NUREG-0928

Safety Evaluation Report
related to the renewal of the operating license for the University of Virginia Open-Pool Research Reactor

Docket No. 50-062

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

September 1982

NOTICE

Availability of Reference Materials Cited in NRC Publications

Most documents cited in NRC publications will be available from one of the following sources:

1. The NRC Public Document Room, 1717 H Street, N.W.
   Washington, DC 20555
2. The NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission,
   Washington, DC 20555
3. The National Technical Information Service, Springfield, VA 22161

Although the listing that follows represents the majority of documents cited in NRC publications, it is not intended to be exhaustive.

Referenced documents available for inspection and copying for a fee from the NRC Public Document Room include NRC correspondence and internal NRC memoranda; NRC Office of Inspection and Enforcement bulletins, circulars, information notices, inspection and investigation notices; Licensee Event Reports; vendor reports and correspondence; Commission papers; and applicant and licensee documents and correspondence.

The following documents in the NUREG series are available for purchase from the NRC/GPO Sales Program: formal NRC staff and contractor reports, NRC-sponsored conference proceedings, and NRC booklets and brochures. Also available are Regulatory Guides, NRC regulations in the *Code of Federal Regulations,* and *Nuclear Regulatory Commission Issuances.*

Documents available from the National Technical Information Service include NUREG series reports and technical reports prepared by other federal agencies and reports prepared by the Atomic Energy Commission, forerunner agency to the Nuclear Regulatory Commission.

Documents available from public and special technical libraries include all open literature items, such as books, journal and periodical articles, and transactions. *Federal Register* notices, federal and state legislation, and congressional reports can usually be obtained from these libraries.

Documents such as theses, dissertations, foreign reports and translations, and non-NRC conference proceedings are available for purchase from the organization sponsoring the publication cited.

Single copies of NRC draft reports are available free upon written request to the Division of Technical Information and Document Control, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Copies of industry codes and standards used in a substantive manner in the NRC regulatory process are maintained at the NRC Library, 7920 Norfolk Avenue, Bethesda, Maryland, and are available there for reference use by the public. Codes and standards are usually copyrighted and may be purchased from the originating organization or, if they are American National Standards, from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

GPO Printed copy price: $5.00

NUREG-0928

Safety Evaluation Report
related to the renewal of the operating license for the University of Virginia Open-Pool Research Reactor

Docket No. 50-062

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

September 1982

ABSTRACT

This Safety Evaluation Report for the application filed by the University of Virginia for a renewal of Operating License R-66 to continue to operate a research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. The facility is owned by the University of Virginia and is located on the campus in Charlottesville, Virginia. Based on its technical review, the staff concludes that the reactor facility can continue to be operated by the University without endangering the health and safety of the public or endangering the environment.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

The University of Virginia (UVA) (applicant) submitted an application by letter (with supporting documentation) dated March 9, 1977 to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the Class 104 Operating License (OL) R-66 for its open-pool research reactor. The letter requests renewal of the Operating License for 20 years to permit continued operation at thermal steady-state power levels up to and including 2 MW. The university currently is permitted to operate the reactor within the conditions authorized in past amendments in accordance with Title 10 of the Code of Federal Regulations (10 CFR), Paragraph 2.109 (U.S. General Services Administration) until NRC action on the renewal request is completed.

The renewal application is supported by information provided in the Physical Security Plan, as supplemented on July 29, 1981; the Technical Specifications, as supplemented on March 11 and May 18, 1982; the Environmental Impact Appraisal Data; the Safety Analysis Report, as supplemented through March 19, 1982; the Reactor Operator Requalification Program; and the Emergency Plan.*

The renewal application contains the information regarding the original design of the facility and includes information about modifications to the facility made since initial licensing. The Physical Security Plan is protected from public disclosure under 10 CFR 2.790(d)(1) and 10 CFR 9.5(a)(4).

The NRC staff technical safety review with respect to issuing a renewal operating license to UVA has been based on the information contained in the renewal application and supporting documents, site visits, and responses to requests for additional information. This material is available for review at the Commission's Public Document Room at 1717 H Street, N.W., Washington, D.C. This Safety Evaluation Report was prepared by Robert E. Carter, Project Manager, Division of Licensing, Office of Nuclear Reactor Regulation, NRC. Assistance with the technical reviews was provided under contract by personnel from Los Alamos National Laboratory (LANL): J. E. Hyder, D. H. Whitaker, and J. G. Boudreau. They provided most of the input for Sections 4 through 14 of this Safety Evaluation Report (SER).

The purpose of this SER is to summarize the results of the safety review of the UVA reactor (UVAR) and to delineate the scope of the technical details considered in evaluating the radiological safety aspects of continued operation. This SER will serve as the basis for renewal of the license for operation of the UVAR facility at steady-state thermal power levels up to and including 2 MW. The facility was reviewed against the Federal regulations (10 CFR 20, 30, 50, 51, 55, 70 and 73), applicable Regulatory Guides (Division 2, Research and Test Reactors), and appropriate accepted industry standards (American National Standards Institute/American Nuclear Society (ANSI/ANS) 15 series). Because there are no specific accident-related regulations for research reactors, the

---

*The Safety Analysis Report (SAR) was used as basic review documentation and is referred to throughout this report.

staff has at times compared calculated dose values with related standards in 10 CFR 20, "Standards for Protection Against Radiation," both for employees and the public.

The initial UVAR Operating License was issued on June 24, 1960, authorizing operation at steady-state thermal power levels up to and including 1 MW. After operating the facility for several years, UVA (1) modified or replaced some of the original instrumentation, (2) increased the reactor cooling capacity, (3) added an automatic core spray cooling system, and (4) applied for a license amendment for authorization to operate the reactor at steady-state thermal power levels up to and including 2 MW. This license amendment, No. 9, was issued by NRC (AEC) on November 4, 1971. Amendment No. 9 included an expiration date of September 13, 1977 for OL R-66.

The UVAR has been operated for more than 21 years with a total energy generation of about 830-MW days. In terms of radiation exposure of reactor components or production of radioactive effluents, this amount of operational use corresponds to about 1200 working days at maximum authorized steady-state power. During this time, the reactor has provided the principal support to a major component of the university's educational and research programs.

Plate-type reactors--using essentially the same kind of fuel, similar control rods and drive systems, and similar safety circuitry as the UVAR--have been constructed and operated in many countries of the world, including the United States where there are more than 50 such reactors. Since the first of this type of reactor was assembled in 1950 there have been no reported events that caused significant radiation risk to public health and safety. Several plate-type reactors have an annual operation at least a factor of 10 greater in MW hours than the UVA reactor, both because of different types of research programs and because of higher operating power levels.

1.1 Summary and Conclusions of Principal Safety Considerations

The staff evaluation considered the information submitted by the applicant, past operating history recorded in annual reports submitted to the Commission by the applicant, reports by the Commission's Office of Inspection and Enforcement, and onsite observations. In addition, as part of the licensing review, the staff obtained laboratory studies and analyses of credible accidents postulated for the plate-type reactor.

The principal matters reviewed and the conclusions reached for the UVA reactor were

(1) The design, testing, and performance of the reactor structure and the systems and components important to safety during normal operation were adequately planned, and safe operation can reasonably be expected to continue.

(2) The expected consequences of several postulated credible accidents have been considered, emphasizing those likely to cause loss of integrity of fuel-element cladding. The staff performed conservative analyses of the most serious hypothetically credible accidents and determined that the calculated potential radiation doses outside of the reactor site are not likely to exceed the guidelines of 10 CFR 20 doses for unrestricted areas.

(3) The applicant's management organization, its conduct of training and research activities, and its security measures are adequate to ensure safe operation of the facility and protection of special nuclear material.

(4) The systems provided for control of radiological effluents can be operated to ensure that releases of radioactive wastes from the facility are within the limits of the Commission's regulations and are as low as reasonably achievable (ALARA).

(5) The applicant's Technical Specifications, which provide operating limits controlling operation of the facility, are such that there is a high degree of assurance that the facility will be operated safely and reliably.

(6) The financial data and information provided by the applicant are such that the staff has determined that the applicant has reasonable access to sufficient revenues to cover operating costs and eventually to decommission the reactor facility.

(7) The applicant's program, which provides for the physical protection of the facility and its special nuclear material, complies with the applicable requirements of 10 CFR 73.

(8) The applicant's procedures for training its reactor operators and the plan for operator requalification are adequate. These procedures give reasonable assurance that the reactor facility will be operated competently.

(9) The applicant has submitted an Emergency Plan in compliance with the existing applicable regulations. This item is discussed further in Section 13.3.

1.2 Reactor Description

The UVAR is a heterogeneous, swimming-pool-type reactor. The core is cooled by either natural or forced convection of light water, moderated by water, and reflected by water and/or graphite. The reactor core is located near the bottom of a water-filled pool, which has inner dimensions of approximately 12 ft wide by 32 ft long by 26 ft deep. The core and control systems are suspended from a bridge that rides on rails above the reactor pool; this arrangement permits controlled movement of the reactor system to provide radiation fields in various locations within the pool. An interlock system prohibits operation of the reactor except under limited conditions at the various positions within the pool.

The reactor core is composed of approximately 20 fuel elements positioned in holes in an aluminum grid plate. The grid plate is suspended from the movable bridge by an aluminum framework. The grid plate contains an 8 by 8 array of holes to allow changing fuel element configurations and to allow insertion of graphite reflector elements to displace reflector water. Each fuel element consists of several thin metal plates assembled into a unit about 3 in. by 3 in. with an active fuel length of approximately 2 ft. Fuel elements of this general configuration were first designed for and used in the Materials Testing Reactor (MTR) and subsequently are referred to as MTR-type fuel elements. Four of the fuel elements are fabricated with the six middle plates missing, providing space for the positioning and movement of the reactor control rods.

Reactivity of the reactor core is changed by the operator by moving the control rods that are suspended from fail-safe electromagnets located on the support bridge. The ionization chambers used for sensing neutron and gamma-ray flux densities are suspended near the core. The control console, from which the operator can observe the reactor room and the top structures of the reactor through a large window, is located in a small room adjacent to the reactor room. The control console consists of typical read-out and control instrumentation.

The reactor pool is formed within a monolithic reinforced-concrete biological shield. Additional details of the reactor facility and auxiliary systems are contained in the applicant's SAR, and in later sections of this safety evaluation report.

1.3 Reactor Location

The UVA reactor is housed in the Nuclear Reactor Facility of the Department of Nuclear Engineering on the UVA campus, approximately 700 m west of the city limits of Charlottesville, Albemarle County, Virginia. The reactor is located in a remote part of the campus, approximately 3 km from the downtown business district of the city of Charlottesville. The reactor building is constructed of conventional masonry, except for the reactor room, which is cylindrical, windowless, and constructed of reinforced masonry. The reactor building, built on sloping land, is partially underground.

1.4 Shared Facilities and Equipment and Special Location Features

The reactor room is attached to the Nuclear Engineering laboratories, dedicated primarily to university education, training, and research. Utilities such as municipal water and nonradioactive sewage, natural gas, and electricity are provided for joint use in the entire building.

The reactor room has its own ventilation control system, capable of isolation, which exhausts air through a short stack located on the roof of the building. This system also exhausts air from other areas of the reactor facility for a typical total flow of about 8600 cfm. The nearest occupied building that is not part of the reactor facility, yet still on the campus, is a nuclear research laboratory about 125 m from the location of the reactor exhaust stack.

1.5 Comparison with Similar Facilities

The fuel used in the UVAR is based on the MTR design and is very similar to the fuel used in approximately 50 other research reactors operating in the USA and at least 25 reactors operating in foreign countries. The control and instrumentation systems, while different in detail, are based on the same operating principles used for these 75 other research or test reactors.

2 SITE CHARACTERISTICS

Chapter 4 of the initial Hazards Summary (1957) and Chapter II of the Revised Safety Analysis Report (1970) provide information pertaining to the site of the UVAR facility.

2.1 Geography

The site is located at an elevation of about 200 m at an abandoned reservoir in a valley between two small mountains, approximately 3 km from the downtown business district of Charlottesville. Figure 2.1 shows the location with respect to the Charlottesville area and Figure 2.2 shows the contours of the site, the location of the exclusion fence, and the nearest offsite occupied building, a nuclear research laboratory. The next nearest occupied buildings are a radio-astronomy research laboratory and UVA student's dormitories located about 250 m and 325 m, respectively, from the site.

2.2 Demography

Except for Charlottesville and the university campus, there are no other large population centers within Albemarle County, which surrounds the reactor site for more than 16 km in all directions. The land use in the county is mainly for agriculture, so the population density is typically low density rural. The highest concentration of the Charlottesville residents, and the majority of the city's population live in the range between about 1.5 to 5 km east of the reactor site. The nearest occupied dwelling is the student's dormitories, approximately 325 m from the reactor.

2.3 Nearby Industrial, Transportation, and Military Facilities

2.3.1 Transportation Routes

The reactor site is in a rugged hilly section of the campus. There is no major highway or railway within hundreds of meters; the closest roads are not heavily travelled. The small Charlottesville airport, lightly used by commercial planes, is more than 15 km from the reactor site.

2.3.2 Nearby Facilities

There are no large industries or major military establishments in the Charlottesville area that cause heavy utilization of local transportation systems.

2.3.3 Conclusion

Because there are no industrial or military facilities near the reactor site that could directly or indirectly cause accidental damage to the reactor facility, the staff concludes that the only accidents that need be evaluated in detail in considering the safety of the public are those which might originate from within the UVAR facility. These are discussed in Section 14 of this report.

2.4 Meteorology

The University of Virginia lies in the western region of the Piedmont Plateau, in the eastern foothills of the Blue Ridge Mountains of the Appalachian complex. The site has a continental type of climate, moderated by the proximity of the Atlantic Ocean.

For most of the year winds from the northern quadrant predominate, with a secondary maximum frequency of winds from the south and southwest, whereas winds from the east and southeast are relatively rare. This holds true also for the various seasons. In winter, most of the wind directions lie in the northeastern quadrant with an isolated maximum frequency of winds from the west. In summer most of the winds are from the southern quadrant with a secondary maximum from the northeast. The frequency of calm or stagnant wind conditions is relatively low during all seasons of the year except in summer. These meteorological features are generally the result of the predominant anticyclonic circulation over the northern portion of the country during the winter and the semipermanent Atlantic high that moves northward and eastward in the spring. These larger features are locally moderated by the generally northeast to southwest course of the Appalachian Mountain chain and its valleys. Tables 2.1 and 2.2 tabulate wind data obtained at the UVAR site several years ago. These tables indicate that the most probable wind direction is generally from the direction of the reactor toward the main campus and the City of Charlottesville. On the other hand, on the average, the winds blow in some other direction most of the time.

2.5 Hydrology

The reactor building is constructed on the side of a small ravine, or draw, between two mountains, some 15 m above an artificial pond that was originally dammed to be used as a reservoir. In this location, the building is well above the flood plain, and not low enough in the ravine to be in the path of credible flash floods caused by heavy rainfall in the mountains. The pond waters can be released into Meadowbrook Creek, which flows into the Rivanna River. In case of failure of the reactor pool, the pond will serve as a temporary holding basin for the water.

2.6 Geology and Seismology

The Central Appalachian region is characterized by a moderate amount of low-level earthquake activity. Because of the low seismic energy release, this region has not received much attention in the form of seismology studies. However, one study completed in 1969 indicates a history of 9 earth tremors in Charlottesville and Albemarle County during the period of 1758 through 1968. Table 2.3 summarizes those data where intensities are given on the modified Mercalli scale, when strong enough to have been determined.

The staff concludes that the history of seismic activity in the Charlottesville area indicates that earthquakes do not pose a significant risk of damage to the reactor facility.

2.7 Conclusion

The staff has reviewed and evaluated the UVAR site for both natural and manmade hazards and concludes that there are no significant risks associated with the site that make it unacceptable for the continued operation of the reactor.

