7590-01

UNIVERSITY OF FLORIDA

NOTICE OF RENEWAL OF FACILITY OPERATING LICENSE

AND

NEGATIVE DECLARATION

DOCKET NO. 50-83

The U. S. Nuclear Regulatory Commission (the Commission) has issued Amendment No. 13 to Facility Operating License No. R-56 to the University of Florida (the licensee), which renews the license for operation of the Argonaut type reactor (the facility) located on the University's campus in Gainesville, Florida. The facility is a research reactor that has been operating at power levels not in excess of 100 kilowatts (thermal).

The amendment extends the duration of Facility License No. R-56 for twenty years from the date of issuance of this amendment.

The application for the amendment complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations. The Commission has made appropriate findings as required by the Act and the Commission's rules and regulations in 10 CFR Chapter I. Those findings are set forth in the license amendment. Notice of the proposed issuance of this action was published in the Federal Register on December 15, 1977 at 42 FR 63236. No request for a hearing or petition for leave to intervene was filed following notice of the proposed action.

The Commission has prepared an environmental impact appraisal for the renewal of the Facility Operating License and has concluded that an environmental impact statement for this particular action is not warranted because there will be no significant environmental impact attributable to the action.

For further details with respect to this action, see (1) the application for amendment dated October 21, 1977, as supplemented by filings dated December 8, 1980; December 19, 1980; January 22, 1981; January 26, 1982; April 23, 1982 and May 5, 1982, (2) Amendment No. 13 to License No. R-56, and (3) the Commission's related Safety Evaluation Report and Environmental Impact Appraisal. All of these items are available for public inspection at the Commission's Public Document Room, 1717 H Street, N.W., Washington, D.C.

A copy of items (2) and (3) may be obtained upon request from the U. S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Director, Division of Licensing.

Dated at Bethesda, Maryland, this 30th day of August 1982.

FOR THE NUCLEAR REGULATORY COMMISSION

Cecil O. Thomas

Cecil O. Thomas, Acting Chief
Standardization & Special
Projects Branch
Division of Licensing

NUREG-0913

Safety Evaluation Report

related to the renewal of the operating license for the research reactor at the University of Florida

Docket No. 50-83

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

May 1982

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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-0913

Safety Evaluation Report

related to the renewal of the operating license for the research reactor at the University of Florida

Docket No. 50-83

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

May 1982

ABSTRACT

This Safety Evaluation Report for the application filed by the University of Florida (UF) for a renewal of Operating License R-56 to continue to operate its Argonaut-type research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. The facility is owned and operated by the University of Florida and is located on the UF campus in Gainesville, Alachua County, Florida. The staff concludes that the reactor facility can continue to be operated by UF without endangering the health and safety of the public.

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1 INTRODUCTION

The University of Florida (UF) (applicant) submitted a timely application for renewal of the Class 104 operating license (R-56) for its Argonaut-universal training reactor (UTR) (reactor or facility) by letter to the U.S. Nuclear Regulatory Commission (NRC) dated October 21, 1977, as supplemented. The letter requested renewal of the UF research license to permit continued operation at power levels up to and including 100 kW until December 31, 1999. The University of Florida is permitted to operate the reactor within the conditions stipulated in past amendments in accordance with Title 10 of the Code of Federal Regulations (CFR) 2.109 until renewal action is completed.

The renewal application is supported by information submitted in four appendices. The application was signed and notarized by the UF Executive Vice President for the President of the University, who is the UF officer responsible for the reactor. The application was reviewed by the UF Radiation Control Committee before being submitted to the NRC, Office of Nuclear Reactor Regulation (staff).

The renewal application, as supplemented, contains substantially all the information regarding the design of the facility included in the application for the original operating license. The application included a Safety Analysis Report, an Environmental Impact Appraisal, proposed Technical Specifications, an Operator Requalification Program, a Fiscal Statement, and, under separate cover, a Physical Security Plan which is protected from public disclosure under 10 CFR 2.790-(d)(1) and 10 CFR 9.5(a)(4).*

The staff's technical safety review with respect to issuing a renewal operating license to the University of Florida has been based on the information contained in the renewal application and supporting appendices plus 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 (SER) was prepared by James H. Wilson, Project Manager, Division of Licensing, Office of Nuclear Reactor Regulation, Nuclear Regulatory Commission. Major contributors to the technical review include the Project Manager and H. Bernard (NRC staff) and J. Koelling, C. Linder, and J. Giannelli of the Los Alamos National Laboratory under contract to the NRC.

The purpose of this SER is to summarize the results of the safety review of the University of Florida training reactor (UFTR) 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 UF facility at power levels up to and including 100 kW. The facility was reviewed against the requirements of 10 CFR 20, 30, 50, 51, 55, 70 and 73; applicable Regulatory Guides (Division 2, Research and Test Reactor); and appropriate accepted industry standards (American National Standards Institute/American Nuclear Society (ANSI/ANS 15

*The Environmental Impact Appraisal data and Safety Analysis Report (SAR) were used as basic review documentation, and are referenced throughout this report.

series)). Because there are no specific accident-related regulations for research reactors, the staff has at times compared calculated dose values with related standards in 10 CFR 20, the standards for protection against radiation both for employees and the public.

The UFTR initially was licensed at 10 kW on December 23, 1959. The reactor was modified slightly by license amendments issued by the Commission and then a license amendment authorizing operation at a maximum power level of 100 kW was issued on January 28, 1964. Since the power increase, license amendments concerning changes to the Technical Specifications and the Physical Security Plan were issued on July 22, 1970 and June 2, 1981, respectively.

1.1 Summary and Conclusions of Principal Safety Considerations

The staff's evaluation considered the information submitted by the applicant, past operating history recorded in annual reports submitted to the Commission by the applicant, and reports by the Commission's Office of Inspection and Enforcement. In addition, as part of its licensing review of Argonaut reactors, the staff obtained laboratory studies and analyses of several different postulated accidents for the Argonaut-UTR which also are applicable to other low-power reactors using materials testing reactor (MTR)-type fuel.

The principal matters reviewed and conclusions reached in the SER for the UFTR were

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

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

(3) The applicant's management organization, its conduct of educational 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 the 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 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 using guidance that was current at the time of license renewal application. The applicant has until November 3, 1982 to submit a revised Emergency Plan that follows new guidance developed since the UF renewal request was tendered. This item is discussed further in Section 13.3.

1.2 Reactor Description

The UFTR is of an Argonaut-UTR type, with some modifications to adapt it to the university training program. The reactor core is heterogeneous in design, currently using about 3.3 kg of fully enriched uranium-aluminum alloy fuel contained in aluminum cladding. Water is used as the coolant and also as the moderator. The remainder of the moderator consists of graphite blocks, which surround the boxes containing the fuel plates and the water moderator. The graphite also serves as a reflector. The fuel is contained in MTR-type plates assembled in bundles. Each bundle is composed of 11 fuel plates, each of which is a sandwich of aluminum cladding around a uranium-aluminum alloy "meat."

The reactor core has a two-slab geometry and is presently composed of 21 fuel bundles and 3 nonfueled bundles arranged in 6 water-filled aluminum boxes, surrounded by reactor grade graphite. There are four swinging-arm-type control blades (three safety and one regulating), consisting of four cadmium vanes protected by magnesium shrouds that operate by moving in a vertical arc within the spaces between the fuel boxes. These blades are moved in or out by mechanical drives or they may be disconnected by means of electromagnetic clutches and allowed to fall into the reactor. The drives, located outside the reactor shield for accessibility, are connected to the blades by means of long shafts. An isometric sketch of the UFTR facility with the shielding removed is presented in Figure 1.1.

The biological shield is made of cast-in-place concrete 3 to 6 ft thick. Access to the ends and top of the reactor is provided by removal of concrete blocks cast to fit openings and to prevent radiation streaming.

The reactor is operated at a maximum power level of 100 kW thermal. The requirements for safe and flexible operation of the reactor as a student training aid and for research have been met by use of the Argonaut-UTR design, shielding design, moderate power level, low excess reactivity, and large negative temperature and void coefficients. In addition, the amount of contained fission products is relatively small, and there are sufficient interlocks and safety trips to make a hazardous incident extremely improbable.

1.3 Experimental Facilities

The UFTR is equipped with a variety of experimental facilities including vertical foil slots, a variety of vertical ports, removable vertical and

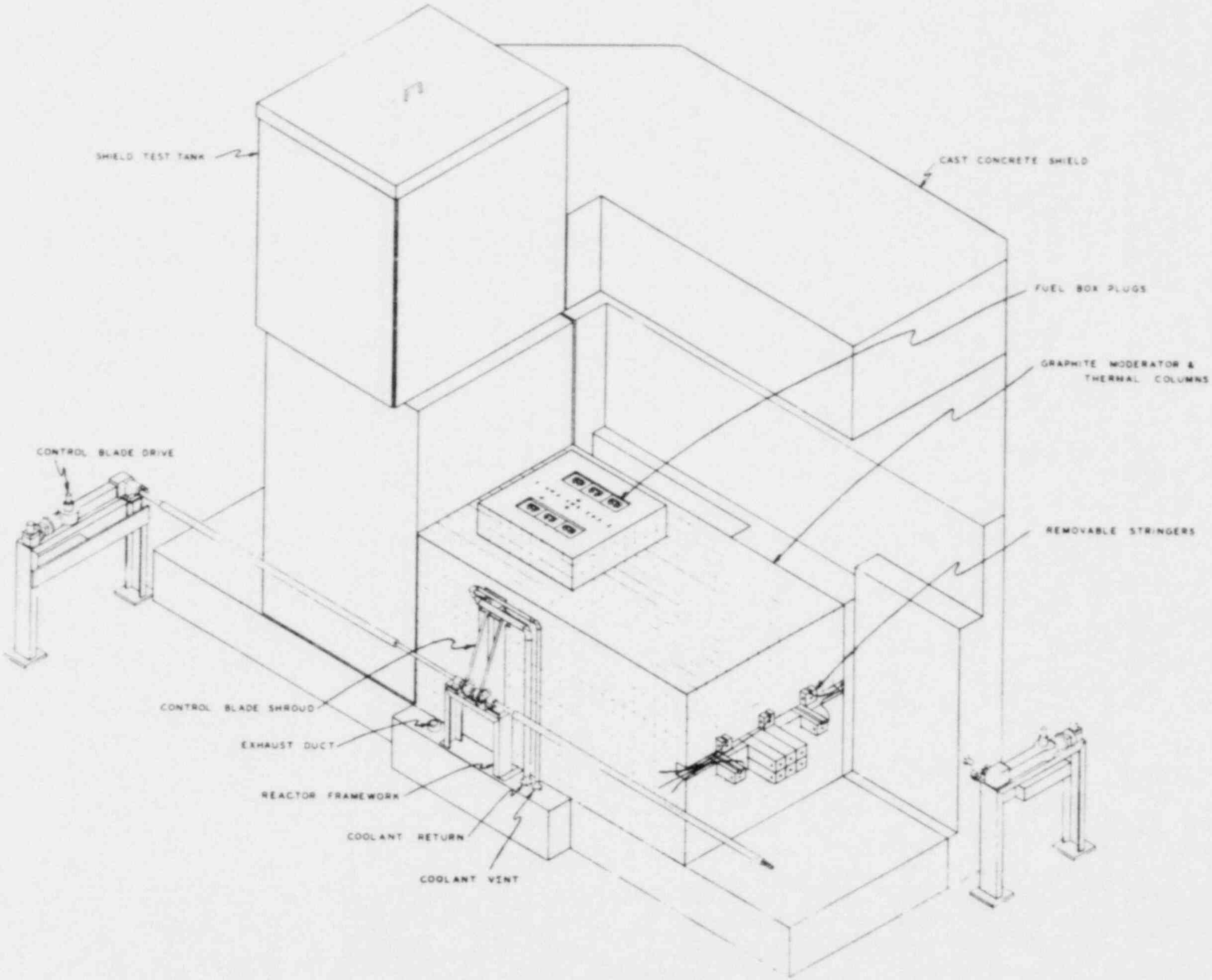

Figure 1.1 Isometric sketch of the UFTR facility with shielding removed

horizontal graphite stringers, a thermal column, a shield tank, a horizontal throughport, and several horizontal openings on the center plane of the reactor.

1.4 Reactor Location

The UFTR is annexed to the Nuclear Sciences Center on the campus of the University of Florida at Gainesville, in Alachua County, Florida. Gainesville is approximately in the center of Alachua County, which covers 961 mi^2 in the north-central part of Florida. The University of Florida campus is located approximately 1 mi from the center of the city of Gainesville.

1.5 Shared Facilities and Equipment (and Any Special Location Features)

The Westside Chiller Unit, located 95 ft west of the reactor building, provides air conditioning and heating for the reactor building, the Nuclear Sciences Center, and other UF facilities in the area.

There are no other exterior electrical or mechanical structures associated with the reactor facility attached to the building other than conventional service connections for electricity, heating, water, and drainage similar to those routinely required in all other campus laboratories.

The diesel generator provides the UFTR with emergency power to vital components of the reactor coolant, vent, instrumentation, radiation monitoring, and physical security system. The generator also provides emergency lighting to both the reactor building and the Nuclear Sciences Center.

1.6 Comparison with Similar Facilities

The reactor is similar in design to several other operating Argonaut-type facilities in the United States as indicated in Table 1.1.

1.7 Modifications

Additional shielding was installed before the 1964 power increase was granted to provide protection against the higher flux rates and doses expected from 100 kW operation.

In the period 1969-1970, a new reactor console and instrumentation system and a completely new (larger capacity and better instrumented with longer fuel boxes) primary coolant system were installed. In 1973, a larger motor to increase exhaust vent system dilution was installed. In 1974, a new secondary coolant system, a larger capacity primary coolant pump, and flow and temperature instrumentation were installed. The new secondary coolant system is fully redundant, the cooling water for this main system is well supplied cooling water, and the water for the backup comes from city water supplies. In the period 1978-1980, the building was significantly modified to increase physical security; this included the installation of a physical security system. In 1981, the UFTR was connected to a diesel generator that automatically supplies ac power to all vital reactor coolant, vent, instrumentation, monitoring, and physical security systems in case of failure of ac power.

