under a federal government contract. The foils were activated for 10 seconds and produced 45 milliwatts of power so they were not considered as fueled experiments. Several other sources for use in the calibration of detector set-ups were also produced.

7. A small number of protein extracts were analyzed for manganese and zinc for a professor in the UVA Pharmacology Department.

C. Service Projects

1. Iodine determination by epithermal neutron activation analysis (ENAA) was performed on behalf of several sponsors, including Ross Laboratories, Woodson-Tenet Laboratories, Industrial Laboratories and the IAMS Company. The substances analyzed were infant formula, liquid diet supplements and pet foods.

2. Various samples were tested by neutron activation analysis in search of the trace levels of several elements for the Kodak Company as part of continuing research being conducted at one of their laboratories.

3. 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.

4. The Protechnics International Company, which supplies various radioactive sources to industry, had the Reactor Facility irradiate and ship to them about 40 canisters of a ceramic powder spiked with iridium. This material is used by companies performing oil well drilling.

5. Silicon samples were examined using NAA for a researcher at a small commercial company.

6. A number of small short-lived radioactive sources were produced for use in graduate and undergraduate nuclear engineering laboratories.

7. A UVA graduate chemistry class used NAA to determine the yield on synthesized transition element compounds.

8. 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-uteru. This is a continuing project for a local company that manufactures and distributes these pipettes.

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

D. Reactor Sharing Program

The Department of Energy has for the past fifteen 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 1995.

School tours:
Twenty-three tours from high schools, middle schools and elementary schools involving 470 students and teachers.

College tours:
Five tours from colleges involving 82 students and instructors.

Special tours in conjunction with U.Va. programs:
Ten tours involving 136 individuals; including faculty, staff, students and guests.

Individual tours:
Individuals, not part of groups, visiting the facility in 1995 totaled 179.

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.

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 1995 utilizing in part services provided by the Reactor Facility.

NE 488 - Nuclear Power Plant Operations
NE 682 - Nuclear Engineering Laboratory

During June 1995, 28 high school and middle 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 1995 by the University of Virginia in the discipline of Nuclear Engineering:

Bachelors of Science, Nuclear Engineering	11
Masters of Science, Nuclear Engineering	3
Masters of Engineering, Nuclear Engineering	6
Doctor of Philosophy, Nuclear Engineering	2
TOTAL	22

The following PhD and Master theses by students majoring in Nuclear Engineering or Engineering Physics were completed during 1995 in part using services or facilities provided at the U.Va. Reactor Facility.

Monte Carlo Simulation of Neutron Computed Tomographic Projection Data, PhD thesis in Nuclear Engineering by Roger O. Johnson

Multiple-Scale Systematic Homogenization Theories for Nodal Diffusion Methods, PhD thesis in Nuclear Engineering by Hongbin Zhang.

Optimization Study for an Epi-Thermal Neutron Beam for Boron Neutron Capture Therapy at the University of Virginia Research Reactor, MS thesis in Nuclear Engineering by Thomas Burns.

A Nodal Intergroup Method for the Linear Steady State Convection Diffusion Equation, MS thesis in Nuclear Engineering by Edward Michael.

A Monte Carlo Study of Dose in Breast Cancer Neutron Capture Therapy, MS thesis in Nuclear Engineering by James Weldy.

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

VI. FINANCES

A. Expenditures

Expenditures for 1995 were as follows:

	State Support	Locally Generated Monies
Salaries + Fringes:	$254,800	$115,400
Operations:	40,300	11,800
Subtotals:	$295,100	$127,200
TOTAL EXPENDITURES:		**$422,300**

B. Income

Income, both the actual amounts received (for work done in 1995 and in previous years) and billed (in 1995) are shown below:

Va. State support in 1995:	$295,100
Local income received in 1995:	187,200
TOTAL INCOME:	**$482,300**
Total billed in 1995:	174,100
Approximate total receivables as of 12/31/95	160,000

Note: In 1995, additional income and expenses in the form of staff salary support from research account budgets was also received and spent. This support has the effect of reducing expenditures from the local account budget. In 1995, the total for salaries and fringe benefits to support reactor staff members from research budgets was about $20,000.

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. During most of 1995 there were two full time salaried staff members receiving the their salaries wholly or in part from local funds. One full time wage employee was supported at about the 30% level with these funds. Several students, two of which are licensed reactor operators, were employed part time utilizing the locally generated monies.

Some 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. During 1995 one staff member took courses and completed his master's degree in Nuclear Engineering.