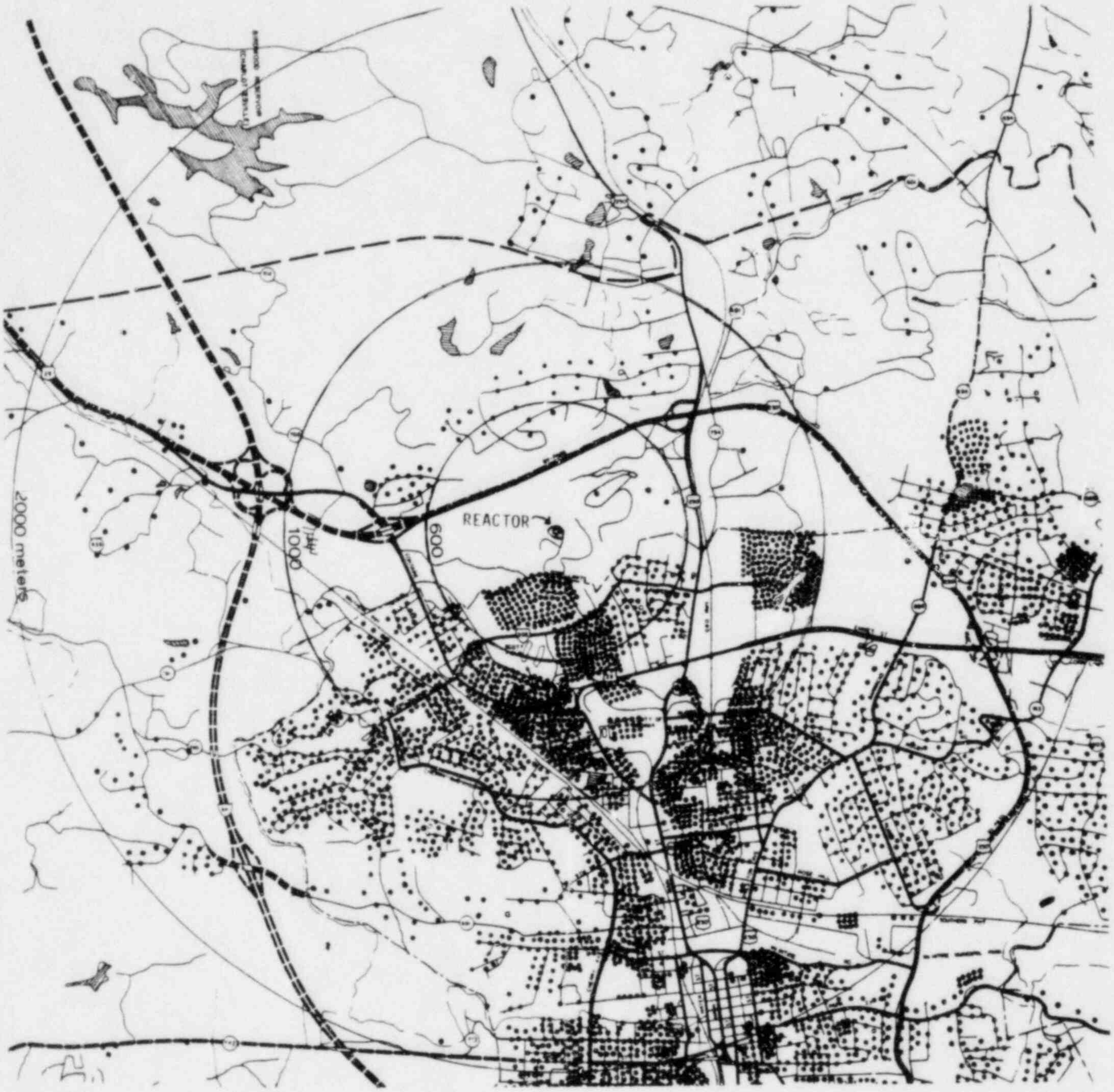


Figure 2.1 Population density distribution (1968)
(each dot = 10 Persons)

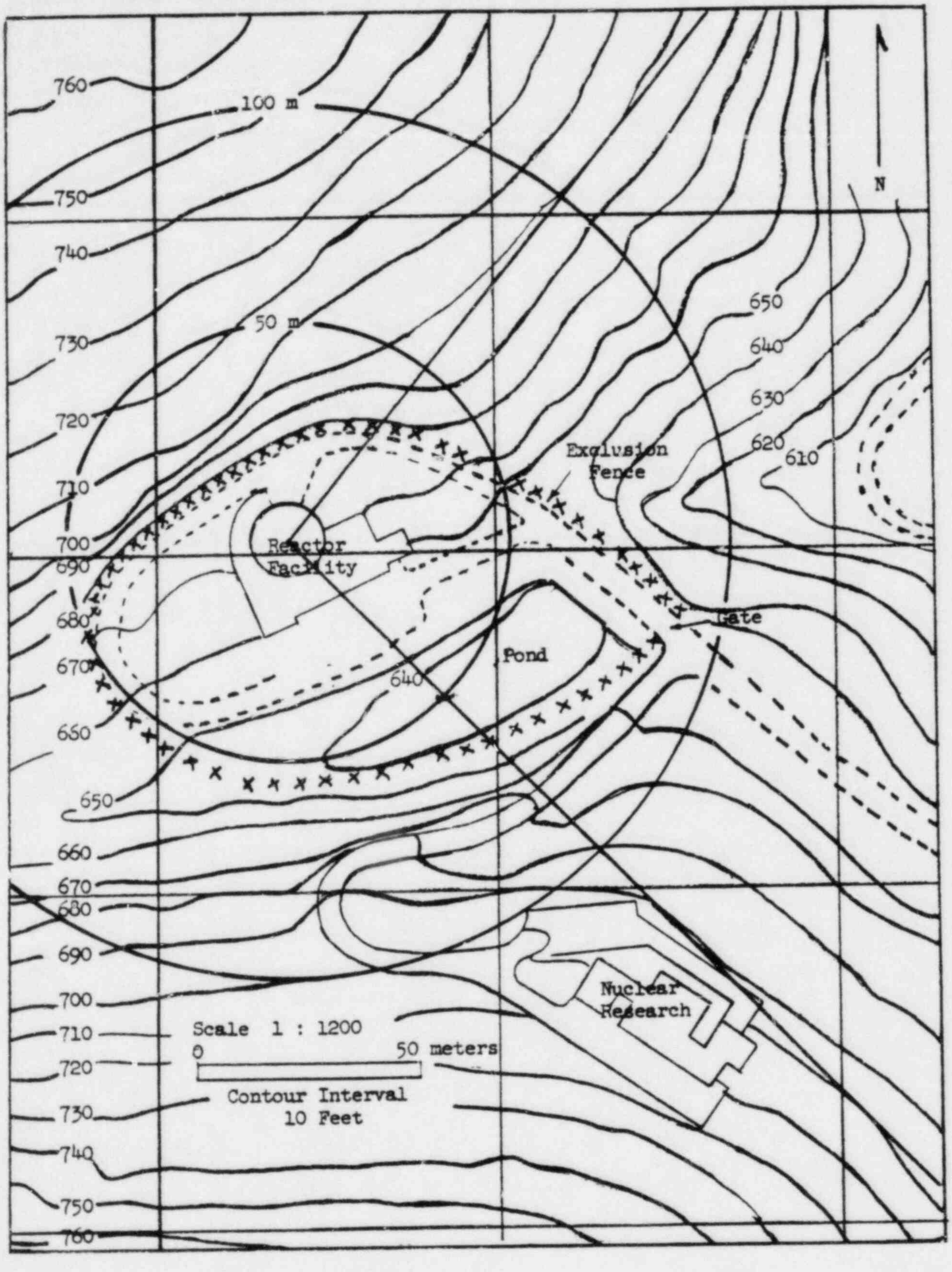


Figure 2.2 Contour map of UVAR site with exclusion fence

Table 2.1 Relative frequency of hourly wind speeds in percent by season

Wind Speed Type	- mph	Summer	Fall	Winter	Spring	Year
Calm	0-1	43.5	9.0	3.5	20.7	18.7
Light	1-3	15.3	2.0	1.4	8.1	6.4
Gentle	4-10	28.0	10.7	14.3	31.7	20.0
Moderate	11-21	11.6	33.3	61.8	37.9	36.3
Strong	21-up	1.6	45.0	19.0	1.6	18.6
Total		100.0	100.0	100.0	100.0	100.0
Avg. Speed (mph)		4.26	15.0	13.1	7.71	10.36*

*The average wind speed of 10.36 mph is equivalent to 4.63 m/sec.

Table 2.2 Relative frequency of hourly wind directions in percent by season

Direction	Summer	Fall	Winter	Spring	Year
North	5.6	27.4	30.3	8.4	16.9
Northeast	7.4	10.2	28.3	24.5	16.8
East	5.7	0.0	2.6	0.0	2.6
Southeast	7.8	12.4	8.0	2.6	8.1
South	10.6	3.8	3.0	10.2	7.8
Southwest	8.5	10.3	4.6	5.0	7.7
West	3.8	15.9	12.5	9.2	10.0
Northwest	7.1	10.9	7.5	10.4	11.4
Calms	43.5	9.1	3.5	20.7	18.7
Total	100.0	100.0	100.0	100.0	100.0

Table 2.3 Earthquake activity recorded in the Charlottesville area

Date	Intensity at Epicenter
August 27, 1833	VI
April 29, 1852	VI
September 1, 1886	V-VI
December 26, 1929	VI
April, 1936	Not Available
February 2, 1937	III-IV
May 24, 1946	Not Available
March 26, 1948	Not Available
September 10, 1952	IV
May 31, 1966	Not Available
November 19, 1969	Not Available

3 DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

The applicant's Safety Analysis Report provides information on the design, construction, and functions of the as-built reactor building, reactor systems, and auxiliary systems.

3.1 Wind Damage

Meteorological data indicate a low frequency of tornadoes and effects of tropical disturbances, but a moderately high frequency of summer thunderstorms. However, the reactor pool is formed by a monolithic reinforced-concrete shield, integrally constructed in a reinforced masonry building located partially below grade. The open pool and reactor building operate at atmospheric pressure, so loss of integrity of either resulting from wind damage could lead to nonexplosive collapse. In turn, loss of pool water might occur; however, the applicant's analysis, with which the staff agrees, provides adequate assurance that loss of coolant would not lead to melting of any fuel. Therefore, the staff concludes that wind or other storm damage to the UVAR facility poses no significant risk to the public.

3.2 Water Damage

The reactor building is situated in the side of a well-drained hill, above the flood plain, and adequately above the level of potential flash flood waters in the ravine. Therefore, the staff concludes that there is reasonable assurance that damage to the reactor structures by flood or groundwater is not likely and risk to the public is not significant.

3.3 Seismic-Induced Reactor Damage

The UVA reactor pool is a reinforced-concrete structure embedded on the side of a ravine. These features will resist damage resulting from seismic activity. No seismic analysis has been performed because (1) Charlottesville is in a region of historically low seismic activity and (2) damage to the reactor and loss of coolant would not result in melting of fuel (see Section 14.1.3).

These considerations give the staff reasonable assurance that the risk to the public resulting from seismic damage to the reactor is not significant.

3.4 Mechanical Systems and Components

The mechanical systems of importance to safety are the neutron-absorbing control rods suspended from the superstructure, which also supports the reactor core. The motors, gear boxes, electromagnets, switches, and wiring are above the level of the water and readily accessible for testing and maintenance. An extensive preventive maintenance program has been in operation for many years for the UVAR to conform and comply with the performance requirements of the Technical Specifications. Furthermore, obsolete components have been replaced in a timely manner with state-of-the-art, higher quality items.

The effectiveness of this replacement and preventive maintenance program is attested to by the small number and types of malfunctions of equipment over the years of operation. These malfunctions generally have been one of a kind (that is, no repeats) and/or of components that were fail safe or self-annunciating. The staff, therefore, concludes that there appears to be no significant deterioration of equipment with time or with operation. Thus there is reasonable assurance that continued operation for the requested period of renewal will not increase the risks to the public.

3.5 Conclusion

The UVA reactor facility was designed and built to adequately withstand all credible and likely wind and water damage associated with the site. The considerations above indicate that a seismic event has a small likelihood of occurring and small consequences if it did. Therefore, the staff concludes that potential seismic events need not be evaluated explicitly.

4 REACTOR

The University of Virginia reactor first went into operation in 1960. It is an open-pool-type reactor using up to 3.5 kg of ^{235}U fuel enriched to approximately 93%. It is a light-water-moderated, graphite- or water-reflected reactor that currently is authorized to operate at steady-state power levels up to and including 2 MW thermal. The fuel, core configuration, control rods, and control instrumentation are similar to some 75 research reactors operating throughout the world. At least 30 MTR-type reactors have been evaluated and licensed by AEC/NRC.

The UVAR generates no electricity and is used primarily for class instruction, student experiments, reactor operator training, research, and radioisotope production.

4.1 Building Layout

The reactor facility (Figure 4.1) consists of the main reactor room, a radiation laboratory area, a hot cell, a low-background counting room, a health physics laboratory, a machine shop, an electronics shop, and office space. The facility also houses the University's low-power (100 W) training reactor, the CAVALIER. Figure 4.2 shows the floor plans for the three levels of the facility.

The facility construction is of conventional masonry with the exception of the main reactor room. The reactor room above the pool is cylindrical and is 54 ft in diameter and 36-1/2 ft high. This portion of the building is designed to withstand a differential pressure of 0.5 psi. The walls are reinforced masonry plastered on the inside for gas tightness; the roof is a concrete slab. The reactor room is windowless, and the only openings into the room are the truck door, the personnel door, the escape manhole, and the air exhaust duct.

The truck door is steel, and a reactor scram signal is initiated when it is moved from a fully closed position. The personnel door and the ventilation exhaust duct damper swing closed against rubber gaskets unless they are held open by electromagnets. The magnets are released automatically in the event of a high radiation monitor signal in the reactor room. In addition, any increase in pressure in the reactor room will tend to seal these openings tighter. In such an event, the operator can exit through an underwater emergency escape hatch that is normally closed and secured.

The reactor control room, which houses the control console, is located within the reactor room along the west wall. A plate-glass window provides a view of the reactor area from the control console while physically isolating the control room from the rest of the reactor room.

4.2 Reactor Core

The core consists of typical MTR-type fuel elements and four bayonet-type control rods. Several different fuel loadings are possible with this reactor, and a reactor grid plate containing an 8 by 8 array of holes for positioning the fuel elements and experimental apparatus is provided. The minimum critical loading with water as the reflector is a 4 by 5 array of fuel elements. Graphite elements also can be loaded around the core to act as a reflector. In this configuration, the minimum critical loading is a 4 by 4 fuel array surrounded on all four sides by two rows of graphite elements. These two typical core loadings are shown in Figure 4.3.

Not all of the positions in the grid plate are filled by either fuel or graphite elements for many core configurations. For these loadings, plugs are fitted into any empty holes so that the cooling water passes down through the fuel elements rather than through the open holes when forced circulation is used. The grid plate also contains a series of small holes interspaced between the positioning holes to provide cooling flow between the elements.

4.2.1 Fuel Elements

The UVAR can operate with either flat-plate or curved-plate MTR-type fuel elements. The plates of both elements are a sandwich of aluminum cladding over a uranium-aluminum alloy "meat" approximately 0.02-in. thick and 23.5-in long. The cladding is 0.015 in. thick except on the outer plates of the curved-plate elements, where it is 0.0225 in. thick. The overall dimensions for both types of fuel elements are approximately 34 in. long, 3 in. wide, and 3 in. thick.

The standard flat-plate fuel element (as shown in Figure 4.4) consists of 12 plates. The control rod element has the center six plates removed to allow space for inserting the rod. Partial elements also are provided, and these have six fuel-bearing plates alternating with six nonfuel-bearing plates. Each standard flat-plate fuel element contains approximately 165 g of ^{235}U, and the control rod or partial element contains approximately one half as much. A 0.211-in. space is provided between each flat plate for coolant flow.

Each standard curved-plate fuel element consists of 18 fuel-bearing plates, and the control rod element contains 9 fuel-bearing plates. A partial element contains 9 fuel-bearing plates alternating with 9 nonfuel-bearing plates. The standard curved-plate fuel element contains approximately 195 g of ^{235}U, and the control rod or partial element contains approximately 98 g of ^{235}U. The coolant gap in the curved-plate elements is 0.122 in.

Although the UVAR may use either flat-plate or curved-plate fuel, the two types are not mixed in one core loading because this is an unreviewed question bearing on reactor safety.

4.2.2 Control Rods

The power level in the UVAR is controlled by three shim rods and one regulating rod. All four rods are of the bayonet type, which fit into a central gap provided in special control rod fuel elements, as discussed in the previous section. The rods and their fuel elements can be located in any core position.