1.8 Operational History

Over the last 5 years, the UFTR has accumulated about 860 effective full-power hours (EFPH) during 3000 hours of operation and has burned up a total of 4.7 g of U-235 for an average of 172 EFPH during 600 hours of operation each year--a little less than 1 g U-235 burns up per year.

Table 1.1 Argonaut research reactors

Reactor and location	kW	Major differences from UFTR: Containment	Fuel
University of Florida Gainesville, Florida (UFTR)	100	Reinforced concrete confinement building	U-Al alloy, 93% U-235, MTR flat plates-- 11 plates/element, 24 elements/core loading
University of California Los Angeles, California (UCLA R 1)	100	Reinforced concrete confinement building	U-Al alloy, 93% U-235, MTR flat plates-- 11 plates/element, 24 elements/core loading
University of Washington Seattle, Washington (UWNR)	100	Confinement room, concrete glass curtain wall	U-Al alloy, 93% U-235, MTR flat plates-- 11 plates/element, 24 elements/core loading
Virginia Polytechnic Institute Blacksburg, Virginia (VPI)	100	Confinement room, reinforced concrete, limestone	U-Al alloy, 93% U-235, MTR flat plates-- 12 plates/element, 12 elements/core loading
Iowa State University Ames, Iowa (UTR-10)	10	Reinforced concrete confinement building	U-Al alloy, 90% U-235, MTR flat plates-- 12 plates/element, 12 elements/core loading

2 SITE CHARACTERISTICS

The UFTR is located on the UF campus in Alachua County. Figure 2.1 shows the geographic location of Alachua County with Gainesville at its center in the north-central portion of the Florida peninsula. Figure 2.2 shows the location of the UF campus within the city of Gainesville. The city of Gainesville is approximately in the center of Alachua County, which covers 961 mi^2 in the north-central part of Florida, approximately midway between the Atlantic Ocean and the Gulf of Mexico. Gainesville is in the Central Highlands of the Florida Peninsula. The nearest approach to the Gulf of Mexico is about 50 mi to the southwest, and to the Atlantic Ocean is about 65 mi to the east.

2.1 Demography

The only significant large permanent population grouping within 10 mi of the reactor site is represented by the city of Gainesville itself, and as shown in Figure 2.2, most of the population is to the north and east of the reactor site.

As shown in Figure 2.2, the UF campus is in the southwestern quadrant of the greater Gainesville area, which has a population of about 125,000. The city proper has a population of about 83,000. The UF campus is approximately 1 mi from the center of the city (University Avenue and Main Street).

The Nuclear Sciences Center is annexed to the reactor building which is labeled Building No. 557 in Figure 2.3. Concentric circles are shown with the UFTR as the center, the first circle having a 250-ft radius and the rest being at 500-ft increments from the central reactor building point. The site is 50 ft south of Reed Laboratory (No. 131); the closest residence hall is East Hall, which is approximately 750 ft due west of the reactor building. The reactor is located about 600 ft north of the J. W. Reitz Student Union, about 100 ft west of the Journalism Building, 250 ft due east of the Materials Building, and about 95 ft due east of the Westside Chiller Unit (air conditioner cooling tower). The J. Hillis Miller Health Center complex is about 3000 ft southeast of the UFTR. Similarly, most of the residence halls, fraternity houses, and Lake Alice, a small lake within the University of Florida boundaries are found within the same range.

Population variations related to the city of Gainesville are caused mainly by the presence of the UF and Santa Fe Community College, both having a great impact on the population composition of the greater Gainesville area.

The UF population is mostly transient in its occupation of the campus buildings denoted in Figure 2.4. Most of the approximately 42,000 students, faculty, and staff workers populate the campus in varying numbers primarily Monday through Friday during the hours from 7:30 a.m. to about 10:00 p.m. As noted previously, this number is a maximum in the fall and diminishes significantly because of reduced enrollment as the academic year progresses. About 6200 persons occupy the campus dormitories while another 1400 occupy the housing areas for married

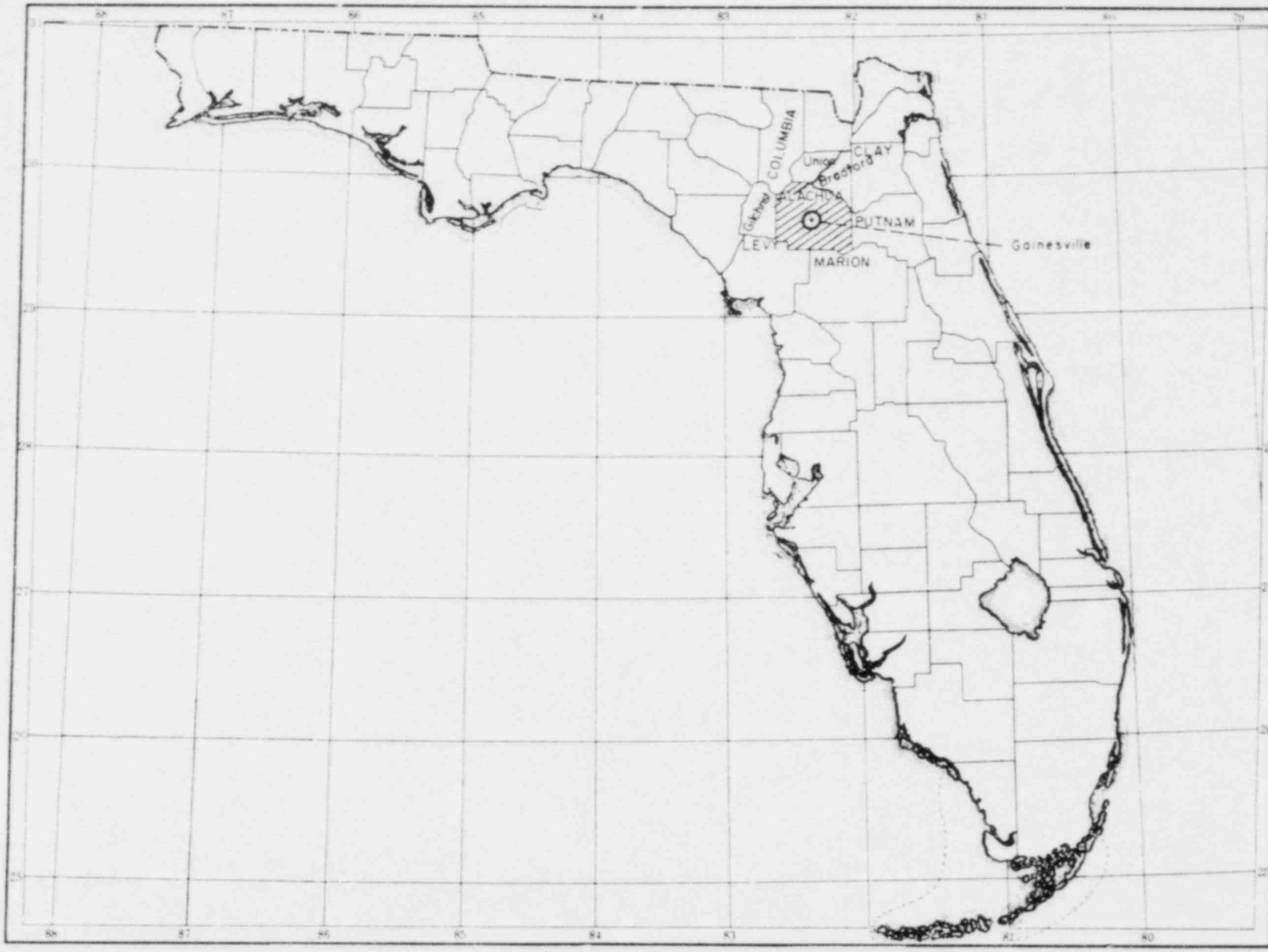

Figure 2.1 Relative geographic location of Alachua County and Gainesville in the State of Florida

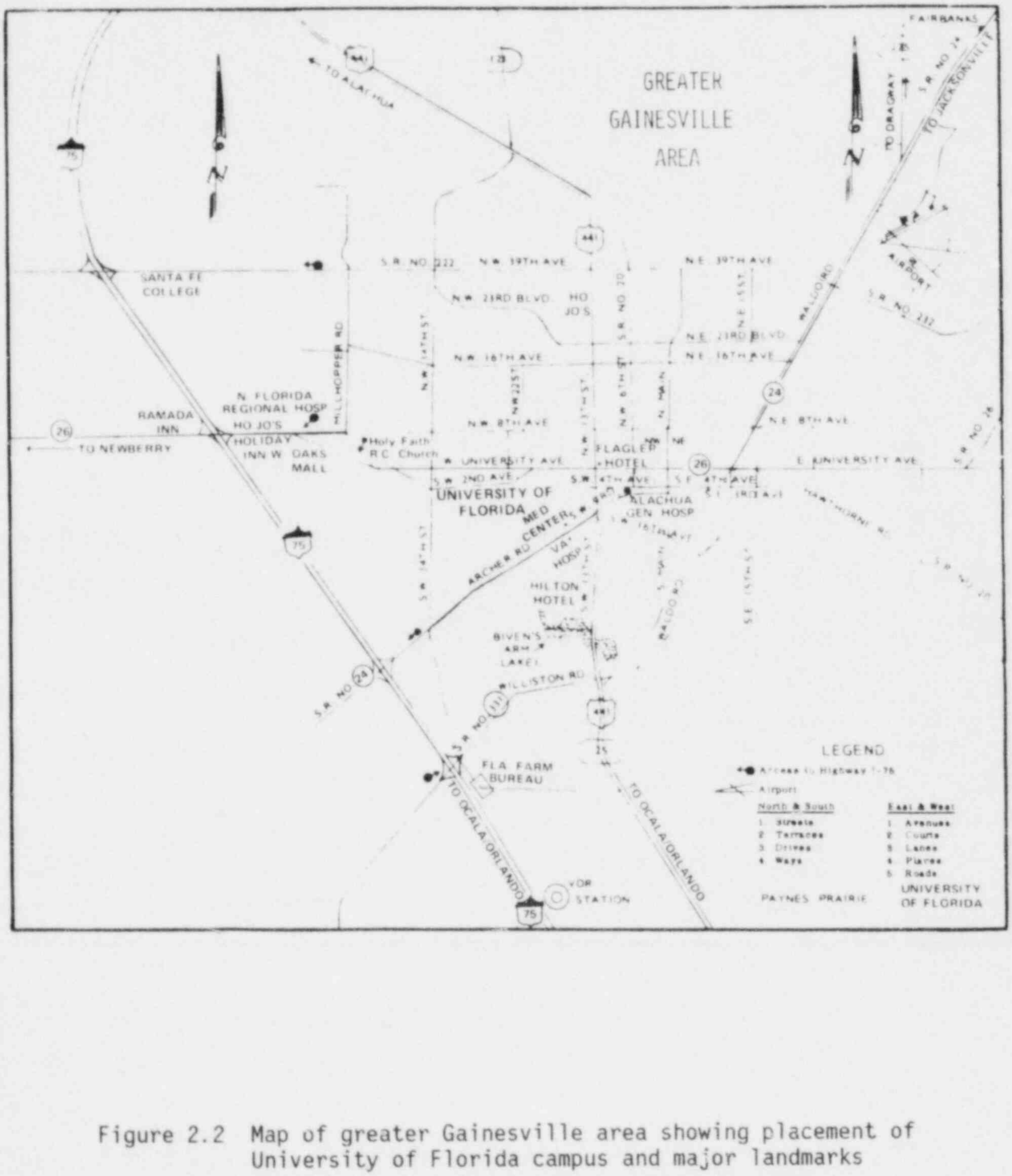

Figure 2.2 Map of greater Gainesville area showing placement of University of Florida campus and major landmarks

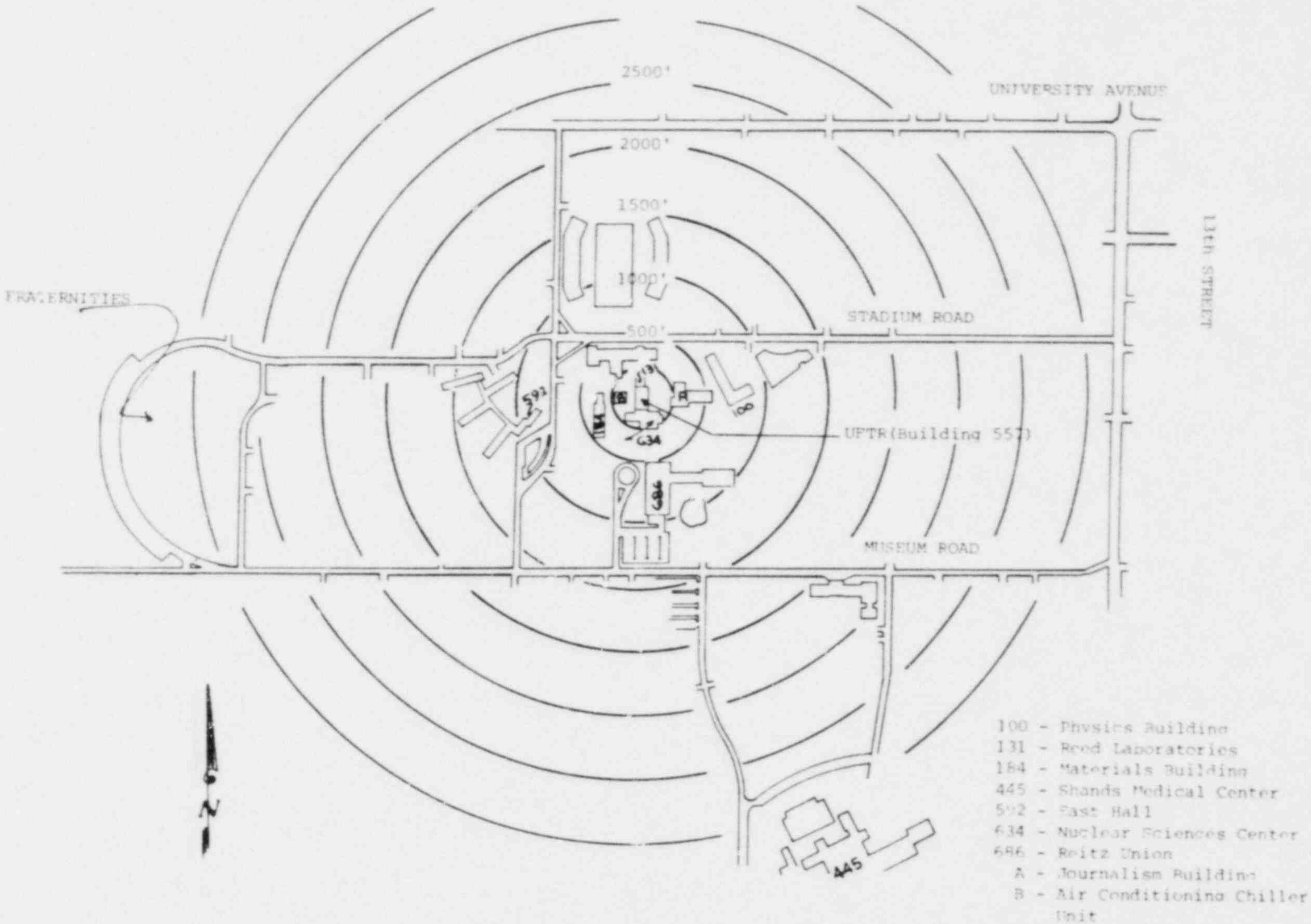

Figure 2.3 UFTR building placement on University of Florida campus with respect to major campus arteries and buildings

Figure 2.4 University of Florida campus map with building locations, primary landmarks, and boundaries

people on the periphery of the campus. The rest, including about 11,600 faculty and staff workers, make up the transient campus population.

The Santa Fe Community College population is completely transient. The fall 1979 semester enrollment was 7063 students while the current enrollment is 7216 students. Because of its location about 6 mi northwest of the UF campus, no further consideration is given to the Santa Fe Community College population.

The staff concludes that there are no demographic characteristics associated with this site that would make it an unfit location of the UFTR.

2.2 Nearby Industrial, Transportation, and Military Facilities

2.2.1 Transportation Routes

Transportation routes located close to campus include State Road 26 known as University Avenue, which is located approximately 2300 ft north of the reactor site, and U.S. Highway 441 known as 13th Street, which is located about 3800 ft east of the reactor site, as shown in Figures 2.3 and 2.4. Interstate 75 is located about 3 1/2 mi southwest of the reactor site at its closest approach.

The Gainesville Regional Airport is the only airport in the vicinity. Although the runway system is essentially unchanged, the airport terminal is a completely new facility to the south of the main runway opposite the old terminal on the north side and about 1/2 mi away. The airport is located approximately 5 mi northeast of the UF campus as shown in Figure 2.2.

There are no main railroad lines near the campus.

2.2.2 Nearby Facilities

There are no heavy industries or major military establishments in the vicinity of the UF campus.

2.2.3 Conclusion

There is no heavy air or railroad traffic, no heavy-truck route, and no heavy industry close enough to the campus to constitute a threat to safe operation of the reactor. The staff concludes that the facility can be operated with an acceptable degree of safety without risk from accidents occurring as a result of activities at industrial, military, or transportation facilities.

2.3 Meteorology

2.3.1 Climate

The following information is based on local climatological summaries for the Gainesville area prepared by the U.S. Weather Bureau. The proximity of the extensive land mass to the north and northwest gives Gainesville a continental type climate in winter, but the nearness of the ocean area and the direction of prevailing winds cause marine climatic characteristics to prevail in summer.

Maximum temperatures in the nineties are common in summer but readings as high as 100°F have been recorded in only 11 of the last 32 years before 1978. Frequent afternoon thunderstorms and associated showers provide relief from the heat in summer. February 14 is the average date for the last occurrence of freezing temperatures in the spring, and the average date for the first occurrence of freezing temperatures in the fall is December 6. Precipitation varies greatly from year to year for any month, but on the basis of mean monthly totals, there is a rainy season of 4 months (June through September). This 4-month period brings about 54 percent of the annual precipitation, nearly all of which is in the form of rain. Hail falls occasionally but usually covers very small localized areas. The only measurable accumulation of snow recorded at Gainesville was 1.0 in. in February, 1899. On January 18, 1977 there was a trace of snow recorded in Gainesville. There was a trace of snow or sleet in December 1971, February 1951, and January 1958. The major portion of the rain comes from showers that are of relatively short duration and frequently associated with thunderstorms. The greatest precipitation total for any month appearing in the records for this station is 15.78 in. in October 1941. The longest drought without measurable rainfall was 39 days, October 18 through November 25, 1903. It is not expected that any of these weather extremes would affect the safe operation of the UFTR facility.

2.3.2 Tropical Storms

From 1891, when more complete weather recordkeeping was started, through 1972, a total of 58 tropical storms or hurricane centers have passed within approximately 75 mi of the UF site. Since 1972, one additional hurricane has come near the UFTR site along the east coast of Florida; however, it was more than 75 mi away at its nearest center. After 1885, weather records differentiated between tropical storms (winds less than 73 mph) and hurricanes (winds more than 73 mph). From 1886 through 1972, there have been 46 passages of tropical storms. Of these a maximum of 13 hurricanes were experienced within 100 mi of the site. Relatively few storms have moved inland on Florida's west coast between Cedar Key (directly west from Gainesville) and Fort Myers in the past 100 years. Most tropical storms have a tendency to move on one of three general courses, which prevents them from having a maximum impact on the UFTR area as they move northward. As shown in Figure 2.5A, the typical tropical storm takes one of three routes; either it (1) recurves north and northeast over the Florida coast, (2) moves northward paralleling the west coast, or (3) moves on a north-westerly course across the Gulf of Mexico. As illustrated on the frequency histogram in Figure 2.5B, the highest frequency of tropical storms in the central Florida area has occurred in September, with October being the month of the second highest frequency. Nevertheless, tropical storms are not considered a great hazard at the UFTR site for two reasons: (1) the severity of the storm is reduced by the overland movement necessary for a storm from the Gulf of Mexico or the Atlantic Ocean to reach the Gainesville area, and (2) tidal flooding is prevented by the inland location of the UFTR site and there are no large bodies of water near the UFTR site.

Experience with the passage of past hurricanes indicates maximum gusts of approximately 60 mph around the site. It should be noted that even thunderstorms with accompanying hail, excessive rain, and strong winds occasionally develop gustiness of this severity.

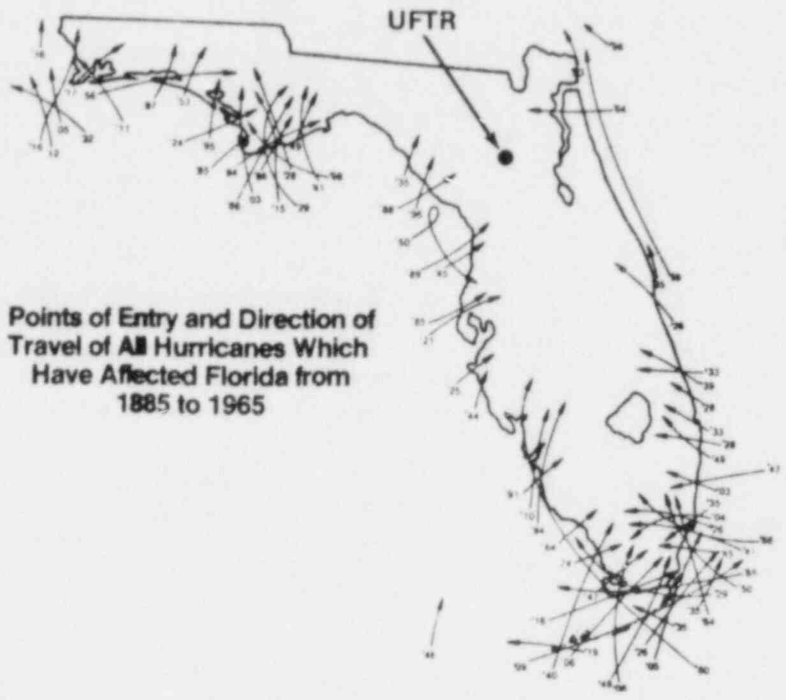

Figure 2.5A Historical hurricane points of entry for the State of Florida

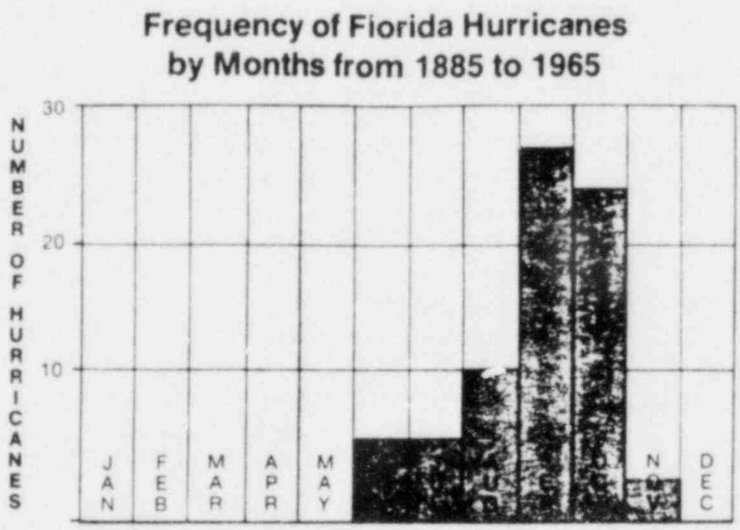

Figure 2.5B Florida hurricane monthly frequency histogram

The staff concludes that hurricanes pose very little risk to the continued safe operation of the UFTR.

2.3.3 Tornadoes

Tornadoes are considered to be the most likely natural disaster to affect the UFTR site. From 1961 through 1972 a total of 776 tornadoes were reported in the State of Florida. Approximately 81 of these tornadoes were associated with the passage of tropical storms. The highest frequency of tornado occurrence is along Florida's southeast coastline, and also south of Tampa. As illustrated in Figure 2.6A, the tornado frequency in Alachua County was between five and nine per year for the typical period of 1959 through 1971. However, tornadoes causing property damage have occurred only six times in Alachua County since 1916. As Figure 2.6B indicates, June is the month in which the highest number of tornadoes have occurred in the Florida area.

The calculated mean probability per year of a tornado striking within the UFTR site is approximately 2×10^{-2} year $^{-1}$. (The probability of such a tornado striking within the UFTR site is very conservative because the mean tornado path area in Florida is much less than the area used in the calculation. Florida tornado areas are typically about 10 percent of the area used.) The mean recurrence interval of a tornado striking a point anywhere in Alachua County, where the site is located, is about 50 years.

The staff concludes that damaging tornadoes are likely to occur near the site. However, for the reasons set forth in Sections 3 and 14, tornadoes, affecting the reactor site are not expected to cause releases of radioactive materials to the environment.

2.4 Hydrology

The terrain in the vicinity of Gainesville is gently rolling and the soil is sandy with the exception of relatively small areas of muckland along the shorelines of the fresh water lakes and ponds, which are numerous to the east and south of Gainesville.

There are no surface streams of any consequence in the Gainesville area. During the dry season, which is generally March, April, and May, the surface flow of the creeks in the area decreases to nearly zero, although there is still a small subsurface flow. The water table is close to the surface and the movement of the ground water is very rapid because of the high porosity and permeability of sandy soil and cavernous limestone bedrock.

The city of Gainesville and vicinity receive their water supply from the municipal water treatment plant. All of the water entering the treatment plant is obtained from seven wells ranging from 367 to 750 ft in depth. Spring or surface water is not used for the municipal supply, but several springs supply water for agriculture and industry.

The reactor site rises to the east. At the base of the rise on the west is a small valley running south and terminating in the vicinity of two sinkholes. Thus, the surface drainage of the site would be to the west and then south to these sinkholes. The surface water enters the underground aquifer through these sinks.

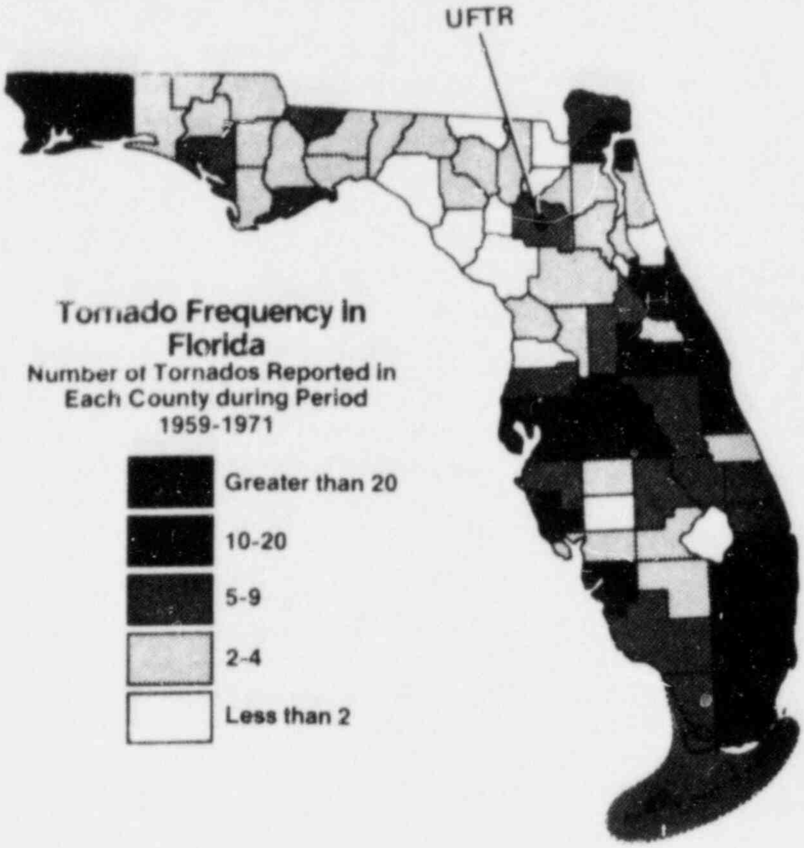

Figure 2.6A Tornado frequency by Florida County for years 1959-1971

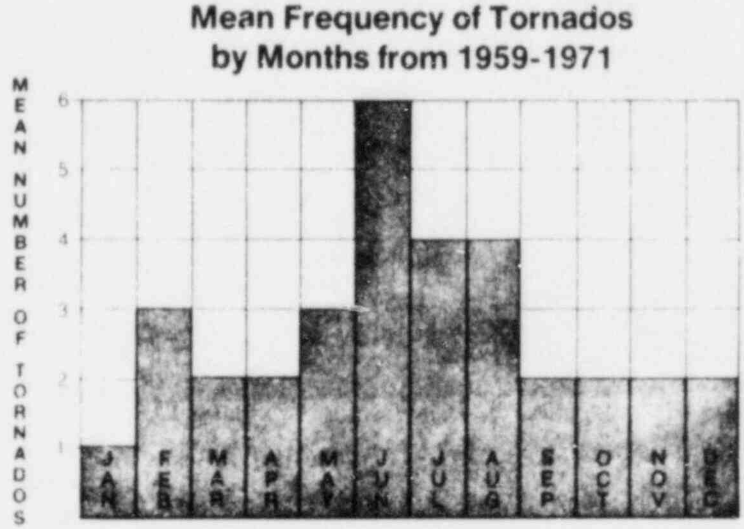

Figure 2.6B Monthly frequency of tornadoes by month for years 1959-1971

The amount of percolating water will determine the soil water dilution factor in the event of accidental liquid release of radioactivity from the UFTR. It should be noted that the amount of percolating water in Gainesville is always relatively small and often there are months when it drops to zero, generally in the spring and summer.