The shim rods are made of boron-stainless steel clad with aluminum. The absorbing section, which is approximately 1.5% boron by volume, is 24.8 in. long and has a cross section of 2.25 in. x 0.875 in. with semicircular ends.

Each shim rod is worth approximately 3% Δk/k, and each is moved in and out of the core by an individual electro-mechanical system. The drive mechanism, which is supported by the bridge, consists of an electric motor and lead-screw drive. The rod, containing the absorber section, is suspended from the drive mechanism by an electromagnet. During normal operation these rods are driven either in or out at a rate of 3.7 in./min. When a scram signal is received, the magnets are deenergized and the shim rods drop freely into the core. The rods are fully inserted in less than 1 sec.

The regulating rod is stainless steel with an aluminum cladding. Its reactivity worth is approximately 0.5% Δk/k. The regulating rod has a similar drive mechanism but the rod is permanently fixed to it. The rod travels at a speed of approximately 24 in./min in either direction and does not drop on a scram signal.

4.2.3 Conclusion

The staff has reviewed the information concerning the mechanical design of the reactor fuel, the control rods, and the control rod drives and has found that the capability of these components is adequate to give reasonable assurance of reliable operation during the proposed licensing period.

4.3 Reactor Pool and Support Structure

The reactor pool is 32 ft long (north-south), 12 ft wide, and 26.3 ft deep and holds about 75,000 gal of water. The core is suspended in the pool by an aluminum framework attached to a movable bridge (Figure 4.5). The bridge moves in a north-south direction on rails positioned along the east and west sides of the pool. The bridge is restrained so the reactor cannot be brought closer than 4 ft from the pool walls. The reactor's vertical position is fixed; the bottom of the core is 4.5 ft above the pool floor. With this core elevation, the top of the active fuel region is 19.75 ft below the surface of the water when the pool is full.

For reasonable lengths of operating time at low power levels, the heat capacity of the pool is sufficient to permit operation at power without the use of an external heat exchanger. However, at power levels of several hundred kW, versatility of operation requires dissipating the heat to an external heat dump. To operate near and above 1 MW, forced convective cooling of the core is necessary. The UVAR systems combine these coolant requirements by having a coolant outlet header at the south end of the pool that can be raised to contact the bottom of the core plenum. For operation at more than 200 kW, the core is located above this header and the primary coolant is pumped downward through the fuel and then through the external heat exchanger and back to the pool. For power levels at 200 kW or less, the reactor core may be operated with natural convective cooling at the north end of the pool, or at the south end of the pool with the header disengaged.

4.4 Shielding

The core is shielded in all directions by the pool water. Additional shielding is provided on three sides by concrete and earth because the reactor pool is below ground level on all but the south face. A massive concrete shield with thicknesses ranging from a maximum of 90 in. at the bottom (near the core elevation) to a minimum of 30 in. at the top forms the south face of the pool. This shield is penetrated by two 8-in. beam ports, a large access facility, and a thermal column. When not in use, these experimental facilities are filled with concrete shield plugs.

4.5 Dynamic Design Evaluation

The reactor is provided with redundant rapid-response controls and nuclear instrumentation (Section 7) to attain versatile and safe operation. The reactor core system is designed to have negative fuel and moderator temperature coefficients of reactivity and a negative void coefficient of reactivity. The ultimate void, total loss of coolant, removes the principal neutron moderator and shuts down the reactor.

The applicant has performed extensive analyses of reactor dynamic behavior initiated by various changes in reactivity. The staff has reviewed these analyses, and finds them acceptable. In the next section, the evaluation of an instantaneous change of reactivity is described. Section 14.1.1 discusses in more detail the evaluation of reactivity insertions by means of the control rods.

4.5.1 Unsecured Experiments

Any unsecured experiments placed in the UVAR are limited by the Technical Specifications to a maximum absolute reactivity worth of 0.45% $\Delta k/k$. If such an experiment were suddenly moved while the reactor is critical, a power excursion with a period as short as 3 sec could result. The licensee has calculated the consequences of such a transient and concluded that no safety limits would be exceeded. The staff's review found the analysis to be conservative, and, therefore, accepts this conclusion.

In the analysis, a reactor period of just greater than 3 sec was assumed so that the scram would be initiated by the high-power signal rather than the "period scram." It also was assumed that the shim rods would have to drop 5 in. from their fully withdrawn position to compensate for the reactivity insertion. Based on the Technical Specification limits for magnet release and rod drop times, it was assumed that it would take the rods 350 msec from the initiation of the scram signal to drop the required 5 in. The scram signal was initiated at a power level of 3.45 MW, corresponding to a conservative true value of the limiting safety system setting. The negative temperature coefficient of reactivity was neglected in this analysis. Under these conditions, it was shown that the power would not increase to more than 3.88 MW. It can be seen from the power-vs-flow curve in the Technical Specifications (Figure 2.1) that even at the 744 gal/min limiting true value of total coolant flow, the safety limits would not be exceeded.

4.5.2 Shutdown Margin

The absolute reactivity worth of all experiments is limited to less than 2.0% $\Delta k/k$, with the two highest-worth experiments totaling less than 1.6% $\Delta k/k$. As stated earlier, the shim rods are worth approximately 3% $\Delta k/k$ each, and the regulating rod is worth approximately 0.5% $\Delta k/k$. The required minimum shutdown margin with the most reactive control rod fully withdrawn is 0.4% Δk/k. These limitations provide adequate flexibility to load sufficient excess reactivity into the core to compensate for the effects of experiments, temperature coefficients of reactivity, and fission product poisoning, while still ensuring that the reactor can be controlled even if the most reactive shim rod were to fail to insert.

4.5.3 Excess Reactivity

Maximum excess reactivity in the UVAR core now is limited to 5.00% Δk/k by Technical Specifications. This amount provides for the effect at 2 MW of the negative power coefficient of reactivity, the negative reactivity effect of xenon at equilibrium at 2 MW, and about 2% Δk/k additional for experiments, uranium burnup, and operational flexibility. Although limiting the minimum shutdown margin (Section 4.5.2) and the total excess reactivity tends to overconstrain the reactor operation, it helps ensure that the core configuration, control rod positions, and power peaking factors assumed in the Safety Analysis Report are consistent with those parameters in the operational core.

4.5.4 Conclusion

Based on the information presented above, the staff concludes that the limitation on reactivity worth for unsecured experiments of 0.45% Δk/k provides assurance that these experiments will not lead to a reactivity insertion incident that will pose a threat to the health and safety of the public. In addition, the staff concludes that the 0.4% Δk/k shutdown margin is sufficient to ensure that the reactor can be adequately shut down under all likely operating conditions.

4.6 Operational Practices

The University of Virginia has implemented a preventive maintenance program that is supplemented by a detailed preoperational checklist to ensure that the reactor is not operated at power without all of the safety-related components fully operational.

The reactor is operated by trained NRC-licensed personnel in accordance with explicit operating procedures, which include specified responses to any reactor control signal. All proposed experiments involving the use of this reactor are reviewed by the Reactor Safety Committee for potential effects on the reactivity of or damage to the core, as well as for possible effects on the health and safety of employees and the general public.

4.7 Conclusion

The staff review of the reactor facility has included studying its specific design and installation features and its operational limitations as identified in the Technical Specifications. The design features of the UVAR are similar to those typical of many pool-type research reactors operating in many countries of the world. Based on its review of the UVAR and its experience with similar facilities, the staff concludes that there is reasonable assurance that this reactor is capable of safe operation, as limited by its Technical Specifications, for the period of the license renewal.

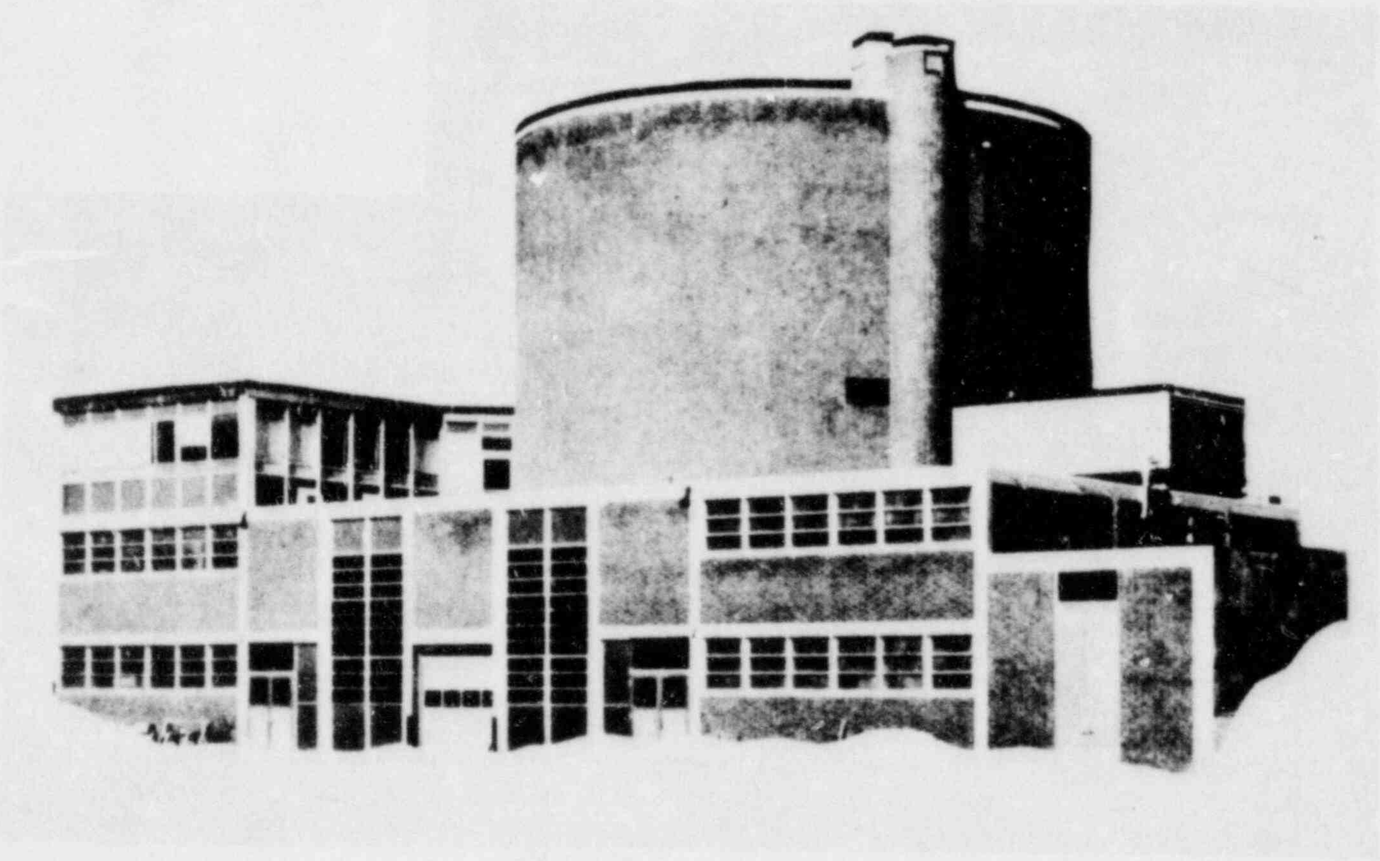
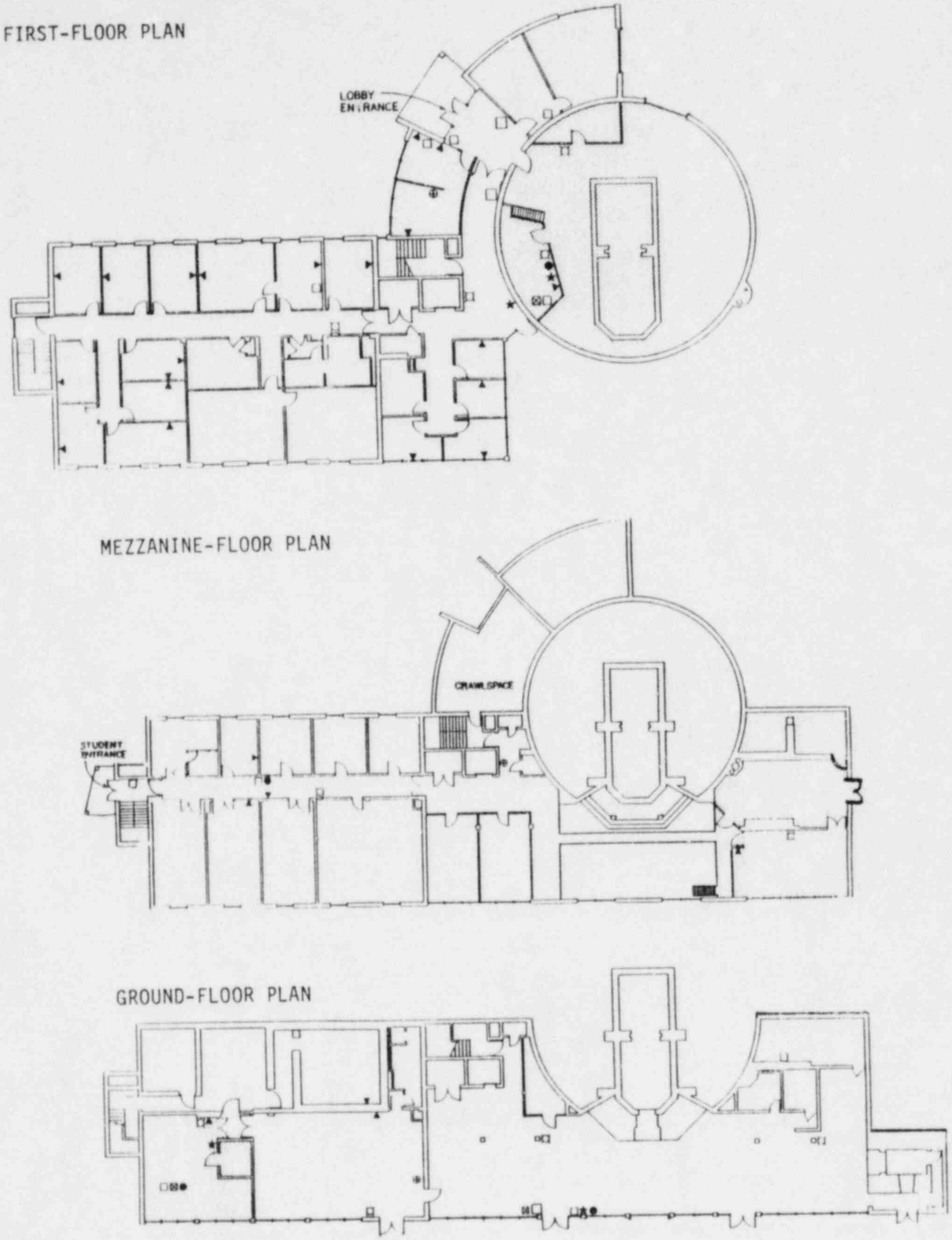


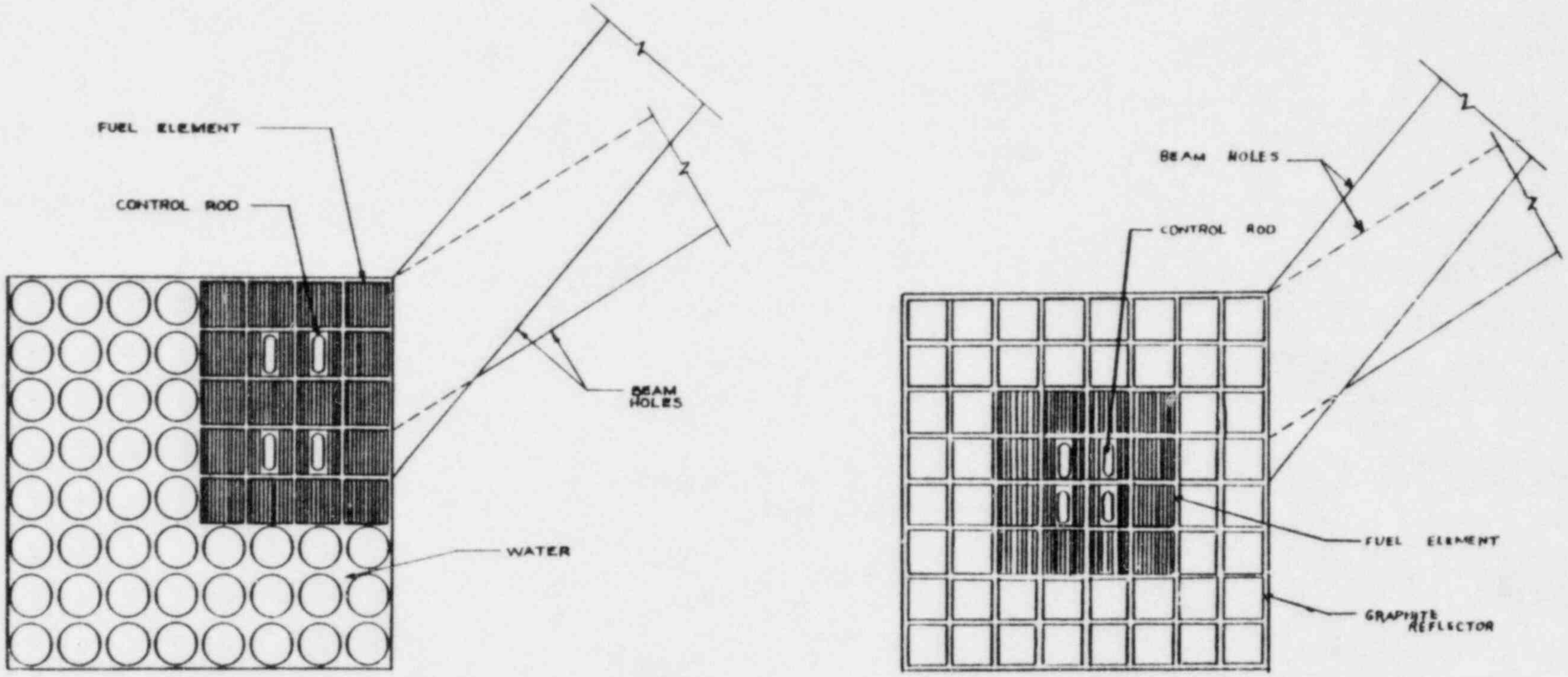
Figure 4.1 University of Virginia research and training reactor facility


FIRST-FLOOR PLAN

MEZZANINE-FLOOR PLAN

GROUND-FLOOR PLAN

Figure 4.2 Plans of the nuclear reactor facility



Reactor loading with water reflector
(Loaded for maximum fast neutron intensity
in beam holes. Thermal column not in
position.)