The staff concludes that there are no hydrological characteristics of the site that render it unacceptable for the location of the UFTR.

2.5 Geology

The bedrock formation in this area is porous and cavernous Ocala limestone which occurs in a broad truncated dome with its crest in Levy County, southwest of Gainesville. The Ocala formation is overlain by other porous limestones and semipermeable sandy clays (Hawthorne formation). This is capped by loose surface sands. In general, all the formations are relatively porous and permeable. Locally, however, the Hawthorne sandy clays confine the ground water in the underlying porous limestones under artesian pressure.

Most of the Gainesville area and that part of the UF campus north of Radio Road, including the UFTR site, is underlain by a loamy fine-sand-type soil. This was derived from residual Hawthorne formation and is characterized by a typical slope of 2 to 7 percent, light brown or brownish grey surface soil, light yellowish brown or pale brown subsoil, nearly loose to loose with good natural drainage.

Studies have shown that these soils are sandy and possess very little ion-exchange capacity. The calcium carbonate (limestone) bedrock has virtually no capacity for preventing the rapid movement of radioactive products toward the ground water table. It would only react chemically to neutralize acid solutions and precipitate insoluble carbonates. It has virtually no ion-exchange capacity and is highly porous and permeable so that any chemical precipitates formed would only slightly retard the flow of radioactive liquids through the bedrock.

The staff concludes that the reactor is founded on competent soil and that there is no significant geologic hazard associated with this site that would make it unfit for the continued operation of the UFTR.

2.6 Seismology

The State of Florida is an area that is considered relatively seismically inactive; there is no record of a severe earthquake in Florida. Florida is considered to be one of the most seismically stable areas in the United States. Only eight earthquakes of Intensity IV (Modified Mercalli Scale) or greater have had their epicenter within 50 mi of the Crystal River nuclear plant site, which is located on the west coast of Florida about 50 mi from Gainesville. Only one tsunami, or seismic sea wave, has ever been noted along the gulf coast of the United States. This wave was caused by the Puerto Rican earthquake of October 11, 1918, and was very small as recorded on the tide gauge of Galveston, Texas. There is no record of a tsunami or seismic sea wave ever having affected the Crystal River area. It is highly unlikely that if a tsunami did occur, it would have any effect as far as Gainesville, Florida, which is over 50 mi inland.

It is the staff's judgment that the seismic hazard associated with this site is very small and poses no unacceptable risk to the UFTR.

2.7 Conclusions

The staff has evaluated the UFTR site for man-made as well as natural hazards and concludes that there are no significant hazards associated with this site that would render it unfit for continued operation of the UFTR.

3 DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

3.1 Wind Damage

Although the reactor building was constructed with the expectation that tornadoes could be expected to occur at the reactor site, the NRC staff has not analyzed the building structure for tornado loadings. Because the building is a vault-type structure partially embedded in the side of a hill, it is felt that with the possible exception of the roof, it would sustain little significant damage in the event that a tornado were to strike the reactor site.

In any case, the health and safety of the public do not depend on reactor building integrity, as demonstrated by the analyses of extreme accidents involving core crushing in Section 1.4. These analyses indicate that even in an accident (of unspecified nature) where the core was to be crushed, the resulting releases of radioactivity would be well within those specified in 10 CFR 20 for release to unrestricted areas.

3.2 Water Damage

Exhaustive studies have indicated no record of any major flood in the general UFTR site area during the past 100 years.

Except where buildings and landscaping intervene, the present contour of the site rises on a 16 percent slope from west to east; consequently, the reactor is partially buried in the side of a hill in well-drained permeable soil. It would be difficult to conceive of an event, natural or otherwise, that would lead to flooding of the reactor site.

Because of its inland position, which removes the potential for tidal flooding, and because of the well-drained location of the UFTR site, no special consideration is given to floods in the UFTR design.

There are no surface bodies of water close enough to affect the UFTR site through seiche flooding or surges of any kind.

There are no dams in the UF-Gainesville area that could affect the reactor site in case of failure. Therefore, dam failures and attendant water levels and effects are not considered.

Because of its inland location (approximately 50 mi from the Gulf of Mexico), tsunami flooding is predicted to have no effect on the UFTR site.

Nevertheless, if flooding were to occur, the self-contained design of the UFTR makes it more resistant to any hypothetical flood condition. Also, detailed procedures designed to minimize the impact of floods and protective measures to be taken in case of floods are outlined in the UFTR Standard Operating Procedure B.4 - Emergency Flood Procedures.

3.3 Seismic-Induced Core Disruptions

Because the UFTR is located in a region that has been seismically stable and free of earthquakes for at least the last million or so years, no special design features to prevent seismic-induced core disruptions have been utilized at the UFTR. It should be noted, however, that the massive concrete shield block design of the Argonaut reactors would offer a significant amount of protection to the core in the unlikely event that a major earthquake should occur.

3.4 Mechanical Systems and Components

The only mechanical system of importance to safety inside the shield of the reactor is the control rod drive system. The four semaphore-type control blades of cadmium metal move in a vertical arc within the spaces between the fuel boxes. A magnetic clutch between the shaft and the motor located outside the core serves as a rapid disconnect allowing the control blades to rapidly drop into the core by gravity. Thus, the mechanical equipment inside the reactor shield is limited to the control blades and the associated shaft plus the support for the blades and shafts. This arrangement reduces maintenance and other complications in the core area and permits easy and continuous maintenance of the motors and gears.

3.5 Conclusion

The reactor facility has been designed to withstand all credible wind and rain contingencies associated with this site. Seismicity considerations have such a small probability of occurrence that they need not be explicitly considered.

4 REACTOR

The UFTR is an Argonaut-UTR reactor using up to 3.8 kg of U-235 fuel enriched to approximately 93 percent. It is a graphite-reflected, water- and graphite-moderated reactor that currently is authorized to operate at a steady-state power level of up to 100 kW thermal.

The UFTR generates no electricity and is used primarily for class instruction, student experiments, reactor operators training, and research.

4.1 Building Layout

The reactor building, pictured in Figure 4.1, is a vault-type building as defined in 10 CFR 73.2(0). The reactor building is divided into two distinct parts based on the difference in utilization and structure. The overall reactor building measures approximately 60 ft by 80 ft inside as depicted in Figure 4.2. The reactor or cell area is 30 ft by 60 ft, with 29 ft of head room, located at the north end of the building. The rest of the building is used for research laboratories, faculty offices, and graduate student study areas. The current floor plan for both levels of the building is shown in Figures 4.3 and 4.4. This plan shows a number of building changes from the original floor plan primarily aimed at increased security and area utilization.

The office laboratory section of the building is constructed of concrete columns and beams with hollow cement block curtain walls and metal sash windows. The floors and roof are poured concrete slabs, covered with vinyl or asphalt tile.

The reactor room or cell (Area 101), while an integral part of the building, is isolated from the laboratory-office section by a two-door lock system. The walls of the cell are constructed of 1-ft-thick monolithic reinforced concrete. The floor slab is 1 ft thick, increasing to 18 in. under the reactor.

The roof of the reactor is built up with 3-in. precast concrete roof tiles supported on steel-bar joists covered with waterproofing material on the exterior and with 2 in. of rigid fiberglass insulation on the interior.

The reactor rests on a 16-in.-high concrete pedestal in order to raise the beam holes to a convenient 40-in. working level and to support the reactor. A concrete service trench, 5 ft wide by 2 ft deep, extends from under the reactor to an equipment pit, measuring 5 ft 3 in wide by 13 ft 6 in long by 6 ft deep, located adjacent to the reactor.

The reactor control area (Space 102), housing the reactor console, is located in the southeast corner of the reactor room inside the reactor cell. A plate glass wall is provided around the control area to give maximum visibility from the control console to the reactor cell and to isolate this area from the rest of the reactor cell.

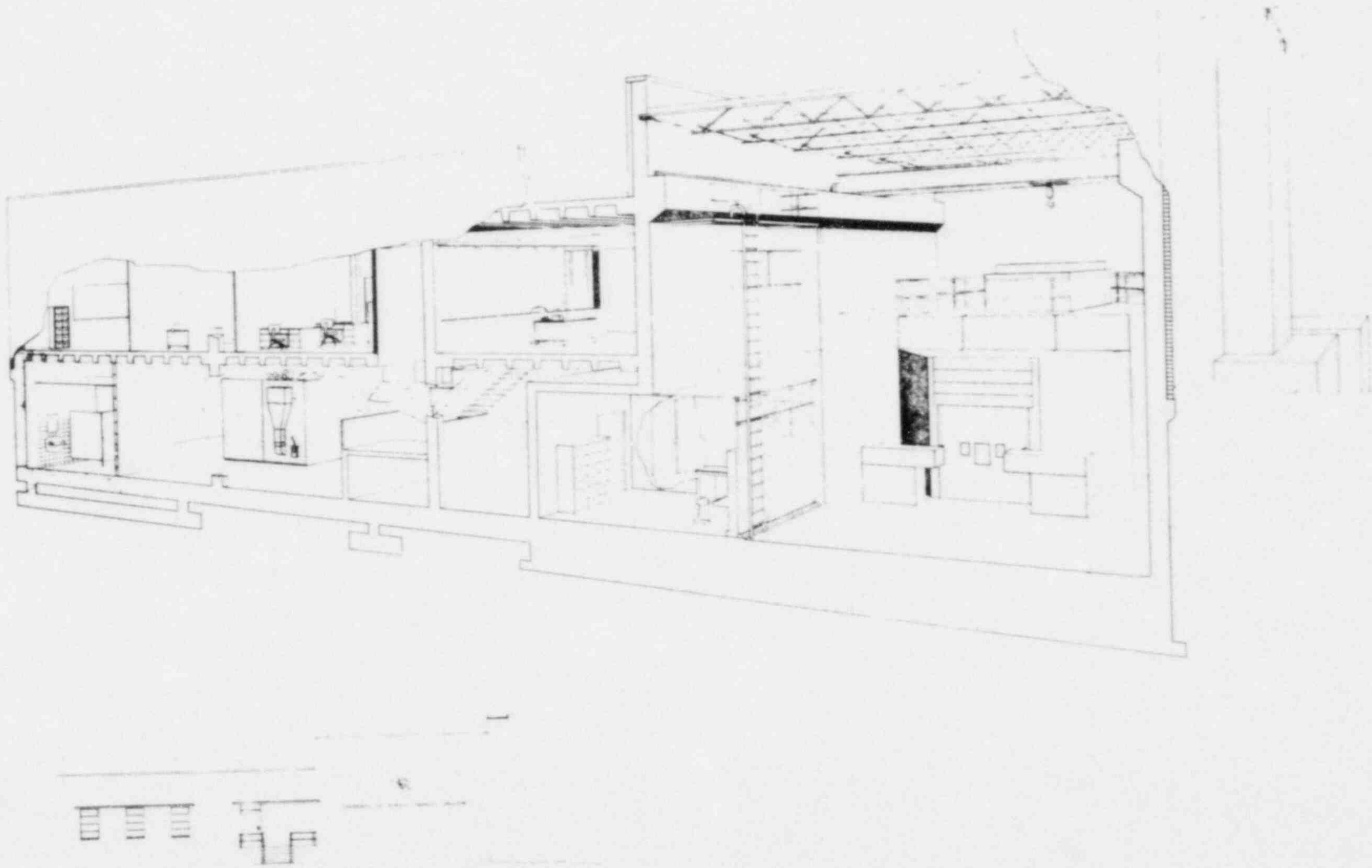

Figure 4.1 University of Florida training reactor facilities -- east face cutaway view

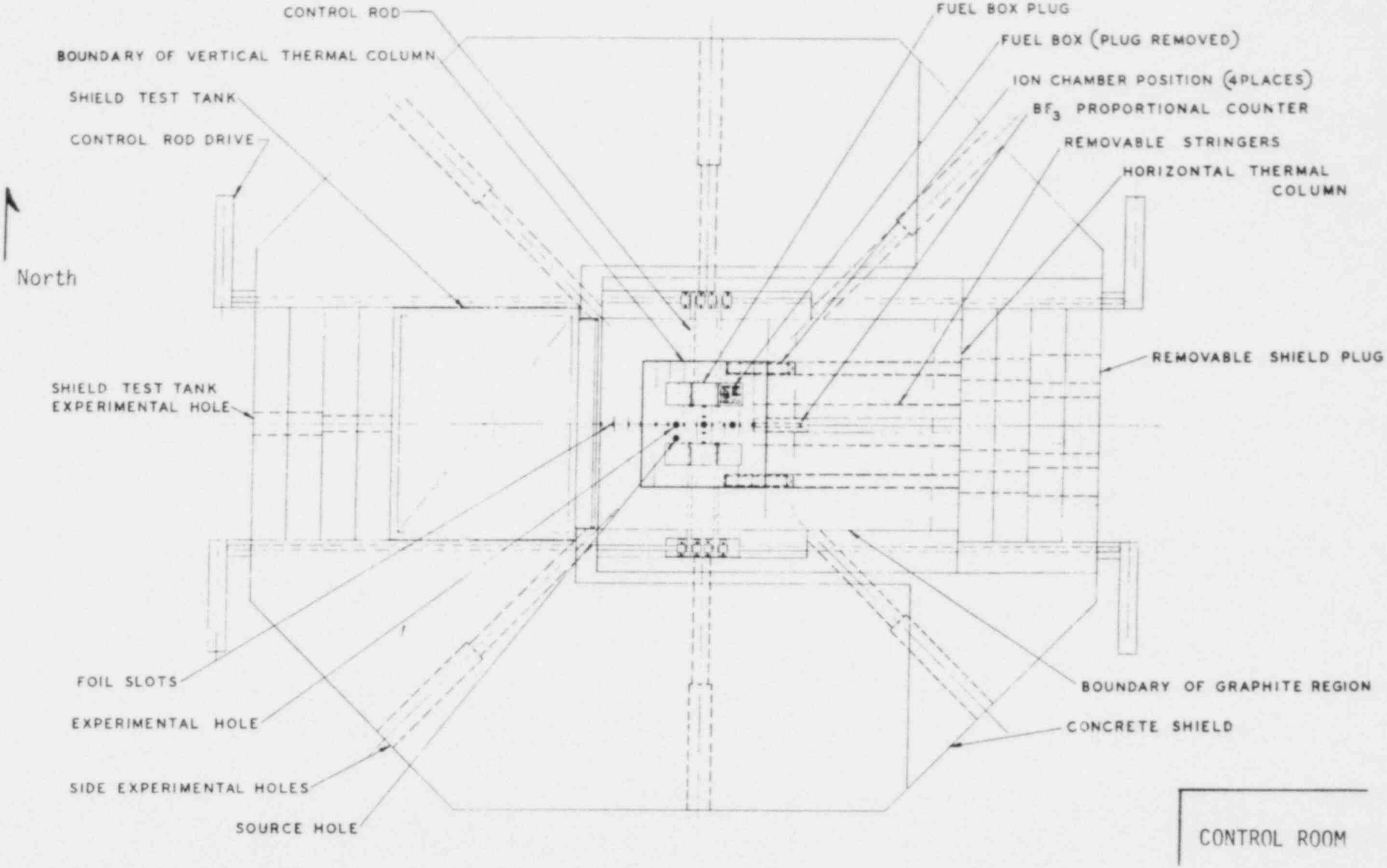

Figure 4.2 Geometric arrangement of major UFTR experimental facilities

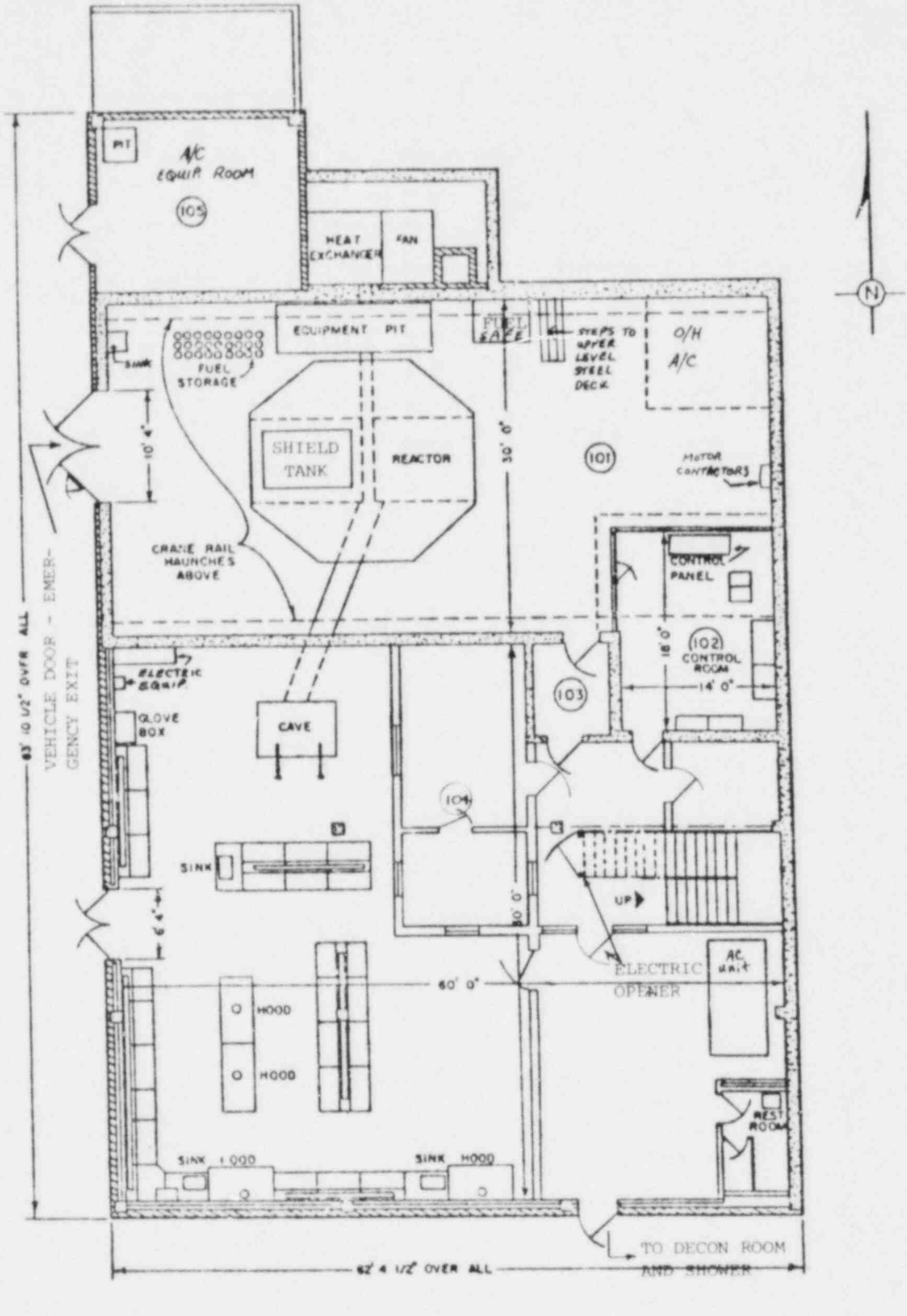

Figure 4.3 First floor plan for the University of Florida training reactor building

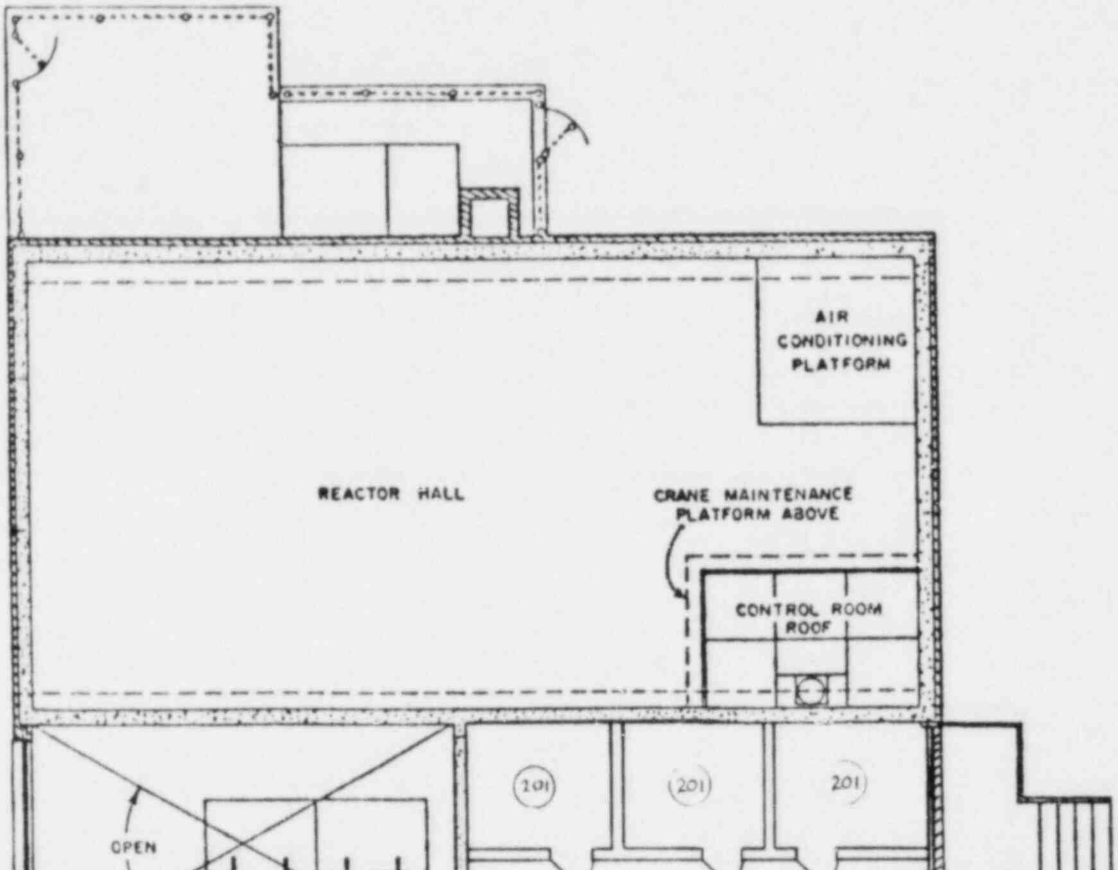

Figure 4.4 Second floor plan for the University of Florida training reactor building

As shown in Figure 4.2 the reactor is an elongated octagon located in the center of the 30-ft dimension of the room, 12 ft from the west end. It has an east-west axis of 20 ft 4 in. and a north-south axis of 15 ft 6 in.

4.2 Reactor Core

The reactor core contains 4 cadmium swing-arm-type control blades and up to 24 fuel elements of 11 plates each. Up to 6 of these elements may be replaced with partial elements (total of 10 plates). Each partial element is composed of either nonfueled (dummy) or fueled plates. Dummy plates and fueled plates are not mixed in one partial element. The UFTR core currently contains 21 fueled and 3 dummy elements. The 24 elements are contained in 6 aluminum boxes arranged in 2 parallel rows of 3 boxes each. Each box contains four fuel elements. The two rows are separated by a 30-cm-wide graphite island. The tops of the fuel boxes are covered by shield plugs and/or gasketed aluminum covers secured to the top of the boxes as shown in Figure 4.5. The devices function to prevent physical damage to the fuel, minimize evaporation/leakage of water from the top of the fuel boxes, and minimize entrapment of argon in the coolant water for radiological protection purposes. The two rows of fuel boxes are surrounded by a 5- by 5- by 5-ft reactor-grade graphite assembly. A massive concrete biological shield surrounds the graphite assembly.

4.2.1 Fuel Elements

The fuel elements are the general MTR type. Each plate is a sandwich of aluminum cladding around a uranium-aluminum alloy "meat." The fuel meat, containing nominally 14.5 g of U-235, is a sheet 0.04 in. thick. The cladding is 0.015 in. thick. Each fuel plate is 25.625 in. long, 2.845 in. wide, and 0.07 in. thick. The overall dimensions of a fuel element are 25.625 in. by 2.845 in. by 2.14 in. A 0.137-in. space is provided between each plate for coolant flow.

4.2.2 Reactivity Control Systems

Reactivity control of the UFTR is provided by four swing-arm-type cadmium control blades as shown in Figure 4.6A. Magnesium shrouds are provided to protect the blades as shown in Figure 4.6B. The blades move in a vertical arc within the spaces on either side of the two center fuel boxes. Three of the blades are used as shim or safety blades, and the other one is used as a regulating blade.

All the blades are driven by motors mounted outside the biological shield. The blades are connected to independent drive mechanisms by electromagnetic clutches. Upon receiving a scram signal, the clutches are deenergized and all four blades are automatically dropped by gravity. All blades can be simultaneously inserted or individually inserted; however, a prohibit circuit allows only one blade to be withdrawn from the reactor at a time. The blades are designed and maintained to become fully inserted in a time of less than 1 second from the time of receiving the scram signal. However, the blade withdrawal time is limited to a minimum of 100 seconds.