Reactor loading with graphite reflector

Figure 4.3 Typical UVAR core loadings

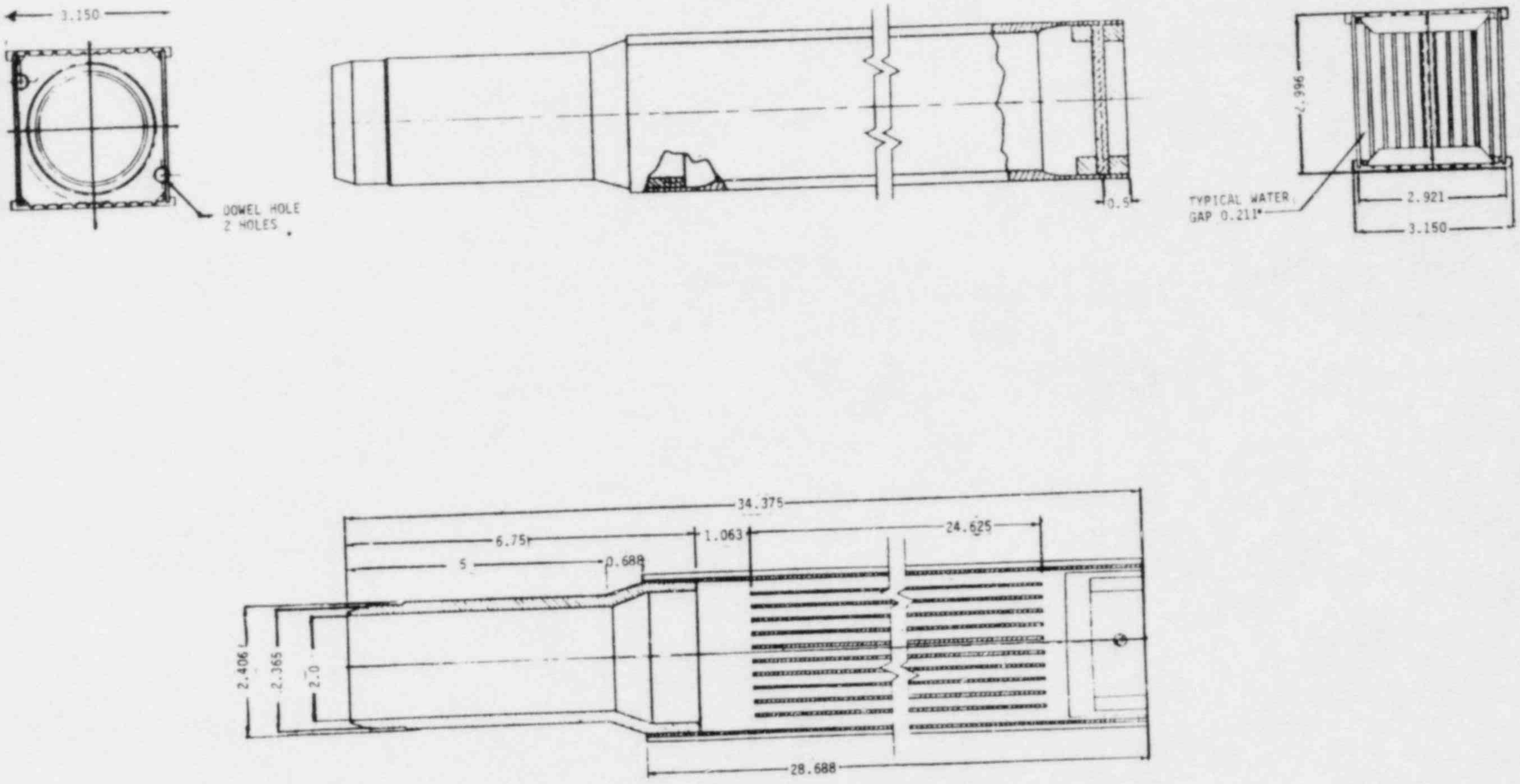


Figure 4.4 Standard fuel element

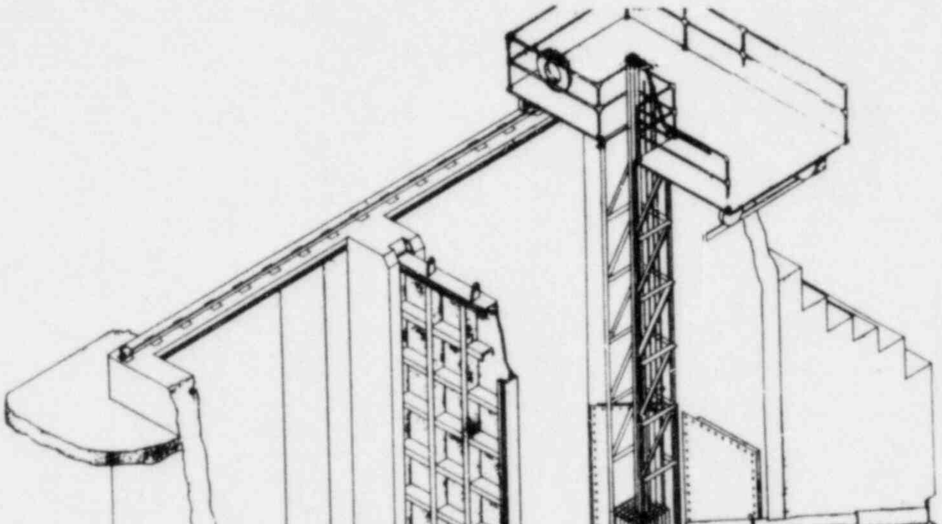


Figure 4.5 Cutaway view of the reactor pool

5 REACTOR COOLING SYSTEM

The reactor cooling system at the University of Virginia is a composite unit consisting of two major subsystems.

(1) The reactor coolant unit is a subsystem that consists of the reactor coolant pool; the primary and secondary pumps; the submerged, movable header and its air-drive supply; the demineralizer system; the heat exchanger; the ^{16}N diffuser; and the cooling tower.

(2) The emergency core cooling unit is a subsystem that is located in the reactor pool and consists of two coolant storage tanks, each with its own spray manifold. (See Section 6.1 for additional details.)

5.1 Cooling System Operation

The reactor is located near the bottom of the reactor coolant pool, which is filled with demineralized water. Before high-power reactor operations, the movable outlet header, which can be moved vertically, is placed in the "up" position. The primary pump is energized to produce a positive flow (~1000 gal/min) down through the core. The coolant water circulates from the reactor core through the shell side of the heat exchanger, and is returned to the reactor pool by way of the ^{16}N diffuser nozzle that is located well below water level in the pool. A small portion of the cooled primary water is diverted through the demineralizer system before being returned to the pool. At low-power operation (interlocked for less than 300 kW), the header is in the "down" position, which allows water to circulate through the core by natural convection.

5.2 Cooling System Safety Features

The cooling system is provided with the following safety features:

(1) Substantial pool construction: The walls and bottom of the pool are built of reinforced concrete. An aluminum gate can be inserted into the pool so that either side of the pool can be drained independently; the shutdown reactor core is adequately shielded by the water when it is in the undrained side.

(2) Low pool water scram: This provides for automatic reactor scram if the pool water level is less than 19 ft 2 in. above the top of the core.

(3) ^{16}N Diffuser. This flow diverter helps prevent ^{16}N from rising rapidly to the surface of the pool and escaping into the air in the reactor building. The ^{16}N is swept into the primary pump intake and circulated through the heat exchanger, where (because of its short half-life) most decays within the coolant loop. Any remaining ^{16}N is delayed in rising to the pool surface as the return coolant is directed toward the wall farthest from the reactor core.

(4) Primary cooling water control: The pressure of the secondary system is higher than that of the primary system in the heat exchanger so that if any leaks occur, potentially radioactive primary water will not have uncontrolled access to the environment by way of the cooling tower.

(5) Redundant water-level sensing: The level of the pool water is sensed by a flow-switch/valve arrangement, an electrical conductivity meter, and operator observation. This redundancy significantly reduces the possibility of the pool water level falling, undetected, below safe limits.

(6) Pool water drain prevent: A fail-closed solenoid valve is provided to prevent inadvertent draining of the pool through a leak or rupture in the demineralizer loop.

(7) Pool water contamination prevent: A fail-closed solenoid valve is provided to prevent circulation of pool water through the demineralizer if the demineralizer resin is conductive.

(8) Emergency core cooling system: This system automatically sprays water on the fuel in the event of loss of pool water, with no requirement for instrumental or manual initiation.

5.3 Cooling System Instrumentation and Control

The instrumentation and controls associated with the cooling system are discussed in detail in Section 7.1.3.

5.4 Conclusion

The main cooling system at the UVAR facility is adequately designed and includes redundant instrumentation and a wide margin of cooling capability. The associated instrumentation and controls provide operations personnel with timely information about the various parameters of the system and enable them to exercise necessary control over the system.

The staff concludes that the main reactor cooling system is adequate to remove heat from the fuel and prevent melting under all normal and likely off-normal operating conditions. There is reasonable assurance that the system can continue to function adequately for the duration of the proposed license renewal.

6 ENGINEERED SAFETY FEATURES

Engineered safety systems associated with the UVAR facility include: (1) a passive core spray system to provide protection against fuel melting following a rapid loss of coolant and (2) the reactor room ventilation system, which isolates the facility from the environment when any excessive radiation levels are detected by the reactor bridge radiation monitor.

6.1 Core Spray Systems

The function of the core spray systems is to provide cooling to the fuel as protection against melting in the event of a loss-of-coolant accident (LOCA). There are two completely independent systems, each with a pair of spray headers and its own emergency water storage tank. Each system is designed to deliver an average spray flow of 10 gal/min over the core for at least 30 min and not less than 7.5 gal/min for an additional 1 hour, which will adequately reduce the core temperature to a point that cooling by air convection is sufficient. (See Section 14.1.3 for details.)

Each spray header is a 1-in.-diameter aluminum pipe, about 2 ft long with approximately 80 small holes drilled at the proper angle and spacing to provide a uniform spray over the top of the core. There are two headers for each system that are mounted on either side of the core support structure about 5 ft above the top of the core.

Each system has a 1500-gal emergency water storage tank mounted on the wall inside the pool. When the reactor bridge is moved into the position for high power operation the piping connecting the storage tank to its pair of spray headers is engaged manually with a remote coupler. This connection is tested for leaks using compressed air. The absence of air bubbles from the coupler is verification that the coupler is securely engaged. Recirculating water from the demineralizer is returned to each of the emergency storage tanks. An overflow from each tank is located about 2 in. above the highest operating level of the pool water. Accordingly, there will always be a slight head (2 in.) of water in the tank and a small flow of water through the headers. This ensures that the tank is always full and that stagnant water and resultant corrosion does not occur in the spray headers. The entire system is made of aluminum and stainless steel to inhibit corrosion.

Thus, the system is always ready for an immediate supply of core spray water in case water is lost from the pool. There are no moving parts that can fail, and there are no automatic electronic or mechanical devices that are required to function.

At the initial installation of these systems, each was tested individually to confirm that the spray covered the entire core area and that adequate water was directed to each of the 64 possible fuel element positions. Flow rate (but not spray distribution) is measured annually as required by Technical Specification Section 4.3.

6.2 Ventilation System

The UVAR is ventilated by a separate system that exhausts air from the reactor room and associated research areas, including the beam ports, the large access facility, and the thermal column.

Under normal conditions air enters the reactor pool area through the personnel door at the rate of about 7000 cfm. Opening the sealed truck door scrams the reactor or prevents reactor startup. Air is exhausted through a short stack on the reactor building roof at a level of about 35 ft above the ground at a rate of approximately 8600 cfm, which includes air from the associated research facilities.

Excessive and unexpected radiation levels detected by a monitor mounted on the bridge above the core deenergizes the electromagnets on the personnel door and on a damper on the exhaust duct, allowing each to close by gravity and isolate the reactor room.

As the reactor control room is located within the 54-ft-diameter by 36.5-ft-high reactor room, isolation would trap operating personnel within the room. An underwater escape hatch positioned below the outside wall is provided as an emergency exit.

Although there are no filters in the reactor room exhaust duct, this is not considered inadequate because normal reactor operations produce no airborne particulate radioactive materials. Any significant release of radioactivity resulting from fuel failure will be detected by the radiation monitor on the reactor bridge. As backup instrumentation, there is both a monitor of radioactive gas and a monitor of airborne radioactive particulates located in the reactor room with readouts and alarms in the control room.

6.3 Conclusion

Either of the two core spray systems will adequately cool the reactor core in the event of a loss-of-coolant accident. These systems are passive, fail-safe, and always operable when the reactor is operated in the high-power mode. Therefore, the staff concludes that there is reasonable assurance that there will be no release of radioactive materials in the event of a LOCA and, hence, no risk to the public or the environment.

The reactor building ventilation system equipment and procedures are adequate to control the release of airborne radioactive effluents in compliance with regulations and to minimize releases of airborne radioactivity in the event of abnormal or accident conditions. Therefore, the staff concludes that the public wll be adequately protected from airborne radioactive hazards related to reactor operations.

7 CONTROLS AND INSTRUMENTATION

General characteristics found throughout the control and instrumentation systems associated with the UVA reactor facility include

(1) The facility is supplied with a stable, solid electrical grounding system, thus eliminating any "ground loop" problems in the instrumentation or control circuitry.

(2) All ac power used to drive amplifiers, mixers, and dc power supplies is common-phase. This eliminates the possible problem of cross-phasing in the instrumentation and control systems.

(3) All circuits are protected from ac power fluctuation.

(4) All the dc power supplies are high quality with specifications in excess of those required to satisfy current NRC guidelines applicable to nonpower reactors, namely good industrial practice.

(5) All instrumentation and control circuit wiring that is connected to crucial and/or NRC-required components is located in protective conduit or cable trays. This minimizes the possibility of physical damage to the wiring.