Reactor shutdown also can be accomplished by draining the water moderator/coolant from the core. This can be done by two independent means. The first involves operating the primary coolant system dump valve, which opens under

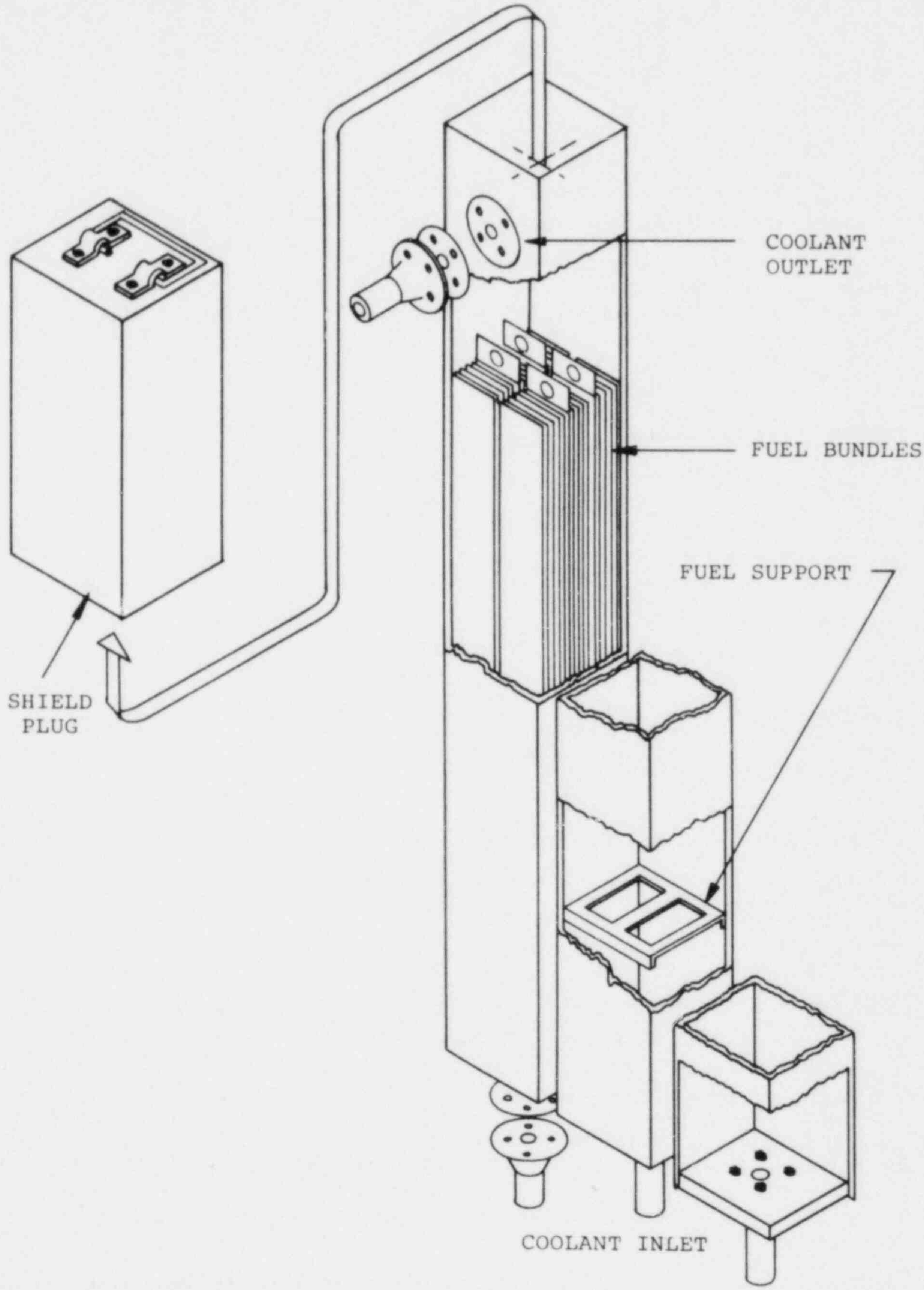

Figure 4.5 Isometric of UFTR fuel boxes

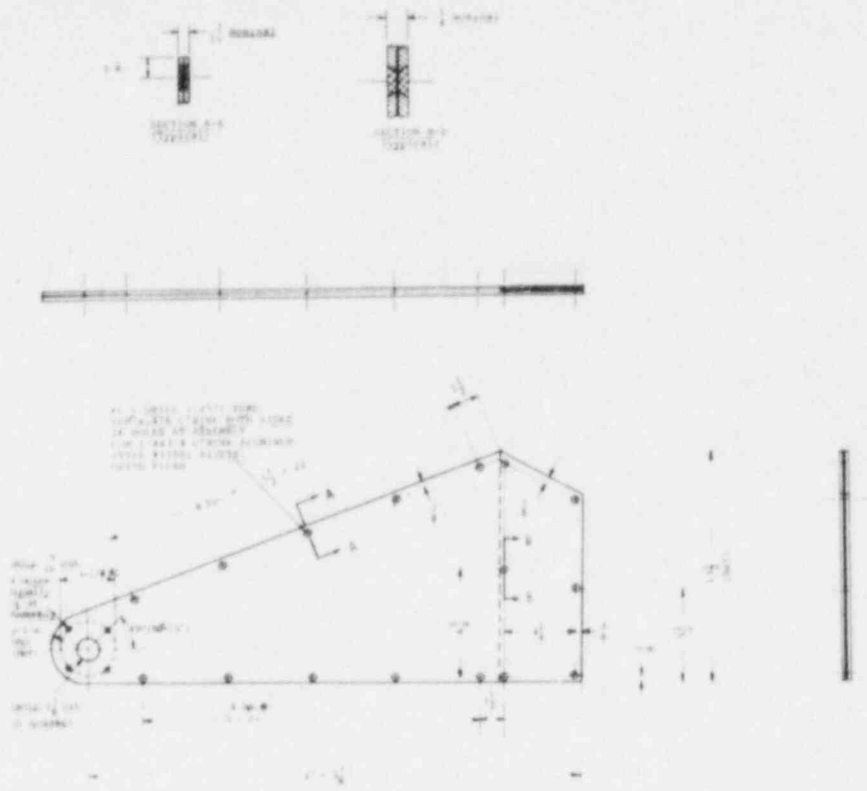

Figure 4.6A UFTR control blade assembly

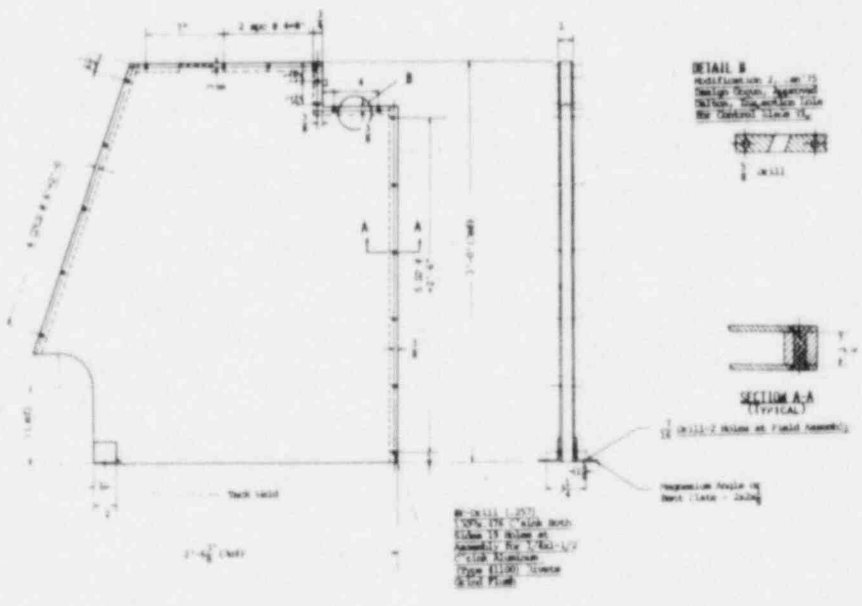

Figure 4.6B UFTR control blade shroud assembly

full-trip conditions. The second involves breaking the rupture disc, which occurs when system pressure is 2 psi above normal operating pressure.

4.2.3 Conclusion

The staff has reviewed the information regarding the reactor fuel and reactivity control systems and found that design and performance capability of the components is adequate to ensure the safe operation of the reactor during the proposed licensing period.

4.3 Shielding

Biological shielding is provided around the UFTR to minimize the exposure to any individual working with the reactor to levels as low as reasonably achievable (ALARA) and as specified by 10 CFR 20. The biological shielding is made of cast-in-place barytes concrete with 3- to 6-ft-thick sections carefully located to minimize radiation exposure and a shield tank located adjacent to the reactor core.

Access to the ends and top of the reactor is provided by removal of ordinary concrete blocks cast to fit the openings. These blocks, weighing up to 4500 lb each, may be handled by means of the overhead bridge crane. The arrangement of these movable blocks is illustrated in the section views of the UFTR shown in Figures 4.7 through 4.9.

The staff concludes that the shielding of the UFTR is adequate to protect the public health and safety and the environment.

4.4 Dynamic Design

4.4.1 Characteristics

The principal design and performance characteristics for the UFTR reactor are summarized in Table 4.1. The UFTR self-limits the maximum power and energy release in an accidental nuclear excursion or loss-of-coolant accident (LOCA) by means of either the negative moderator void coefficient or the negative temperature coefficient. These inherent nuclear control features are effective even if the control rods or the instrumentation (both of which are part of the reactor protection system) fails or if the operator mistakenly or deliberately violates established operating procedures and rules. The Technical Specifications limit the maximum excess reactivity for the UFTR with the present fuel loading to 2.3 percent $\Delta k/k$. Calculations have shown that instantaneous reactivity insertions of this magnitude will not raise the temperature of the fuel plates to the melting point. Therefore, there is no danger of fission product release or damage to the structural integrity of the reactor as a result of a large addition of reactivity into the system. Reactivity accidents are discussed further in Section 14.

Reactivity control is provided by the three control blades and one regulating blade described in Section 4.2.2. Table 4.1 shows the corresponding reactivity worths for each blade, along with the maximum allowed reactivity addition