(6) As time and budgetary restraints permit, the various components in the control and instrumentation systems are continuously upgraded to reflect the latest in related technology. Two examples of this are the future plans to install ceramic-insulated wiring on all inpool detectors (thus eliminating the possibility of short circuits caused by the high voltage insulation being degraded by neutron irradiation); and the current plans (work in progress) to replace all the existing electromechanical relays in the scram logic circuits with more modern devices. This will eliminate the possible problems of relay-contact "chattering" and "point-welding" and will enhance the overall reliability of the scram system. Once completed, these changes will be reviewed in accordance with 10 CFR 50.59.

(7) There are two mixer-drivers in the primary scram system, each receiving identical input in parallel. If one mixer-driver fails completely, the other could still scram the reactor.

(8) The overall system is very flexible, with provisions for incorporating experiment scrams into the existing reactor operations scrams.

The individual control systems at UVAR are described and evaluated in the following sections.

7.1 Control Systems

7.1.1 Shim Rod Control

The three shim rods are controlled from the operator's console and are magnetically coupled to the rod drive mechanism. Any loss of power to the drive mechanism or any other scram signal will deenergize the magnetic coupling, allowing all three rods to fall by force of gravity into the reactor core. The drive mechanism consists of position-indicating equipment, lead screw drives, and 115-V, 60-cycle split-phase synchronous motors. The positions of the rods are indicated on the operator's console. Following a scram, the supporting magnets must be driven down to contact the shim rods before they can be raised from the core.

7.1.2 Regulating Rod Control

The regulating rod is permanently attached to the drive mechanism, which consists of a 115-V, 60-cycle two-phase servo motor, lead screw, and position-indicating equipment. The regulating rod control is interlocked to the automatic reactor control system described in Section 7.1.5. The regulating rod control does not drop the rod on a scram signal. The position of the regulating rod is indicated on the operator's console.

7.1.3 Pool Water Control System

Pool water is monitored and controlled with respect to depth and electrical conductivity. Pool depth is monitored by two independent devices, each one provided with scram logic circuitry. Electrical conductivity is monitored downstream of the water purification system, which consists of a carbon filter and a mixed-bed ion exchange demineralizer. If the conductivity exceeds the setpoint, the condition is annunciated in the control room. Facility water is provided from a catch tank connected to the city water line. A vacuum break prevents UVAR pool water from flowing back into the city water line. Additional features include two fail-closed solenoid valves. One prevents draining the reactor pool through the demineralized loop; the other prevents pool water from flowing through the demineralizer loop if the demineralizer resin is conductive.

7.1.4 Header Position and Motion Control

A header is provided in the reactor pool just below the reactor core. The purpose of this header (which can be moved vertically using air pressure) is to connect the core to the heat exchanger by way of the primary coolant pumping system. This provides forced-flow cooling of the reactor core. The system is equipped with a pressure switch and solenoid valve arranged to fail close and scram the reactor in case air pressure exists in the header, which (if the primary pump lost power) could prevent the header from falling away from the reactor core. Thus, in case of primary pump failure, the header drops automatically away from the core, thereby allowing natural convection cooling of the reactor core. A reactor scram is initiated if the primary pump fails and forced water flow is interrupted while the reactor is operating in the hign-power mode.

7.1.5 Safety Circuits and Automatic Control

The safety circuits are fail-safe types that automatically scram the reactor in case of facility power failure or major circuit difficulty. The circuits also cause automatic reactor scram under the following conditions:

(1) excessive neutron flux density
(2) excessively short reactor period
(3) low pool water level

The automatic mode of reactor control is achieved by electromechanical control of the regulating rod.

Four conditions will automatically cause control to shift into the manual mode and produce an audible alarm to alert the operations staff that the reactor is no longer being controlled automatically. These are

(1) any attempt to move the regulating rod with the manual control switch, which ensures that manual control is always instantly available to the operator

(2) the regulating rod either at its top limit or bottom limit, which ensures that the regulating rod has free movement to control reactor power

(3) the error signal, as displayed on the deviation meter, exceeds 7.5% (arbitrary units), which ensures control is shifted if the regulating rod is unable to control power for any reason, such as the regulating rod or its drive system being inoperable

(4) loss of electrical power to the linear recorder

7.2 Nuclear Instrumentation

The nuclear instrumentation system at UVAR serves two purposes.

(1) It provides the components and circuitry necessary to monitor and display the reactor operating parameters over all ranges of operation from startup to full power.

(2) It provides the required logic and components to automatically scram the reactor (primary scram) before any limiting safety condition is reached.*

Brief descriptions of the major subsystems are given in the following sections.

7.2.1 Source Range Subsystem

This subsystem contains all the circuitry necessary to monitor the reactor period and reactor power level from shutdown through 6 decades of power level increase. This range of instrumentation contains the low count rate interlock and is used for monitoring; output information is recorded on a dedicated recorder located on the control console.

---

*Two other types of scram, the manual scram (which is initiated by a conscious act of the operator) and an auxiliary scram (which is automatically initiated by circuitry not directly coupled to the nuclear instrumentation) also exist as supplementary safety features.

7.2.2 Intermediate Range Subsystem

Input is received from a compensated ion chamber, and both power level and period are indicated and recorded over 7 decades. This unit provides protection against a too-rapid period by use of a bistable period trip (set for no less than 3 sec) connected to a modulator/demodulator input circuit. Redundancy is achieved by a parallel signal (also originating at the bistable period trip) that is sent directly to the mixer drivers.

7.2.3 Power Range Subsystem

Two completely independent power range channels indicate reactor power over the range from 0 to 3 MW. Each channel has its own detector power supply and its own ± 24-V power supply. Loss of the common 110-V ac power to the instrument drawer itself will send "unsafe" signals to the scram logic system. Input from the independent uncompensated ion chambers is fed into a dc amplifier that is designed so that an electrical short or open circuit on any of the inputs will not affect any of the others by more than a fraction of a percent. Output of the power range subsystem is displayed on the control console.

7.2.4 Scram Logic System

This unit contains the electronic logic circuitry necessary to process the scram function input signals, any one of which can bring the reactor to a rapid, safe shutdown if conditions warrant. It also contains the interlock circuitry to prohibit withdrawing the safety rods from the reactor core if certain minimum conditions are not satisfied.

Basically, the scram logic system is composed of four modules (negative logic is used throughout the system).

(1) Transistor negative logic "AND" gate, numbering five units, each with four separate inputs. The rod withdrawal interlock is derived from two logic inputs to this module. One is a 10-V signal emitted from the source-range-level bistable if the source count rate exceeds 2 counts per second. The second 10-V signal is derived from the intermediate-range recorder if the indicated neutron flux density exceeds 2 x 10^3 $n \cdot cm^{-2} \cdot s^{-1}$.

(2) Auxiliary control module, which provides a 110-V ac, 2-amp output from an input of 10 V to a four-input "OR" gate.

(3) Mixer-drive module that consists of two mixer drivers, each with a 28 input "OR" gate. Any of the 28 logic inputs falling to 0 V will cause the driver output to fall to 0 V. Thus, one logic signal is derived from 28 separate signal inputs.

(4) Two solid-state relay modules that provide up to 5 amps of dc current to the shim rod (scram) magnets if safe input conditions exist.

A special safety circuit is provided in the scram-logic system to provide redundant scram-magnet power if a short circuit occurs in the silicone control rectifiers located within the solid-state relay modules. Such a short circuit could prevent the solid-state relays from deenergizing the scram magnets if the redundancy were not provided.

From a systems viewpoint, the scram logic system is composed of two sections. One is a logic processing section that receives electrical input from the various relays, bistables, and power supplies; processes these signals with respect to a well-defined set of preconditions; and emits output signals that act either on scram control or rod motion control. The second section is the activation section, which consists of the mixer drivers and the solid-state relay modules. These devices receive safe/not-safe logic inputs and control the current to the scram magnets.

7.2.5 Bistable Display System

This unit is provided to indicate the state or mode of each bistable in the system. The output of each bistable is connected to an annunciator light on the control console. If a particular bistable is in the "tripped" mode, the indicator light will energize, thereby notifying the operator.

7.2.6 Radiation Instrumentation

The radiation instrumentation at UVAR consists of several different types of instruments in fixed locations that are supplemented by portable instruments. The descriptions and other information concerning the fixed location instruments are given in Table 7.1.

7.3 Process Instrumentation

The process instrumentation system at UVAR provides the input to the auxiliary scram system and supplements the nuclear instrumentation system. The process instrumentation system also is interlocked with the automatic control system and the primary scram system. A description of the instruments is provided in Table 7.2.

7.4 Auxiliary Scram System

The auxiliary scram system provides safe/unsafe logic signals to the scram logic system from the various process instruments discussed in Section 7.3. The parameters on which the safety settings are based have a redundant means of detection. These are the two pool-level indicators, the low-flow indicator, and the loss-of-primary-pump-power indicator. These indicators are combined to provide Go/No-Go signals directly to the mixer drivers through two 10-V power supplies. If either of these supplies fails, an "unsafe" signal is sent to the mixer drivers, scramming the reactor. If any of the redundant indicators fail, the safety of the system is not compromised because of the remaining indicators and the administrative procedures designed to cope with this eventuality.

All other process scrams beside those mentioned above are connected in a series string and are incorporated into one logic signal to the mixer drivers by way of two relays so that any one process scram function will cause an "unsafe" logic signal to be sent to the mixer driver.

7.5 Scrams, Interlocks, and Alarms

The various scrams, interlocks, and alarms discussed in previous sections are summarized below.

Scrams

(1) safety channel 1
(2) safety channel 2
(3) period amplifier
(4) pushbutton on console
(5) high radiation level on bridge*
(6) high radiation level, reactor face*
(7) primary coolant pump turned on or off**
(8) low reactor coolant flow***
(9) pushbutton at reactor room personnel door
(10) pushbutton on ground floor
(11) reactor room truck door open
(13) air pressure to primary header
(14) high reactor inlet water temperature
(15) low pool level (2 channels)
(16) key switch on console
(17) evacuation alarm
(18) range switch in 2 MW with header down

Interlocks

(1) Fission chamber (source range) channel must be indicating at least two counts per second or Log N must be on scale on lowest power decade, and nuclear instrumentation must be out of "test" mode to withdraw shim rods.

(2) Power level by linear power channel must be within ±7.5% of set power level and the linear power recorder must be turned on to operate the reactor in servo control.

Audible Alarms

(1) An intermittent tone on the control console sounds under any of the following conditions. Each audible alarm is accompanied by a red indicating light and an amber light that locks in.

    (a) high radiation on any area monitor or on either ^{41}AR monitor
    (b) high conductivity of water leaving the demineralizer
    (c) high ΔT across the reactor core
    (d) regulating rod control shifting from automatic to manual
    (e) high radiation on core gamma monitor

---

*High radiation level at this point also automatically closes the ventilation door and closes the reactor room personnel door.

**Turning the pump on will cause scram and loss of electrical power to the pump will cause scram. The reactor may be operated while the pump is running if the header is up.

***A reading of less than 800 gal/min on the flowmeter will cause a scram. The reactor may be operated with no flow indicated by the flowmeter if the header is down.

  - (f) high radiation on criticality monitor
  - (g) high radiation on constant air particulate monitor
  - (h) secondary pump deenergized
  - (i) primary pump energized with the reactor core header in the "down" position
  - (j) entry into the demineralizer room
  - (k) entry into the heat exchanger room

(2) A constant tone alarm is sounded at the primary console in the event of a scram.

(3) All of the audible alarms must be manually reset. However, the bell on the secondary console will stop after 2 min.

(4) All area monitors alarm locally as well as in the control room.

7.6 Instrumentation Applicability

In addition to the various interlocks that prevent the unsafe operation of the UVA reactor, the following administrative controls are rigidly enforced with respect to the instrumentation system and reactor operation. These limiting modes are imposed by the UVAR Technical Specifications as follows.

Technical Specification 3.3 "Reactor Instrumentation"

> The reactor shall not be operated unless the measuring channels described in Section 3.2 "Reactor Safety Systems" and in the following table are operable.

Measuring Channel	Minimum No. Operable	Operating Mode in Which Required
Linear Power	1	All Modes
Log N and Period	1	All Modes
Core Gamma Monitor	1	Forced Convection Mode
Reactor Room Constant Air Monitor	1	All Modes*
Bridge Radiation Monitor	1	All Modes
Reactor Face Monitor	1	All Modes*
Pool Water Level Monitor	2	Forced Convection Mode
Pool Water Temperature	1	All Modes
Primary Coolant Flow	1	Forced Convection Mode
Start-Up Count Rate	1	Reactor Start-Up
Reactor Power Level	2	All Modes

*The reactor room constant air monitor and the reactor face monitor may be out of service for a period not to exceed 7 days without requiring reactor shutdown. If the reactor face monitor cannot be repaired within 7 days, it may be replaced by a monitor that alarms locally in a similar range for up to 30 days without requiring a reactor shutdown.

7.7 Conclusion

The UVAR control and instrumentation systems make extensive use of modern, solid-state components. Reliability, predictability, and redundancy are built into the systems. Rigid administrative controls and knowledgeable personnel complete the overall operations approach. Configuration control is maintained through proper documentation, and the quality of the individual components composing the various systems is generally higher than the minimum required. In addition, system and component upgrading are encouraged by management and form an integral part of ongoing activities.

Based on its review and analysis of the control and instrumentation systems at the UVAR, the staff believes that these systems are adequate to ensure the reliable and safe operation of the UVAR within the limits of approved Technical Specifications for the time period of the requested license renewal.

Table 7.1 Radiation instrumentation

Nomenclature	Detector Type	Detector Location	Annunciator Location
Core gamma	Ion chamber	in-pool, approx. 10 ft directly above reactor core	Secondary console in control room
Bridge radiation	Ion chamber	Reactor room, attached to front of core support structure	Secondary console in control room
Room Argon	Geiger/ Mueller tube	Reactor room, on center buttress	Secondary console in control room
Constant air Particulate Monitor	Filter and Geiger/ Mueller tube	Reactor room, at extreme north end of the reactor pool	Secondary console in control room
Hot cell Radiation Monitor	Ion chamber	Hot cell window	Secondary console in control room
Criticality Monitor	Geiger/ Mueller tube	Attached to wall at first floor level of fuel	Control consoles of both UVAR and Cavalier reactors
Face Radiation Monitor	Ion chamber	First floor level, adjacent to south access point	Locally and on secondary console in control room
Demineralizer Room Monitor	Ion chamber	Inside the demineralizer room	Locally and on secondary console in control room
N-16 Monitor secondary	Ion chamber	Under heat exchanger	Control and secondary consoles in control room

Table 7.2 Process instrumention

Nomenclature	Detector/Sensor	Function	Detector/Sensor Location	Annunciator Location
Pool temp. monitor	RTD	To monitor pool water temp.	In-pool, approx. 10 ft above reactor core	Control console
Pool temp. monitor	Thermistor	To monitor pool water temp.	In-pool, approx. 10 ft above reactor core	Secondary console in control room
Delta-temp. monitor	RTD	To monitor water temp both upstream and downstream of the reactor core	In-pool, approx. 3 ft above reactor core and in the primary coolant line	Control console
Pool level monitor	Electromechanical float switch	To monitor pool water level and intiate scram signal	In pool behind bridge	Scram at control console
Pool level monitor	Conductivity switch (electrical)	To monitor pool water level and intiate scram signal	In pool behind bridge	Scram at control console
Safety rod position indicators (top/bottom)	Limit switches	To monitor the safety rod positions	On lead screw drive	Control console
Safety rod position indicator (rod seated)	Limit switch	To verify rod seating positions	Extension collar of safety rod	Control console
Safety rod position indicator (magnet engaged)	Limit switch	To verify rod/magnet engagement	Top of rod extension	Control console
Control rod Position	20-turn potentiometer	To monitor the control rod position	Motor drive	Control
Header air pressure indicator	Pressure switch	To monitor air pressure to header and initiate scram signal	Air line to header	At the switch location
Header position indicator	Limit switch	To monitor header position	On bridge	Control console
Demineralizer condition indicator	Salinity cell	To monitor the condition of the demineralizer resin	Outlet of demineralizer	Locally and control console
Primary coolant flow indicator	Pressure comparitor	To monitor flow of coolant through the heat exchanger	Above the heat exchanger room	Secondary console in the control

8 ELECTRIC POWER SYSTEM

8.1 Main Power

The main electrical power is supplied at 440 V to the UVAR complex by a commercial source through transformers located near the facility. The power is standard 3-phase ac and is noise filtered. The reactor power, control, and instrumentation circuits as well as the scram logic circuits are all protected against the ac powerline fluctuations.

8.2 Emergency Backup Power

The reactor control system and the facility ventilation system are not provided with emergency backup power because the reactor automatically scrams to a safe-shutdown condition upon loss of ac power. However, the security alarm system is provided with emergency battery power, and there are several standard battery-powered emergency lighting units placed strategically thoughout the nuclear engineering building.

8.3 Conclusion

Based on the staff's review and the above information, the staff concludes that the electrical power provisions at the UVA reactor facility provide reasonable assurance of adequate operation and that loss of offsite power will not lead to unsafe reactor conditions.

9 AUXILIARY SYSTEMS

9.1 Fuel Handling and Storage

Irradiated fuel that is not in current use in the reactor core is stored in metal storage racks located on the bottom of the reactor pool. The fuel elements are oriented in the storage racks in the same manner as in the core--long axis vertical. The fuel elements are moved using long-handled manually operated tools designed to facilitate grasping the fuel elements while they are totally submerged in pool water, which minimizes exposure of the operations personnel to radiation.

9.2 Facility Compressed Air System

The compressed air system consists of a compressor, solenoid valves, piping, an accumulator, regulators, gauges, and filtration units. The system also is provided with a pressure transducer whose output is routed into the scram logic circuitry. The primary function of the air system is to provide motive force for the header position and motion control system. When coolant flow is established by the primary pump, air pressure to the header is removed.

9.3 Water Purification System

The pool water purity is maintained by circulating it at a rate of 20 gal/min through a carbon filter and a mixed-bed ion exchange demineralizer. The water is normally maintained at a pH of 6.0 to 7.0 with a conductivity of less than 2.5 μmhos per cm.

9.4 Liquid Waste Disposal System

All operational radioactive liquid waste from the reactor facility is normally discharged to holdup tanks located between the complex and the pond. Here the waste is retained for decay and dilution before being released to the Rivanna River.

Liquid radioactive wastes generated by experimental programs are collected and disposed of by the health physics personnel. Two special 5000-gal retention tanks are provided to receive the effluent from the discharge of the demineralizer. This water is recirculated and filtered, as well as being given additional decay time in the underground tank before it is discharged along with the pond diluent as a normal procedure.

The water released from the pond is sampled at the beginning, during, and at the end of each release, and the results of these samples are maintained in a permanent record by the health physicist. No waste is released with an activity concentration in excess of 10 CFR 20 guideline values.

9.5 Building Ventilation and Airborne Discharge

Controlled release of airborne radioactivity is accomplished by the ventilation system consisting of two ventilation fans that draw air from the reactor room, hot cell, and the experimental area. The air is discharged through a short stack on the roof of the reactor room at a rate of 8600 cfm.

Airborne radioactivity is monitored in the reactor room and in the ventilation line from the experimental area. Each of these monitors alarms at a concentration of ^{41}Ar corresponding to no greater than 500 times the concentrations listed in Appendix B, Table II, 10 CFR 20. The applicant's analysis, with which the staff agrees, has shown that this limit on reactor room concentrations of ^{41}Ar will not lead to excessive dose rates in unrestricted areas (see Section 11.1.3).

9.6 Conclusion

The auxiliary systems at the UVAR facility are adequately designed and maintained, and, in the opinion of the staff, are capable of performing their intended functions to help protect the health and safety of the public and the environment.

10 EXPERIMENTAL PROGRAMS

The UVAR serves as a source of ionizing and neutron radiation for research and radionuclide production. In addition to inpool irradiation capabilities, experimental facilities include a hydraulic transfer system, two large access facilities, and two beam ports.

10.1 Experimental Facilities

10.1.1 Pool Irradiations

The open pool of the reactor permits the irradiation of experiments submerged in the vicinity of the core. The decision to perform experiments in the reactor pool--as opposed to using the hydraulic transfer system or a beam tube--is dictated by specimen size and the type and intensity of radiation fields required. The actual placement of experiments or samples in the core region is controlled by their effect on reactivity, which is limited by the Technical Specifications.

10.1.2 Hydraulic Transfer System

The hydraulic transfer system allows small, sealed samples to be rapidly transported between the reactor core and the bridge structure. The system consists of a 1.0-in.-outside-diameter aluminum tube for the sample and an 0.5-in.-outside-diameter aluminum tube for return water.

10.1.3 Large Access Facilities

The south wall of the reactor pool is penetrated by two large access facilities measuring 5 ft wide by 6 ft high. When not in use, these experimental facilities are filled with concrete and lead bricks backed by a dolly-mounted, stepped concrete block. Each facility is closed off from the pool by a gasketed aluminum plate.

A thermal column may be incorporated into one of these large access facilities by replacing most of the shielding with graphite blocks. At the present time, one of these large access facilities is equipped wih a small penetration that views a tangential exposure chamber so that target radiations may be studied without the interference of direct core radiation.

10.1.4 Beam Ports

Two 8-in. beam ports penetrate the concrete shield on the south side of the pool. When not in use, these beam tubes are filled with concrete plugs with an offset in diameter to reduce radiation streaming. The door to each port contains a 3-in. lead shield. Aluminum ports extend the beam ports to the reactor face. These ports are normally filled with water but may be drained individually when in use. A blank-flange aluminum plate separates the aluminum port extension from the concrete shield penetrations.

When these beam ports are used, external shield walls, beam stops, or beam catchers are installed to control radiation levels in the experimental areas.

10.2 Experimental Review

Before any new experiment can be conducted using the reactor or experimental facilities, it must be reviewed by the Reactor Safety Committee. This committee is composed of at least five members, one of whom is the University Radiation Safety Officer. Furthermore, no more than two members are allowed to be from Reactor Operations. In addition to ensuring safe and licensed reactor utilization, this review and approval process for experiments allows personnel specifically trained in radiological safety and reactor operations to consider and recommend alternative operational conditions (such as different core positions, power levels, and irradiation times) that might decrease personnel exposure and/or the potential release of radioactive materials to the environment.

10.3 Conclusion

The staff concludes that the design of the experimental facilities, combined with the detailed review and administrative procedures applied to all research activities, is adequate to ensure that experiments (1) are unlikely to fail, (2) are unlikely to release significant radioactivity to the environment, and (3) are unlikely to cause damage to the reactor systems or its fuel. Therefore, the staff considers that reasonable provisions have been made so that the experimental programs and facilities do not pose a significant risk of radiation exposure to the public.

11 RADIOACTIVE WASTE MANAGEMENT

The major radioactive waste generated by reactor operations is activated gases, principally ^{41}Ar produced by neutron irradiation of air. A small volume of radioactive solid waste, primarily resins, is generated by reactor operations, and some additional solid waste is produced by the associated research programs. No radioactive liquid wastes are generated directly by normal reactor operations. However, liquid radioactive waste is produced by the regeneration of the resin bed in the water demineralizer system. Additional small amounts of radioactive liquid waste are developed as a result of several of the reactor-based research activities. The University administration instructs all personnel to develop procedures to maintain the generation and possible release of radioactive waste materials as low as reasonably achievable (ALARA).

11.1 Waste Generation and Handling Procedures

11.1.1 Solid Waste

Solid waste generated as a result of reactor operations consists primarily of ion exchange resins and filters, potentially contaminated paper and gloves, and occasional small, activated components. Some of the reactor-based research results in the generation of solid low-level radioactive waste in the form of contaminated paper, gloves, and glassware. The amount of solid waste generated has typically been 15 to 20 ft^3 containing a few millicuries of radionuclides per year. In 1981, approximately 125 ft^3 of solid waste containing less than 10 mCi of activity were shipped from the reactor facility as a result of a major cleanup campaign.

Solid waste is collected by the Health Physics staff and held temporarily before being packaged and shipped to an approved disposal site in accordance with applicable regulations.

11.1.2 Liquid Waste

Normal reactor operations produce no radioactive liquid waste. However, many of the research activities conducted within the reactor complex are capable of generating such waste. Liquid waste drains in the reactor room and equipment areas drain into a holding pond. Other laboratories and experimental areas in the reactor complex where radioactivity may be used also are provided with collection retainers.

The largest volume of potentially contaminated water is produced by the regeneration of the demineralizer. This periodically generated effluent is discharged to two special 5000-gal retention tanks. This water then is recirculated, filtered, and given additional decay time. Before the next demineralizer regeneration, representative samples are collected from the retention tanks and the pond and analyzed by standard techniques. Release rates for the tanks and pond are then planned to ensure that the actual combined concentration in a final discharge stream is within the guideline values of 10 CFR 20.

11.1.3 Airborne Waste

The potential airborne radioactive wastes are ^{16}N produced by fast neutron irradiation of the oxygen in the coolant water, ^{41}Ar produced by slow neutron irradiation of the small component of argon-40 in the air, and neutron-activated dust particulates. No fission products escape from the fuel cladding during normal operations. The radioactive airborne waste is produced principally by the neutron irradiation of water, air and airborne particulate materials in the pool, access facilities, and beam ports. Air is constantly swept from the experimental and reactor rooms and discharged to the environment through the short stack at the roof of the reactor building.

The coolant flow down through the core to the heat exchanger at elevated power levels precludes the release of ^{16}N, as this isotope ($T_{1/2}$ = 7.1 s) has essentially decayed within the piping system by the time the water returns to the open pool.

Although the air exhaust stream is not monitored at the point of discharge, most individual components are monitored. There is a gas monitor in the experimental room exhaust duct, and there is both a gas monitor and a particulate monitor in the reactor room with readouts on the control console.

During normal operations, UVAR staff finds no measurable quantity of airborne particulate radioactivity on that monitor. Thus, ^{41}Ar is the only significant airborne radionuclide formed during normal operations which is released as a gaseous effluent.

UVAR facility has monitored the release of ^{41}Ar over the years with calibrated detectors, and has determined that no more than 10 Ci has been discharged in a year of heavily scheduled operations. If averaged over a year, this is equivalent to a continuous release of 0.3 μCi$\cdot$s^{-1}. The applicant has analyzed the potential exposure to offsite persons resulting from an assumed release rate of 10 μCi$\cdot$s^{-1}, and computed an average concentration of ^{41}Ar at the nearest point of the perimeter fence of less than 10% of the maximum permissible concentration given in 10 CFR 20, Appendix B, Table II. The staff has reviewed this analysis, and finds it acceptable. Therefore, since the actual annual average release rate of ^{41}Ar from UVAR is so much smaller than the hypothetical 10 μCi$\cdot$s^{-1}, dose to a maximally exposed person in the unrestricted area near the UVAR facility would be less than 2 mrem during a year.

11.2 Conclusion

The staff concludes that the waste management activities of the UVAR facility have been conducted and are expected to continue to be conducted in a manner consistent both with 10 CFR 20 and with ALARA principles. Among other guidance, the staff review has followed the methods of ANSI/ANS 15.11, 1977, "Radiological Control at Research Reactor Facilities."

Because ^{41}Ar is the only potentially significant radionuclide released by the reactor to the environment during normal operations, the staff has reviewed the history, current practice, and future expectations of operations. The staff concludes that the doses in unrestricted areas as a result of actual releases of ^{41}Ar have never exceeded or even approached the guideline values specified in 10 CFR 20 when averaged over a year. Furthermore, the staff's conservative computations of the dose beyond the limits of the reactor facility give reasonable assurance that potential doses to the public as a result of ^{41}Ar would not be significant, even if there were a major change in the operating schedule of the reactor.

12 RADIATION PROTECTION PROGRAM

The University of Virginia has a structured radiation safety program with a Health Physics staff equipped with radiation detection instrumentation and procedures to determine, control, and document occupational radiation exposures at its reactor facility. The reactor facility monitors liquid effluents before release and calculates its ^{41}Ar effluents based on reactor use. The University has developed an environmental monitoring program to verify that radiation exposures in the unrestricted areas around the reactor facility are within regulations and guidelines and to confirm the results of calculations and estimates of environmental effects resulting from the reactor program.

12.1 ALARA Commitment

The UVA administration has formally established the policy that all operations are to be conducted in a manner to keep all radiation exposures ALARA (as low as reasonably achievable). This policy is implemented by a set of specific guidelines and procedures. All proposed experiments and procedures at the reactor are reviewed for ways to minimize the potential exposures of personnel. All unanticipated or unusual reactor-related exposures are investigated by both the Health Physics and the operations staff to develop methods to prevent recurrences.

12.2 Health Physics Program

12.2.1 Health Physics Staffing

The normal full-time Health Physics staff at the UVA consists of three professionals and several technicians. One professional is located full time at the reactor facility; technicians are available as needed. The onsite staff has sufficient training and experience to direct the radiation protection program for a research reactor. The Health Physics staff has been given the responsibility, the authority, and adequate lines of communication to provide an effective radiation safety program.

The University Health Physics staff provides radiation safety support to the entire University complex, including a teaching hospital and many radioisotope laboratories. However, the staff believes that the reactor complex Health Physics staff is adequate for the proper support of the research efforts within this facility.

12.2.2 Procedures

Detailed written procedures have been prepared that address the Health Physics staff's various activities and the support that it is expected to provide to the routine operations of the University's research reactor facility. These procedures identify the interactions between the Health Physics staff and the operational and experimental personnel. They also specify numerous administrative limits and action points as well as appropriate responses and corrective action if these limits or action points are reached or exceeded. Copies of these procedures are readily available to the operational and research staffs and to the Health Physics and administrative personnel.

12.2.3 Instrumentation

The University has acquired a variety of detecting and measuring instruments for monitoring potentially hazardous ionizing radiation. The instrument calibration procedures and techniques ensure that any credible type of radiation and any significant intensities will be detected promptly and measured correctly.

12.2.4 Training

All reactor-related personnel are given an indoctrination in radiation safety before they assume their work responsibilities. Additional radiation safety instructions are provided to those who will be working directly with radiation or radioactive materials. The training program is designed to identify the particular hazards of each specific type of work to be undertaken and methods to mitigate their consequences. Retraining in radiation safety is provided as well. As an example, all reactor operators are given an examination on Health Physics practices and procedures at least every 2 years. The level of retraining given is determined by the examination results. All of the above-mentioned radiation safety training is provided by the Health Physics staff.

12.3 Radiation Sources

12.3.1 Reactor

Sources of radiation directly related to reactor operations include radiation from the reactor core, ion exchange columns, filters in the water cleanup systems, and radioactive gases, primarily ^{16}N in the primary coolant loop and ^{41}Ar.

The fission products are contained in the aluminum cladding of the fuel. Radiation exposure rates from the reactor core are reduced to acceptable levels by water and concrete biological shielding. The ion exchange resins and filters are routinely changed before high levels of radioactive materials have accumulated, thereby limiting personnel exposure.

Personnel exposure to the radiation from chemically inert ^{41}Ar is limited by dilution and prompt removal of this gas from the reactor room and experimental areas and its discharge to the atmosphere where it diffuses further before reaching occupied areas. Access to the heat exchanger room is controlled during reactor operation.

12.3.2 Extraneous Sources

Sources of radiation that may be considered as incidental to the normal reactor operation but associated with reactor use include radioactive isotopes produced for research, activated components of experiments, and activated samples or specimens. A small, sealed plutonium-beryllium neutron source and a ^{237}Np source are authorized by the reactor license in connection with reactor operations.

Personnel exposure to radiation from intentionally produced radioactive material as well as from the required manipulation of activated experimental components is controlled by rigidly developed and reviewed operating procedures that use the normal protective measures of time, distance, and shielding.

Additionally, a ^{60}Co gamma irradiator is located in the far end of the UVAR pool. While this facility is authorized within the reactor license, there is no significant interaction between the radiations of the two units.

The Nuclear Engineering Department also operates a low-power (100 W thermal) training reactor in the building housing the UVA reactor; it is at the other end of the building, and its operation is governed by an independent NRC license.

12.4 Routine Monitoring

12.4.1 Fixed Position Monitors

The UVAR facility uses several fixed-position radiation monitors, a constant air particulate monitor, and a radioactive gas monitor in the reactor room. Additionally, there is a radiation monitor on the bridge above the reactor and a radiation monitor in the experimental room. All monitors have adjustable alarm setpoints and read out in the control room. (See Section 7.2.6 and Table 7.1 for additional details about fixed-position monitors.)

12.4.2 Experimental Support

The Health Physics staff participates in experiment planning by reviewing all proposed procedures for methods of minimizing personnel exposures and limiting the generation of radioactive waste. Approved procedures specify the type and degree of Health Physics involvement in each activity. As examples, standard operating procedures require that changes in experimental setups include a survey by Health Physics personnel using portable instrumentation and all items removed from the reactor room or experimental room must be surveyed and tagged by knowledgeable personnel.