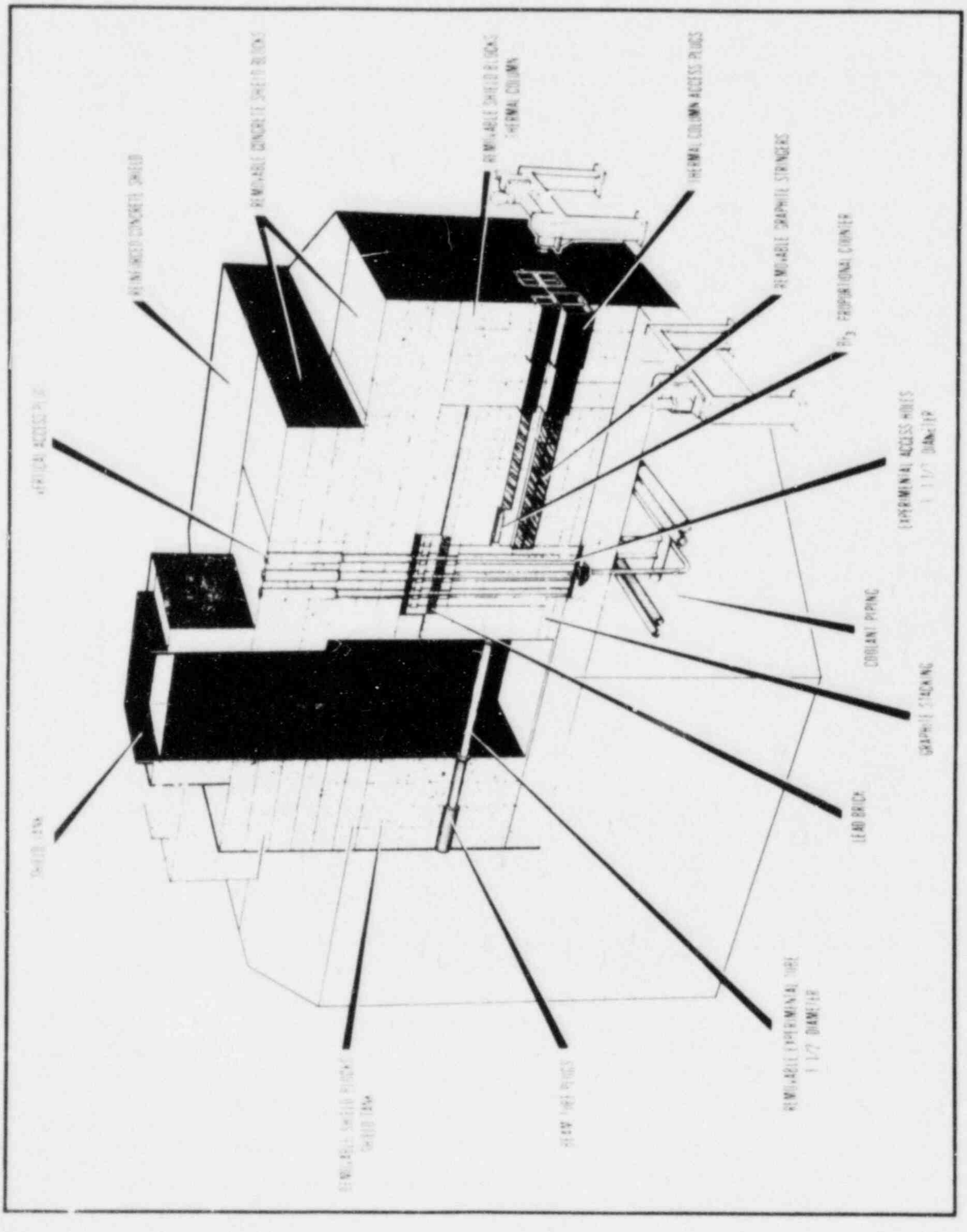

Figure 4.7 Longitudinal section diagram of UFTR

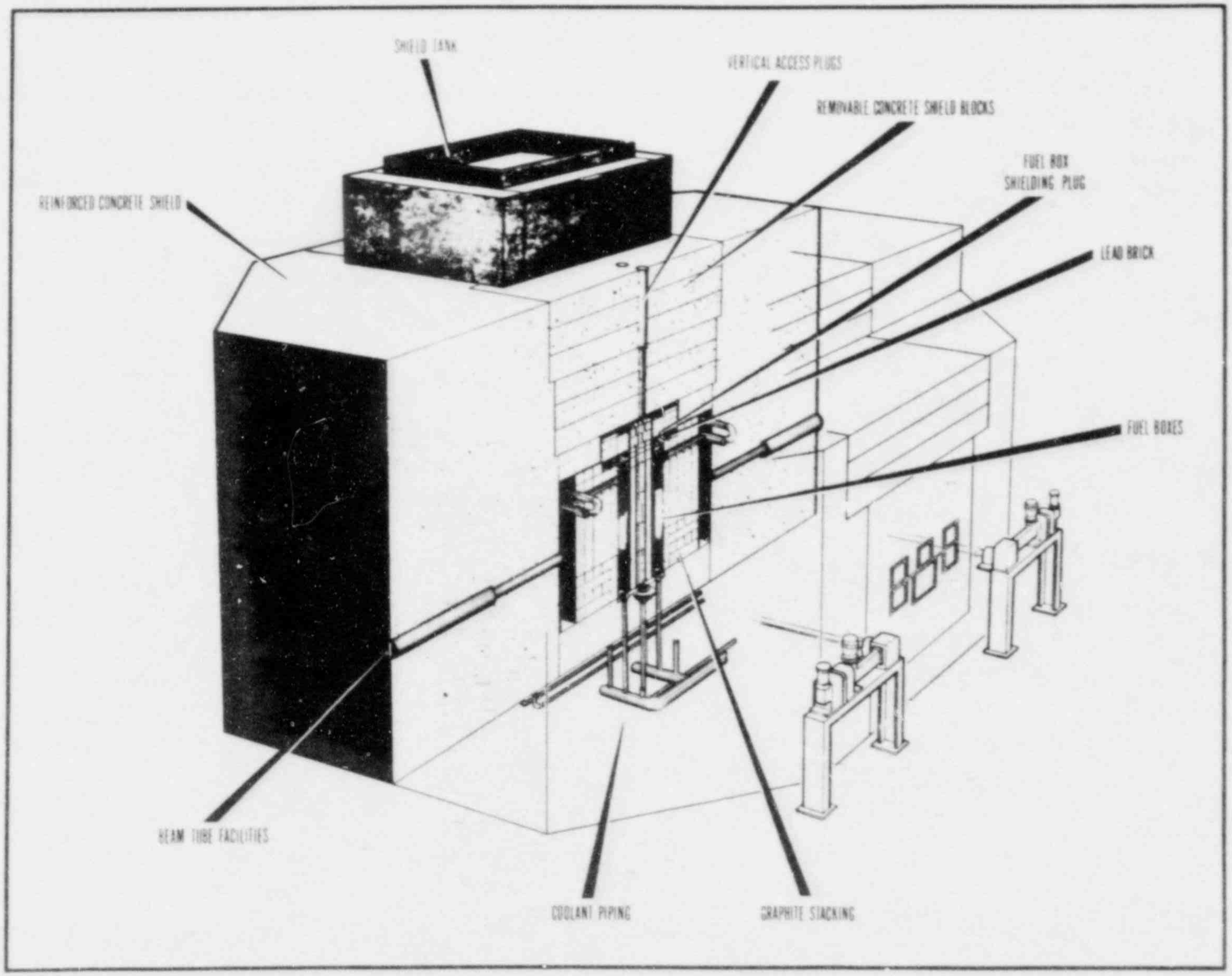

Figure 4.8 Transverse section through the UFTR core center

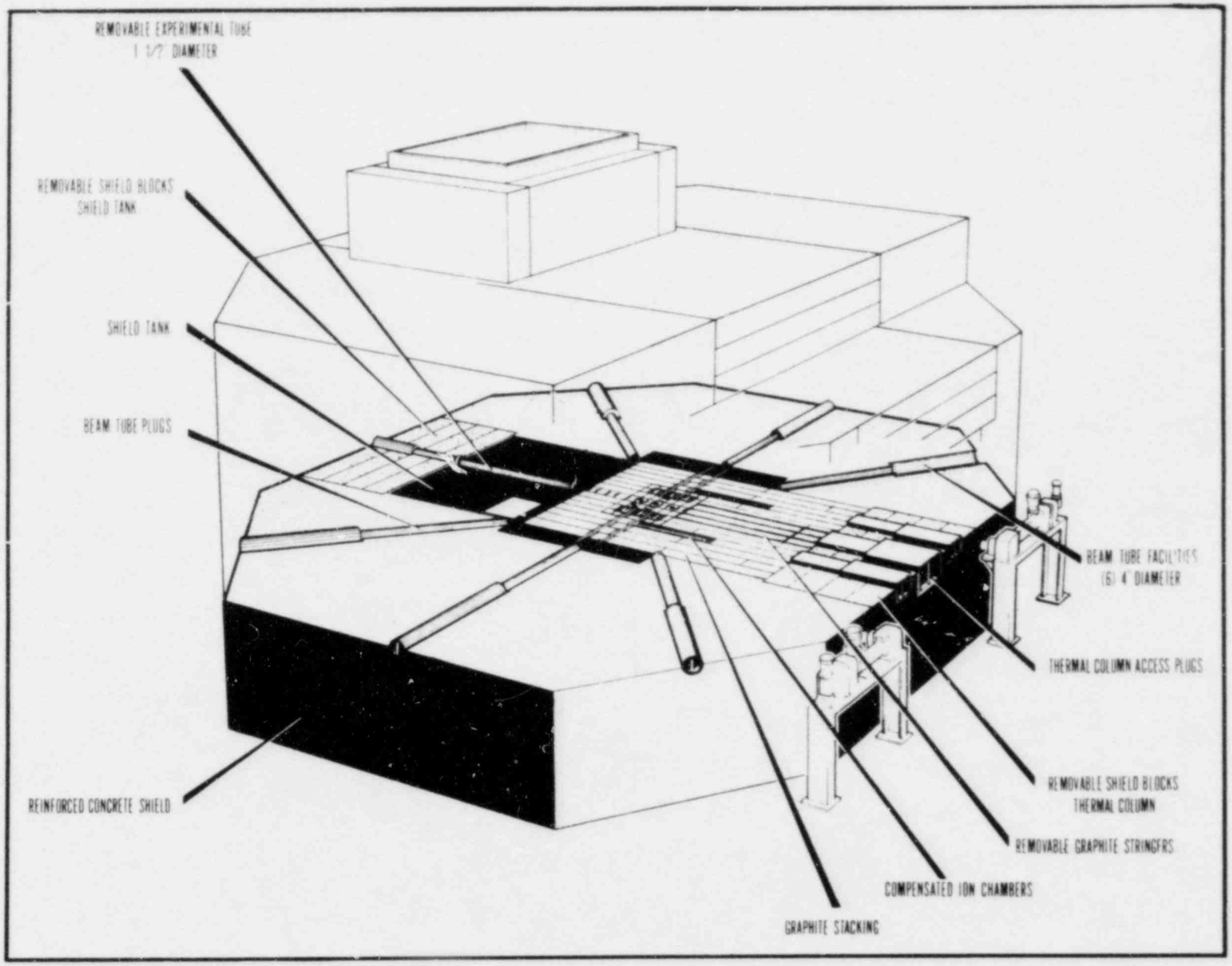

Figure 4.9 Horizontal section diagram of UFTR at beam tube level

Table 4.1 Present UFTR characteristics

General features	
Reactor type	Heterogeneous
Licensed rated power level	100 kW thermal
Maximum thermal flux level in center vertical port at 100 kW	1.5×10^{12} n/cm^{2}sec
Excess reactivity (at 72°F)	1.0% $\Delta k/k$
Clean, cold critical mass	3.07 kg U-235
Effective prompt neutron lifetime	2.8×10^{-4} sec
Uniform water void coefficient	-0.2% $\Delta k/k$/% voids
Temperature coefficient	-0.3×10^{-4}% $\Delta k/k$ °F
U-235 mass coefficient	0.4% Δk/% U-235
Startup source	Sb-Be $\leq$ 25 curies or PuBe $\leq$ 10 curies
Reflector	Graphite (1.6 gm/cm^3)
Moderator	H_2O and graphite
Fuel plates	
Fuel	93% enriched, U-Al
Fuel loading	3343.94 g U-235
Plate thickness	0.070 in.
Plate width	2.845 in.
Plate length	25.625 in.
Water channel width	0.137 in.
Aluminum to water ratio (volume)	0.49
"Meat" composition	14.05 w/o U
Coolant	
Type	H_2O
Flow (at 100 kW)	40.5 gpm
Equilibrium inlet temperature (100 kW)	86 ±2°F
Equilibrium outlet temperature (100 kW)	103 ±2°F
Control blades	
Type	Cd, swinging vane, gravity fall
Number	3 safety; 1 regulating
Insertion time	$<$ 1 sec
Removal time	100 sec (minimum)
Blade worth, safeties	#1 - 1.5% $\Delta k/k$ #2 - 1.3% $\Delta k/k$ #3 - 2.1% $\Delta k/k$
Blade worth, regulating	0.91% $\Delta k/k$
Reactivity addition rate, maximum allowed	0.06% $\Delta k/k$/sec

Table 4-1 (Continued)

Shield (concrete)	
Sides, center	6 ft, cast, barytes
Sides, ends	6 ft. 9 in., cast, barytes
Middle	Barite concrete blocks
Top	5 ft 10 in.
End	3 ft 4 in.
Experimental Facilities	
Thermal column, horizontal	60 in. x 60 in. x 56 in. high
Thermal column, vertical	2-ft diam x 5 ft; H_2O or D_2O
Shield test tank	5 ft x 5 ft x 14 ft high
Experimental holes	5 vertical, 4 in. x 4 in. 3 vertical, 1 1-1/2 in.
Foil slots	16 vertical, 3/8 in. x 1 in.

rate for the UFTR. The shutdown margin available with the most reactive blade out is approximately 2.7 percent Δk/k. As described in Section 4.2.2, the control blades are "fail safe" in the sense that they will drop into the core by gravity in the event of a loss of electrical power.

4.4.2 Evaluation

The basic Argonaut reactor design was based on reactor tests by Argonne National Laboratory and SPERT/BORAX destructive testing. The BORAX and SPERT data have been extensively used in the safety analyses of Argonaut reactors.

Because four of the five existing U.S. Argonaut-type reactors are currently being reviewed for a license renewal, the staff requested Pacific Northwest Laboratory (Battelle) and Brookhaven National Laboratory to evaluate the consequences of reactivity insertions in these reactors. Battelle reviewed the BORAX and SPERT information and used the latest mathematical models to extrapolate the effects on the current Argonaut fuel (NUREG/CR-2079).

The applicant's analysis indicates that it would take an instantaneous reactivity insertion of greater than 2.4 percent to raise the fuel temperature to a level where melting may occur. The UFTR reactor currently licensed by the NRC is limited to a maximum excess reactivity of 2.3 percent Δk/k ($3.54). The Battelle study and analysis considered an instantaneous reactivity insertion of 2.6 percent Δk/k ($3.90). The energy spike resulted in an increase in the average temperature for all the fuel plates of 240°C. Assuming an initial fuel temperature of 79°C, the resultant average fuel temperature would be 319°C. If 25 percent of the energy burst were assumed to be absorbed by just the centermost fuel plates, the temperature rise in those plates would be 388°C. Adding this conservatively high temperature rise to the initial operating temperature of approximately 79°C, the cladding temperature reaches a maximum of approximately 467°C. This is almost 200°C below the melting point of the aluminum cladding and more than 170°C below the melting point of the fuel meat.

The Brookhaven analysis, discussed in detail in Section 14, is consistent with the above analysis.

Although the Technical Specification limit on total excess reactivity is 2.3 percent $\Delta k/k$, the current worth of the UFTR core, which contains the original 93 percent enriched fuel, is approximately 1.0 percent $\Delta k/k$. The absolute reactivity worth of any single experiment is limited to a maximum of 0.6 percent $\Delta k/k$. The total absolute reactivity worth of all experiments is limited to 2.3 percent $\Delta k/k$. The required minimum shutdown margin with the most reactive control blade (2.1% $\Delta k/k$) fully withdrawn is 2 percent $\Delta k/k$. The shutdown margin for the UFTR with the other three blades in place in a core having the maximum authorized excess reactivity would be approximately 1.4 percent $\Delta k/k$ (1.5% + 1.3% + 0.9% - 2.3%). Therefore, to comply with the minimum shutdown margin limit and be able to perform experiments of positive reactivity worth, the normal core loading must be less than the maximum authorized. For a core with approximately 1.0 percent $\Delta k/k$ excess reactivity, the minimum shutdown margin would be about 2.79 percent $\Delta k/k$.

4.4.3 Conclusion

From the applicant's analysis and a review of the information obtained from the BORAX/SPERT tests and the Battelle analysis described above, the staff has concluded that the limitations on excess reactivity of 2.3 percent $\Delta k/k$ in the UFTR core (indicated in the Technical Specifications) provide assurance that there can be no excess reactivity incident that will pose a threat to the health and safety of the public. In addition the staff concludes that the 2 percent $\Delta k/k$ shutdown margin is sufficient to ensure the reactor can be adequately shut down under all conditions.

5 REACTOR COOLANT SYSTEM AND CONNECTED SYSTEMS

In general, the primary coolant system transfers the heat from the reactor to the heat exchanger. This heat is removed by the secondary coolant system to the storm sewer with no mixing of water between the two systems.

5.1 Primary Coolant System

The primary coolant loop and purification system of the UFTR are shown schematically in Figure 5.1. The UFTR has a reactor core capacity of 33 gal. A 65-gpm (rated) pump circulates demineralized water at a rate of 40 gpm. Primary coolant is stored in a 200-gal storage tank, which is 6 times the capacity of the core. Makeup water is obtained by demineralizing city water.

The primary pump circulates water through the heat exchanger, up and around the fuel bundles, out an orifice near the top of the fuel boxes and back to the storage tank. A flow-measuring instrument, which is located on the exit line from the heat exchanger, transmits a flow indication and a scram signal to the control console. A reactor trip will occur at a flow rate less than 30 gpm and in the event of loss of power to the primary coolant pump.

Each of the six fuel box inlet and discharge lines includes a thermocouple which transmits to a continuous sequential recorder in the control room. The information from this thermocouple is supplied to the reactor protection system with an alarm set point at 150°F and a reactor trip at 155°F. This safety measure prevents reactor operation under conditions such as restriction or reduction of primary coolant flow, reduction or restriction of secondary coolant flow, a malfunction of the heat exchanger, excessive reactor power, or the malfunction of a thermocouple.

One flow switch located in the coolant return line also will actuate a reactor trip signal in the event of loss of primary coolant flow; this serves as a backup to the low-flow reactor trip in the fill line previously discussed and also monitors the integrity of the piping.

The "dump valve" (see Figure 5.2) is a solenoid-operated valve which opens automatically when a scram signal is generated by the control system, allowing water in the fuel boxes to drain into the coolant storage tank. Only nuclear-type scrams open the dump valve (high power, fast period, loss of neutron chamber high voltage loss of electrical power, console switch OFF). These scrams are termed <u>full trips</u>.