12.5 Occupational Radiation Exposures

12.5.1 Personnel Monitoring Program

The UVAR personnel monitoring program is described in its Radiation Safety Instructions. To summarize the program, personnel exposures are measured by the use of film badges assigned to individuals who might be exposed to radiation. In addition, self-reading dosimeters are used, and instrument dose rate and time measurements are used to administratively keep occupational exposures below the applicable guidelines specified in 10 CFR 20.

All visitors are provided self-reading dosimeters for monitoring purposes.

12.5.2 Personnel Exposures

During the past 5 years, between 125 and 165 personnel, including faculty, staff, and students, were monitored annually with film badges and the data are shown in Table 12.1. The highest exposures have been to the three staff members who were directly involved with the operation of the facility. The maximum exposure in one year was 580 mrem, and the average annual exposure to any one of these individuals has been approximately 300 mrem. During this same period, between 2400 and 3000 visitors have toured the facility annually with no measured exposures below measurable levels.

12.6 Effluent Monitoring

12.6.1 Airborne Effluents

As discussed in Section 11, airborne effluents from the reactor facility consist principally of activated gases. Conservative calculations based on reactor use show that less than 10 Ci of ^{41}Ar are discharged annually. The experimental room exhaust duct monitor and the gas monitor in the reactor room confirm that significantly large quantities of ^{41}Ar are not produced.

12.6.2 Liquid Effluents

The reactor generates very limited radioactive liquid waste during routine operations. However, leaks in the primary coolant system do have the potential for releases, and experimental activities associated with reactor usage also may generate radioactive liquids. The major source (volume) of liquid waste is from regeneration of the demineralizer system.

All potentially contaminated liquids are released either to liquid waste containers or are collected in the two holdup tanks. The tanks and pond are periodically sampled, and the samples are analyzed for radioactive content using standard techniques. The contents of the tanks and the pond then are released at rates that ensure that the concentration of the combined flow is less than the guideline values specified in 10 CFR 20. Samples are collected during the release and analyzed to confirm the actual effluent concentration. During the last 5 years, between 400 and 650 μCi of activity have been released annually in this manner at concentrations ranging from 1×10^{-8} to 8.6×10^{-8} μCi/ml, which were generally at least a factor of 10 below the limits of the applicable sections of 10 CFR 20.

12.7 Environmental Monitoring

The environmental monitoring program consists of air particulate and rainwater samples collected at the reactor site and at two locations within the City of Charlottesville.

12.8 Potential Dose Assessments

Natural background radiation levels in the Charlottesville area result in an average exposure of about 80 mrems/yr to each individual residing there. At least an additional 10% (approximately 8 mrems/yr) will be received by those living in a brick or masonry structure. Medical diagnosis exposures may add to this natural background.

Conservative calculations by the staff based on the amount of ^{41}Ar released from the reactor complex stack predict a maximum potential annual dose of the order of a millirem in the nearest unrestricted areas. The radioactivity levels detected by the environmental samples collected near the reactor facility have not been significantly distinguishable from the ambient background at adequately large distances.

12.9 Conclusion

The staff considers that radiation protection receives appropriate support from the University administration. The staff concludes that (1) the program is properly staffed and equipped, (2) the reactor Health Physics staff has adequate authority and lines of communication, and (3) the procedures are integrated correctly into the research plans.

The staff concludes that the effluent and environmental monitoring programs conducted by UVA personnel are adequate to promptly identify significant releases of radioactivity and confirm possible effects on the environment, as well as to predict maximum exposures to individuals in the unrestricted area. These predicted maximum levels are well within applicable regulations and guidelines of 10 CFR 20.

Additionally, the staff concludes that the UVA radiation protection program is acceptable because the staff has found no instances of reactor-related exposures of personnel above applicable regulations and no unidentified significant releases of radioactivity to the environment. Furthermore, the staff considers that there is reasonable assurance that the personnel and procedures will continue to protect the health and safety of the public during the requested renewal period.

Table 12.1 History of personnel radiation exposure at the University of Virginia reactor

	Number of Individuals in Exposure Interval	
Year	<0.5 Rem	>0.5 but <1.0 Rem
1977	165	0
1978	149	0
1979	150	0
1980	125	1
1981	123	0

13 CONDUCT OF OPERATIONS

13.1 Overall Organization

Responsibility for the safe operation of the reactor facility is vested within the chain of command shown in Figure 13.1.

13.2 Training

Most of the training of reactor operators is done by inhouse personnel. The licensee's Operator Requalification Program has been reviewed, and the staff concludes that it meets applicable regulations (10 CFR 50.34(b)).

13.3 Emergency Planning

10 CFR 50.54(q) and (r) require that a licensee authorized to possess and/or operate a research reactor shall follow and maintain in effect an emergency plan that meets the requirements of Appendix E to 10 CFR 50. At the staff's request, as part of the application for license renewal, the applicant submitted a plan following guidance contained in Regulatory Guide 2.6 (1978 For Comment Issue) and in ANS 15.16 (1978 Draft). In 1980, new regulations were promulgated, and licensees were advised that revised guidance would be forthcoming. Thus, revised ANS 15.16 (November 29, 1981 Draft) and Regulatory Guide 2.6 (March 1982 For Comment) were issued. On May 6, 1982, an amendment to 10 CFR 50.54 was published in the Federal Register (47 FR 19512, May 6, 1982) recommending these guides and establishing new submittal dates for Emergency Plans from all research reactor licensees. The deadline for submittal from a licensee in the UVAR class (≥2 MW) was September 7, 1982. The applicant/licensee transmitted an updated Emergency Plan by letter dated August 27, 1982, thereby complying with existing applicable regulations.

13.4 Operational Review and Audits

In addition to the line personnel for reactor operations and the radiation safety personnel, a Reactor Safety Committee, reporting to the President of the University, reviews and oversees the facility operations. This committee presently consists of one individual from the reactor operations staff and qualified people from the UVA management and faculty who are experts in radiological and reactor technologies. Another committee, the Radiation Safety Committee, is responsible for reviewing all radiation facilities and radioisotope utilization at UVA but is not solely involved with the reactor. The Reactor Safety Committee must review and approve plans for modifications to the reactor, new experiments, and proposed changes to the license or to procedures. This committee also is responsible for (1) arranging and conducting review audits of reactor facility operations and management, and (2) for reporting the results of these audits to the President of the University.

13.5 Physical Security Plan

UVA has established and maintained a program designed to protect the reactor and its fuel and to ensure its security. The staff has reviewed the plan and visited the UVAR site. The staff concludes that the plan, as amended, meets the current requirements of 10 CFR 73.67 for special nuclear materials of moderate strategic significance. UVA's licensed authorization for reactor fuel falls within that category. Both the Physical Security Plan and the staff's evaluation are withheld from public disclosure under 10 CFR 2.790(d)(1) and 10 CFR 9.5(a)(4). Amendment 14 to the facility OL R-66 dated August 25, 1981, incorporated the Physical Security Plan as a condition of the license.

Based on the above discussions, the staff concludes that the licensee has sufficient experience, management structure, and procedures to provide reasonable assurance that the reactor will be managed in a way that will cause no significant risk to the health and safety of the public.

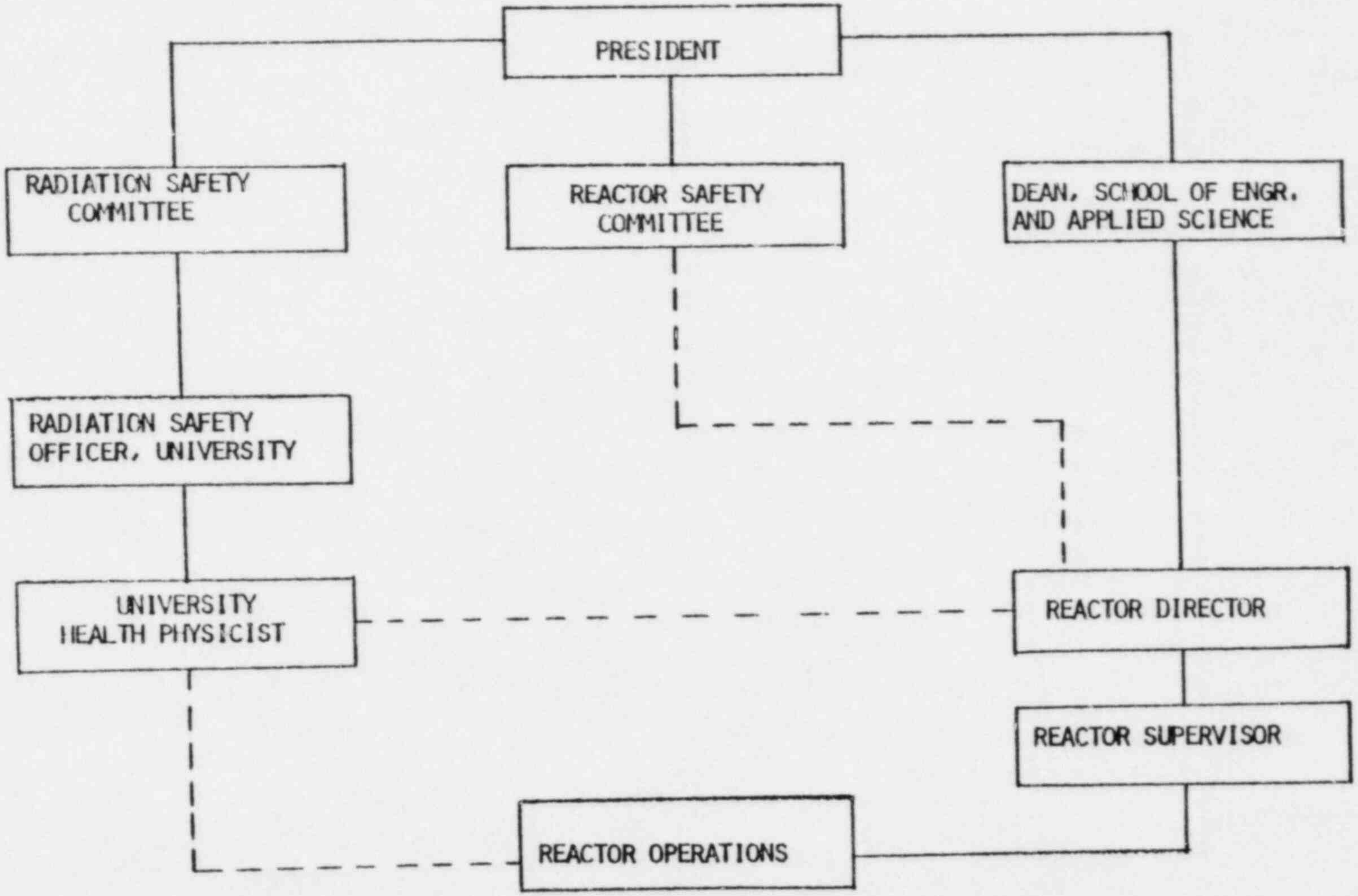


Figure 13.1 Organization of the reactor facility at the University of Virginia

14 ACCIDENT ANALYSIS

In establishing the limiting safety system settings and the limiting conditions for operation for the UVAR Technical Specifications, the applicant analyzed potential transients to ensure that these events would not result in the safety limits being exceeded. Hypothetical accidents and their effects on the core and the health and safety of the public also were analyzed.

Among the accidents postulated, the one with the greatest potential effect on the environment and the unrestricted area outside the exclusion fence is the failure of a fueled experiment (one containing fissile material intended for irradiation by neutrons) and the subsequent release of its fission product inventory. None of the reactor transients or other accidents analyzed posed a significant risk of fuel clad failure and would not result in a release of radioactivity.

The failure of a fueled experiment is designated for the UVAR as the maximum hypothetical accident (MHA). An MHA is defined as an accident for which the risk to the public health and safety is greater than that from any other credible event. Thus, the staff assumes that the accident occurs but does not try to describe or evaluate the mechanical details of the accident or the probability of its occurrence. Only the consequences are evaluated.

14.1 Accidents Analyzed

The following postulated transients and accidents are considered sufficiently credible to evaluate. The LANL group reviewed and independently evaluated the applicant's analyses, providing the bases for the remainder of Section 14.

14.1.1 Reactivity Insertion

The applicant analyzed potential transients that might result from the control rods rapidly being withdrawn from the core. Two reactivity insertion rates were considered, 1×10^{-4} Δk/k/sec and 2×10^{-4} Δk/k/sec (the second approximately corresponds to the simultaneous withdrawal of all three shim rods). A number of cases for each insertion rate were analyzed. Initial power levels ranging from 1 W to 500 kW were used. For each case it was assumed that a reactor period of 3 sec or a true value power level of 3.45 MW would activate the safety circuits and initiate a scram.

It was shown that at low initial power levels the reactor would scram on period before a high power level could be reached. As the initial power level was increased, the minimum reactor period increased and the scram signal was initiated by the slower high-power trip. When the power began to increase in these slower period events, the negative temperature coefficient further decreased the rate at which the power rose. Thus, as initial power level increases, the period at time of scram increases and the peak power decreases. Therefore, the highest power level is reached in an event whose minimum period is just greater than 3 sec. On the other hand, if the temperature coefficient is neglected for such an event, the period would remain approximately constant. Assuming a 50-msec magnet decay time for the shim rods, this event would result in a transient peak power of 3.5 MW.

This peak power was obtained for both reactivity insertion rates. It can be seen that although these insertion rates affect the period at a given initial power, the peak power is more a function of the trip settings for power and period and the magnet decay time. The analyses showed that the power increase was turned around as soon as the rods began to insert (50 msec after the scram signal). In Section 4.5.1 it was conservatively assumed that the power increase was not terminated until the rods were inserted 5 in. (50 + 300 msec after the scram signal). This assumption resulted in a transient peak power of 3.88 MW for that event. The analysis presented in this section shows that this power level will not be reached even with a zero temperature coefficient.

Although the events discussed above are less severe than the instantaneous insertion of all the excess reactivity allowed by the Technical Specifications, the staff considers the analyzed events to envelope all credible reactivity insertion transients. The staff has not been able to postulate a credible method for inserting all the excess reactivity instantaneously and considers that event to be unrealistic and overly conservative.

The above analyses have demonstrated that for the most severe credible reactivity insertion the transient peak power will remain below the safety limit for the 744 gal/min true value of total coolant flow. It should be noted that these safety limits, as shown in Figure 2-1 of the Technical Specifications, were developed for steady-state operation. Thus, because the peak power reached following the reactivity insertion is only a transient instantaneous power level, there is even a greater margin to the safety limits.

Based on the above considerations, the staff concludes that there is no credible nuclear excursion possible with the UVAR that could exceed the safety limits for the fuel. Therefore, there is reasonable assurance that fission product activity will not be released from the fuel to the environment as a result of a reactivity insertion event.

14.1.2 Loss of Flow

The applicant analyzed a loss-of-flow transient in which power to the primary coolant pump was lost suddenly. It was assumed that this loss of power initiated a scram signal to the reactor, which had been operating at the limiting true values of power and flow, namely, 3.45 MW and 744 gal/min. As an additional conservatism it was assumed that the flow header did not drop away from the core upon loss of flow but became jammed in a cocked position instead. This left a gap of 0.956 in. between one side of the header and the grid plate for the flow path.

Because the coolant flows down through the core during forced circulation, a loss of power to the pump results in the flow decreasing to zero and then reversing direction and moving upward by natural convection. The applicant determined the flow coastdown for this event by using the results of experimental measurements. The power coastdown was calculated using the Technical

Specification limit for rod drop time to full insertion (50 + 700 msec), a conservative total rod worth of 3% $\Delta k/k$, and a constant beta decay power of 6% of the steady-state power. The results were compared with the power-vs-flow curve in the Technical Specifications out to the values of 790 kW and 225 gal/min. At this point (less than 1 sec into the transient), the coastdown curve intersects the safety limit curve. If the reactor were to operate at steady-state under these conditions, a flow instability would occur in the hot channel. However, a transient is now being considered in which the flow rate is changing rapidly. Therefore, a new limiting criterion based on fuel temperature was established. The safe limit on maximum fuel-plate temperature was set at 350°F to provide a large margin to the melting point of the fuel meat (1185°F) and the cladding (1220°F). The applicant then calculated the flow rate and maximum and average fuel temperatures for the remainder of the transient. It was shown that the peak fuel temperature for this event was 303°F, well below the safe limit.

Based on the above analysis, with which the staff agrees, it is concluded that the peak fuel temperature that would result from a loss-of-flow transient at this reactor is sufficiently low that it would not result in fuel melting or cladding failure. Therefore, there is reasonable assurance that this event would pose no significant threat to the health and safety of the public.

14.1.3 Loss of Coolant

A loss-of-coolant accident (LOCA) was postulated for the UVAR, and the resulting peak fuel temperature was calculated. It was assumed that the reactor had been operating at a steady-state power level of 2 MW for 120 hours before the accident. The initiating event was assumed to be a pipe break or a crack in the pool wall. The reactor was assumed to scram on low pool level while there was still about 19 ft of water above the core. After the water is lost, the reactor is cooled predominantly by the ambient air flowing through the core by natural convection. Because beta-decay power decreases with time after shutdown, the faster the core is postulated to uncover, the higher the peak fuel temperature will be.

The applicant calculated the time required to uncover the core for several break locations. The fastest core uncovery resulted from a double-ended guillotine break in the 6-in. outlet coolant pipe at its lowest elevation--between the reactor and the heat exchanger. At this location the pipe is surrounded by concrete or earth, and it would be difficult to dissipate the pool water rapidly. However, to be conservative this was ignored, and an 0.3-hour minimum time from scram to uncovery was calculated. This resulted in a peak fuel temperature of approximately 1080°F. The applicant's analysis showed that even if the core uncovered in 0.167 hour, the peak fuel temperature would not exceed 1122°F. This is still below the melting points of the fuel meat (1185°F) and cladding (1220°F).

This analysis is very conservative because it ignored the core spray systems installed in the pool. The spray systems consist of two independent trains each of which is designed to deliver at least 10 gal/min for 30 min and 7.5 gal/min for the next 60 min. The flow from either train is capable of removing about 6 times the beta-decay power that would be produced by the core 0.3 hour after shutdown, that is, at core uncovery. Functioning of the spray systems would result in a much lower peak fuel temperature than computed above.

The applicant also considered a loss-of-coolant event in which the reactor was not scrammed by the low pool level interlock. The shutdown mechanism in this case would be the loss of moderator from the core. This second case is equivalent to the instantaneous loss of coolant from a reactor operating at rated power. For this event, it was shown that one train of the spray system still was capable of removing all of the decay power from the core. The staff's analysis shows that even if the reactor had been operating for an infinite time at 2 MW before the event, the heat removal capability of one train of the spray system would be equal to the beta-decay power from the core within 2 sec after shutdown.

Based on the analysis presented above, the staff concludes that the peak fuel temperature following credible LOCAs will remain sufficiently low to prevent fuel damage and the subsequent release of fission products to the environment. For the more probable accident scenarios, the reactor will scram on low pool level and the core will not be uncovered until approximately 18 min later. The analysis has demonstrated that ambient air cooling is sufficient to maintain the fuel temperature below the melting point under these conditions. For the less probable events in which the reactor does not scram or all the water is lost instantaneously, the staff concludes that the core spray system will provide adequate cooling. Thus, it has been demonstrated that no reliance needs to be placed on reactor scram circuits or operator action to mitigate the consequences of a LOCA. Therefore, the staff concludes that a LOCA at the UVAR will not pose a significant threat to the health and safety of the public.

14.1.4 Failure of a Fueled Experiment

As mentioned above, the failure of a fueled experiment is defined as the MHA for this reactor. Accordingly, the UVAR Technical Specifications allow fueled experiments generating up to 1 W to be run in the experimental facilities outside of the reactor confinement room. Fueled experiments generating power levels from 1 W to 100 W must be run in the reactor pool under at least 15 ft of water. The staff reviewed the applicant's analysis of failure of experiments at the two limiting power levels and based its evaluation on methods outlined in Regulatory Guides 1.25, 1.109, and 3.35. For both the 1 W and 100 W failure events, it was conservatively assumed that 100% of the noble gas, 50% of the halogen, and 1% of the solid (such as ^{90}Sr) fission products inventory would be released from the experiment upon total failure (AEC TID 14844 and NUREG-0772). For the relatively short-lived radionuclides (I, Kr, Xe), at both 1 W and 100 W, infinite irradiation time was assumed. For the long-lived ^{90}Sr, continuous irradiation for 6 years at 100 W was assumed for both experiment locations. These irradiation conditions represent conservatively high levels for this reactor facility.

Additionally, it is assumed that the fission products are instantaneously released into the room, and uniformly dispersed within the air. It is assumed that a person within the room would be exposed to the radioactivity for 5 min before being alerted and evacuated from the room. The free-air volumes of the experimental room and reactor room are 1700 m^3 and 2300 m^3, respectively. For evaluating inhalation volumes, a breathing rate of 3.47×10^{-4} $m^3 \cdot s^{-1}$ was assumed. The computed doses in the experiment room were as follows:

(1) whole-body gamma ray dose of 10 mrem resulting from immersion, assuming a semi-infinite sized cloud of noble gases (Correction for the finite room size reduces this potential dose to approximately 1 mrem.)

(2) a skin dose of approximately 10 mrem resulting from the beta rays from the noble gases

(3) total body intake of iodines of approximately 7 μCi, which would lead to an accumulated dose to the thyroid of approximately 2 rems, most of it during the next two to three weeks

(4) total body intake of ^{90}Sr of approximately 0.4 μCi, which would lead to an accumulated dose to the bones of approximately 6 rems during the lifetime of the exposed person, or approximately 0.13 rem per year during the first few years following the exposure

Radiation doses were calculated also for a location just outside the building. It was assumed that all of the contaminated air would escape from the building at a constant rate during a 2-hour time interval, with no decrease in source strength due to radioactive decay. Since this location is within the reactor facility fence, the reactor staff could restrict occupancy of the area. However, it is assumed that the exposure extends over the entire 2-hour leakage time. A short-term transport dilution factor ($^{\chi}/q$) of 10^{-2} s·m^{-3} was assumed.

The computed doses for this scenario are

(1) whole-body gamma ray dose of 0.3 mrem (semi-infinite cloud)
(2) skin beta ray dose of 0.3 mrem
(3) total accumulated dose to the thyroid from inhalation of iodines of 0.13 rem
(4) total lifetime accumulated dose to the bones from inhalation of ^{90}Sr of 0.32 rem

The second case considered the failure of a fueled experiment running at 100 W in the reactor pool. The same assumptions were made about the percentage of the various radionuclides released from the experiment. It is also assumed that 100% of the noble gases and ^{90}Sr escape the pool water and are uniformly dispersed in the reactor room air. However, it was assumed that 90% of the iodines released from the experiment are trapped in the water, so that only 5% of the total inventory is dispersed in the room air. A 5-minute exposure time was assumed for a person in the reactor (confinement) room.

The computed doses were

(1) whole-body gamma dose of 0.8 rem (semi-infinite cloud)
(2) skin dose from betas of 0.8 rem
(3) accumulated dose to the thyroid from the iodines of 16 rems
(4) lifetime accumulated dose to the bones from ^{90}Sr of 4 rems

For a person just outside the building, the doses were computed assuming that the exfiltration time from the confinement room was 20 hours. However, the exposure time again was assumed to be 2 hours. The computed doses were

(1) whole-body dose resulting from gamma rays of 3 mrems (semi-infinite cloud)
(2) skin dose resulting from beta rays of 3 mrems
(3) accumulated dose to the thyroid from inhalation of the iodines of 0.13 rem
(4) lifetime accumulated dose to the bones from inhalation of the ^{90}Sr of 32 mrems

Potential exposure to an individual in the unrestricted area outside of the perimeter fence around the reactor facility would be less than that computed above to an individual just outside the building.

Based on the above conservative analysis, the staff concludes that fueled experiments can be used at the UVAR facility in accordance with the limitations stated in the Technical Specifications without undue risk to the health and safety of the public. The analysis demonstrated that even if a conservatively high fission product release were assumed, the radiation doses to a person within the affected area and to a person in the unrestricted areas would be below the limits which form the basis for 10 CFR 20, Appendix B.

14.2 Conclusion

The staff has reviewed the credible transients and accidents for the UVAR. Based on this review and that provided by the LANL group, the most significant event that is postulated to result in a release of fission products to the environment is the total failure of a fueled experiment. The analysis has demonstrated that even if this unlikely event should occur, the resultant doses would be below limits which form the bases of 10 CFR 20. Therefore, the staff concludes that the design of the facility together with the Technical Specifications provide reasonable assurance that the UVAR can continue to be operated without significant risk to the health and safety of the public for the requested renewal period.

15 TECHNICAL SPECIFICATIONS

The applicant's Technical Specifications evaluated in this licensing action define certain features, characteristics, and conditions governing the continued operation of this facility. These Technical Specifications are explicitly included in the renewal license as Appendix A. Formats and contents acceptable to the NRC have been used in the development of these Technical Specifications, and the staff has reviewed them using the Draft Standard ANS 15.1 (September 1981) as a guide. Accordingly, these Technical Specifications contain several minor changes from the previously approved set. The applicant has either requested or concurred in these changes.

Based on its review, the staff concludes that normal plant operation within the limits of the Technical Specifications will not result in offsite radiation exposures in excess of 10 CFR 20 limits. Furthermore, the limiting conditions for operation, surveillance requirements, and engineered safety features will limit the likelihood of malfunctions and mitigate the consequences to the public of off-normal or accident events.

16 FINANCIAL QUALIFICATIONS

The UVAR reactor is operated by the University of Virginia, an agency of the State of Virginia, in support of its assigned educational and research mission. Therefore, the staff concludes that funds will be made available as necessary to support continued operations, and eventually to shut down the facility and maintain it in a condition that would constitute no risk to the public. The applicant's financial status was reviewed and found to be acceptable in accordance with the requirements of 10 CFR 50.33(f).

17 OTHER LICENSE CONSIDERATIONS

17.1 Prior Reactor Utilization

Previous sections of this SER concluded that normal operation of the reactor causes insignificant risk of radiation exposure to the public, and that only an off-normal or accident event could cause some measurable exposure. Even a design-basis accident would not lead to a dose to the most exposed individual greater than applicable guideline values of 10 CFR 20.

The staff concluded (AEC, May 16, 1960) that the reactor was initially designed and constructed to operate safely, with additional engineered safety features, and also considered whether operation would cause significant degradation in the capability of components and systems to perform their safety function. Since fuel cladding is the component most responsible for preventing release of fission products to the environment, possible mechanisms that could lead to detrimental changes in integrity were considered. Prominent among the considerations were the following: (1) radiation degradation of cladding integrity, (2) high fuel temperature or temperature cycling leading to changes in the mechanical properties of the cladding, (3) corrosion or erosion of the cladding leading to thinning or other weakening, (4) mechanical damage resulting from handling or experimental use, and (5) degradation of safety components or systems.

The staff's conclusions regarding these parameters, in the order in which they were identified above, are

(1) Nearly identical fuel has been laboratory tested elsewhere, and has been exposed in similar irradiation conditions to much higher total radiation doses in operating reactors, such as at the Oak Ridge Research Reactor and the Omega West Reactor (Los Alamos National Laboratory). No significant degradation of cladding has resulted.

(2) The power density, coolant flow rates, and maximum temperatures reached in the UVAR fuel are far below similar parameters in some other nonpower reactors using similar fuel. No damage has occurred during normal operations.

(3) The coolant flow rate at UVAR is much lower than used at several higher powered research reactors using MTR-type fuel. No erosion problems have been observed. At UVAR, corrosion is kept to a reasonable minimum by careful control of the conductivity and pH of the primary coolant water.

(4) The fuel is handled as infrequently as possible, consistent with required surveillance. Any indications of possible damage or degradation are investigatied immediately, and damaged fuel would be removed from service, in accordance with Technical Specifications. All experiments placed near the core are isolated from the fuel cladding by a water gap and at least one barrier or encapsulation.

(5) UVA performs regular preventive and corrective maintenance and replaces components as necessary. Nevertheless, there have been some malfunctions of equipment. However, the staff review indicates that most of these malfunctions have been random one-of-a-kind incidents, typical of even good quality electromechanical instrumentation. There is no indication of significant degradation of the instrumentation, and the staff further has determined that the preventive maintenance program would lead to adequate identification and replacement before significant degradation occurred. Therefore, the staff concludes that there has been no apparent significant degradation of safety equipment, and because there is strong evidence that any future degradation will lead to prompt remedial action by UVA, there is reasonable assurance that there will be no significant increase in the likelihood of occurrence of a reactor accident as a result of component malfunction.

18 CONCLUSIONS

Based on its evaluation of the application as set forth above, the staff has concluded that

(1) The application for renewal of Operating License R-66 for its research reactor filed by the University of Virginia, dated March 9, 1977, as supplemented, complies with the requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR, Chapter 1.

(2) The facility will operate in conformity with the application as supplemented; the provisions of the Act, and the rules and regulations of the Commission.

(3) There is reasonable assurance (a) that the activities authorized by the Operating License can be conducted without endangering the health and safety of the public; and (b) that such activities will be conducted in compliance with the regulations of the Commission set forth in 10 CFR, Chapter 1.

(4) The applicant is technically and financially qualified to engage in the activities authorized by the license in accordance with the regulations of the Commission set forth in 10 CFR, Chapter 1.

(5) The renewal of this license will not be inimical to the common defense and security or to the health and safety of the public.

19 REFERENCES

American National Standards Institute/American Nuclear Society (ANSI/ANS), 15 Series.

---, ANSI/ANS 15.11, "Radiological Control at Research Reactor Facilities," 1977.

American Nuclear Society (ANS), 15.1, "Standard for the Development of Technical Specifications for Research Reactors," Draft-May 1982.

---, ANS 15.16, "Standard for Emergency Planning for Research Reactors," Draft-1978 and Draft 2-November 29, 1981.

U.S. Atomic Energy Commission (AEC), TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites," DiNunno, J. J., et al., March 23, 1962.

---, Hazards Analysis (Safety Evaluation), May 16, 1960.

U.S. General Services Administration, Office of the Federal Register National Archives and Records Service, Code of Federal Regulations, Title 10, "Energy," U.S. Government Printing Office, Washington, D.C., January 1981.

U.S. Nuclear Regulatory Commission (NRC), NUREG-0772, "Technical Bases for Estimating Fission Product Behavior During LWR Accidents," June 1981.

---, Regulatory Guide 1.25, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors," March 23, 1972.

---, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 10 CFR Part 50, Appendix I," Rev. 1, October 1977.

---, Regulatory Guide 2.6, "Emergency Planning for Research Reactors," For Comment Issue, 1978 and March 1982.

---, Regulatory Guide 3.35, "Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Plutonium Processing and Fuel Fabrication Plant," Rev. 1, July 1979.

NRC FORM 335
(7 77)

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*
NUREG-0928

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*
Safety Evaluation Report Related to Renewal of the Operating License for the University of Virginia Open-Pool Research Reactor

5. DATE REPORT COMPLETED

MONTH	YEAR
September	1982

DATE REPORT ISSUED

MONTH	YEAR
September	1982

6. *(Leave blank)*

7. AUTHOR(S)

8. *(Leave blank)*

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Licensing
Washington, D. C. 20555

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*
Same as 9 above.

13. TYPE OF REPORT
Safety Evaluation Report

PERIOD COVERED *(Inclusive dates)*

14. *(Leave blank)*

15. SUPPLEMENTARY NOTES
Docket No. 50-62

16. ABSTRACT *(200 words or less)*

This Safety Evaluation Report for the application filed by the University of Virginia for a renewal of Operating License R-66 to continue to operate a research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. The facility is owned by the University of Virginia and is located on the campus in Charlottesville, Virginia. Based on its technical review, the staff concludes that the reactor facility can continue to be operated by the University without endangering the health and safety of the public or endangering the environment.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT
Unlimited

19. SECURITY CLASS *(This report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES

22. PRICE
$

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

120555078877   1 AN
US NRC
ADM DIV OF TIDC
POLICY & PUBLICATIONS MGT BR
PDR NUREG COPY
LA 212
WASHINGTON
DC   20555

NUREG-0928

SER RELATED TO THE RENEWAL OF THE OPERATING LICENSE FOR THE
UNIVERSITY OF VIRGINIA OPEN-POOL RESEARCH REACTOR

SEPTEMBER 1982