A sight glass located on the north wall of the reactor room allows visual check of the reactor core water level. An electric level switch located behind the sight glass is wired to the reactor protection system actuating a reactor trip when the water level in the core falls below preset limits.

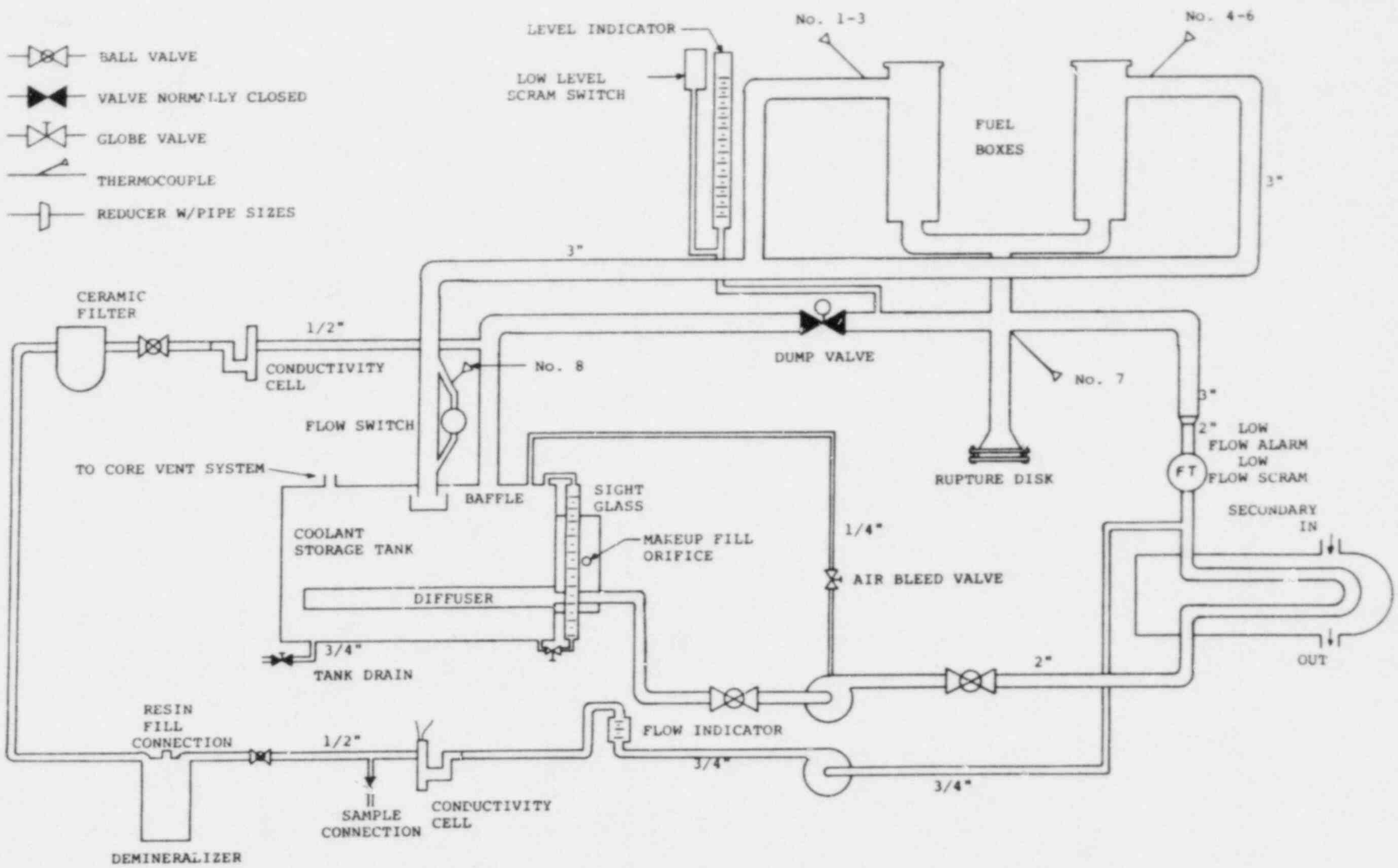

Figure 5.1 Schematic of UFTR primary coolant loop and purification system

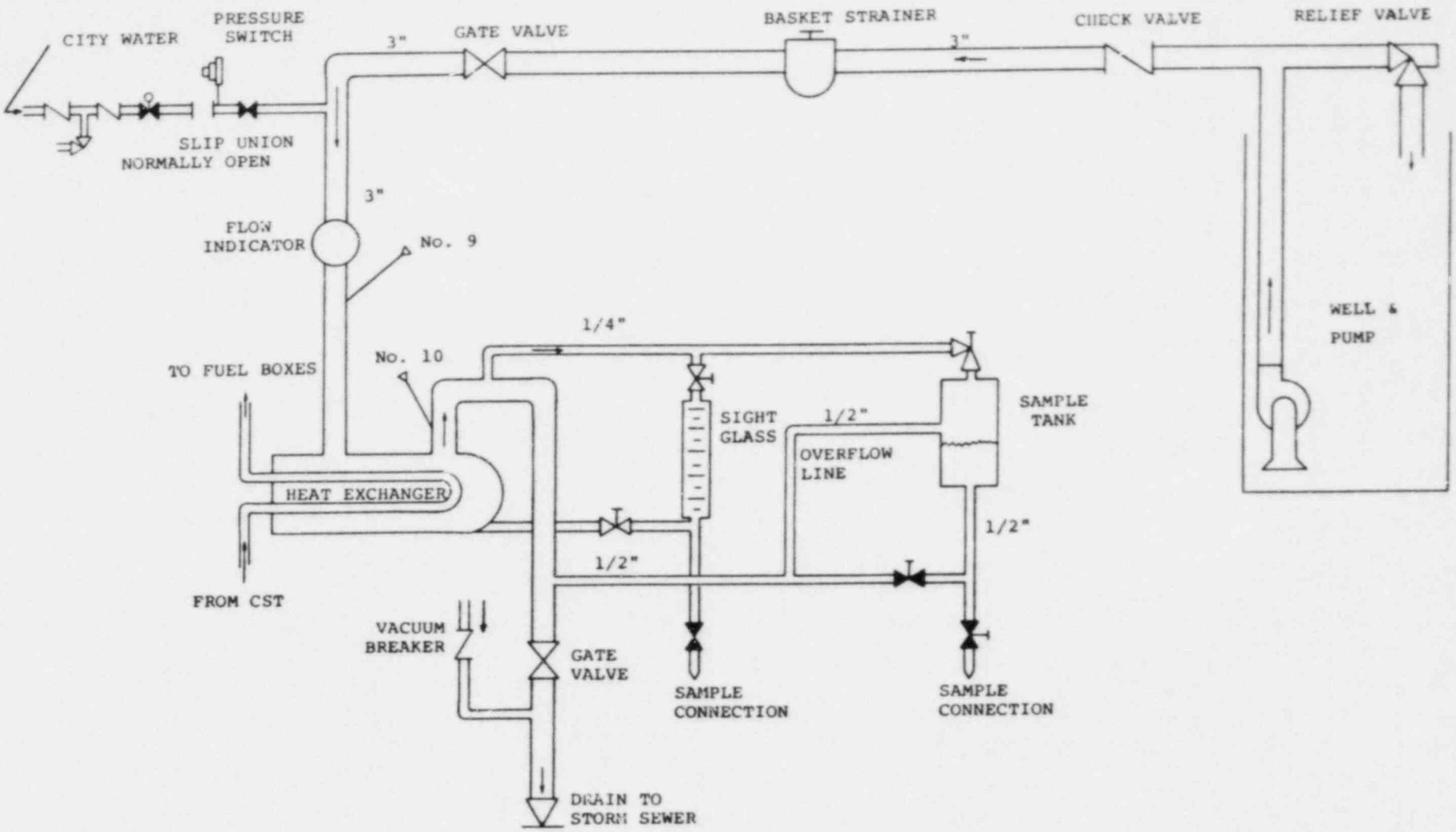

Figure 5.2 Schematic of UFTR secondary water cooling system

The system is further protected by a graphite rupture disc set to burst at 7 psi, 2 lb above the normal operating pressure. Should a power excursion occur, this diaphragm will rupture causing the water from the core to be drained into the equipment storage pit, shutting down the reactor.

5.1.1 Heat Exchanger

The heat exchanger located in the equipment storage pit is a stainless steel water-to-water N stamp heat exchanger rated at 1 MW. With from 150 to 250 gpm of well water through the shell side and 75 gpm of reactor coolant water through the tube side, the system is capable of removing up to 500 kW thermal heat load. The tubes are welded to the tubesheet to minimize leakage.

5.1.2 Primary Water Makeup System

The demineralized water makeup system consists of two demineralizers in series filled with amberlite, H-OH, nuclear grade resin. The unit has a temporary hose connection to the coolant storage tank, supplying makeup coolant whenever necessary.

5.1.3 Primary Purification System

The primary purification system loop is included in Figure 5.1; it is supplied with a separate pump allowing continuous purification flow. The purification pump is interlocked with the primary coolant pump in a manner that prevents its operation when the primary coolant pump is running. The feed of the primary coolant pump is sufficient to maintain a flow through the purification loop when it is in operation.

The purity of the primary coolant is monitored by the use of a resistivity bridge set up to accept two conductivity cell signals--one before the demineralizer and one after the ceramic filter. The location of the purification system and a schematic showing its components as depicted in Figure 5.1. The Technical Specifications limit the resistivity to a minimum of 400,000 ohms; however, records indicate that a resistivity of approximately 10^6 ohms is typical for normal operation.

5.2 Secondary Cooling System

Secondary cooling water for the UFTR is required by the Technical Specifications for operation at power levels above 1 kWt and can be obtained from two sources. A 200-gpm well is used as the principal source, and city water is used as a backup system or for training purposes. Secondary cooling water is discharged to the storm sewer.

5.3 Conclusions

For the above reasons, the reactor primary and secondary cooling systems are determined to be adequate for all operating conditions allowed by the license and Technical Specifications.

6 ENGINEERED SAFETY FEATURES

The only engineered safety systems relate to the ventilation system for minimization of effluents released to the atmosphere and the coolant-moderator dump valve to quickly make the core subcritical in the event of a reactor scram.

6.1 Ventilation System

The UFTR facility provides confinement for reactor effluents. All doors into the reactor cell are provided with seals and are kept closed during reactor operation, which allows the cell to be maintained at a negative pressure and permits control of the flow of air into the cell.

Reactor room exhaust air flows around the reactor structure (entraining any radioactive gaseous or particulate effluents) and into the suction of the vent system. This air then passes through roughing and absolute filters and into the stack. A 12,000-cfm blower at the stack dilutes this vent flow with outside air. The primary coolant storage tank is also vented into this system upstream of the filter banks. A motor-operated damper is installed upstream of the vent blower and is interlocked with the dilution blower motor so that the damper automatically closes when the dilution blower is deenergized, preventing any undiluted air effluent to be discharged through the stack. Loss of power to either the vent or dilution blower motors automatically causes the reactor to scram.

The staff concludes that the ventilation system and its interlocks to the reactor scram system are adequate to ensure the safe operation of the facility and that no significant amount of radioactivity will be released to the environment.

6.2 Dump Valve

The dump valve is a solenoid-operated valve that opens automatically when a scram signal is generated by the control system, allowing water in the fuel boxes to drain into the coolant storage tank. Only nuclear type scrams or full trips open the dump valve. Without water in the core to serve as a moderator, the reactor shuts down. The fuel elements are then cooled by air convection and any evaporation of ambient moisture on the plates.

There is no need for an emergency core cooling system for this reactor since fuel temperatures during operation get up to only 120-160°F, cooling occurs through natural air convection, and water is not required for cooling when the reactor is shut down. Part of the safety of its operation depends on rapidly emptying the water (moderator) from the core if the reactor scrams, shutting down the reactor. This is a second scram system independent of the safety and regulating blades of the reactivity control system.

The staff concludes that the dump valve system interlocks with the reactor scram system are adequate to ensure the safe operation of the facility and that no significant amount of radioactivity will be released to the environment.

7 INSTRUMENTATION AND CONTROLS

7.1 Instrumentation Systems for Operation of UFTR

The reactor instrumentation monitors several reactor parameters and transmits the appropriate signals to the regulating system during normal operation; during abnormal and accident conditions, it transmits signals to the reactor trip and safety systems.

The minimum number and types of channels for operation of the reactor are

Channel	No. operable
Safety channels	2
Linear w/auto controller	1
Log N and period channel	1
Startup channel	1
Rod position indicator	4
Coolant flow indicator	1
Primary coolant temperature indicator	6
Secondary coolant temperature indicator	1
Core coolant level	1
Ventilation system	1
Core vent annunciator	1
Exhaust fan annunciator	1
Exhaust fan rpm	1

7.2 Nuclear Instrumentation

Two channels of neutron instrumentation provide the UFTR with separate, independent neutron monitors of reactor power level from 10^{-3} W to 150 percent of rated power.

Nuclear instrumentation channel 1 takes the output from a B-10 proportional counter and a fission chamber in the reactor core and produces a signal proportional to the logarithm of reactor power, which is displayed and recorded. The derivative of this signal, which is the inverse of the reactor period, is displayed and is the source of the reactor period scram. The fission chamber output also goes through a linear amplifier and then to a power level display on a linear scale ranging from 1 to 150 percent of rated power. This linear output causes the reactor trip at 125 percent of rated power.

Nuclear instrumentation channel 2 uses the output from two core ion chambers. The output from one ion chamber (compensated) goes through a picoammeter to a linear power recorder. This linear power indicator also is used by a servo-amplifier as a part of the automatic reactor control circuit used during steady-state operation. The output from the other ion chamber (uncompensated) goes through a linear amplifier to a power indicator. This amplifier output also initiates a reactor trip at 125 percent power.

In addition to the power and period scrams, a scram also is initiated when the high voltage to the nuclear instrumentation channel 1 chamber or the channel 2 ion chambers drop to 10 percent below normal.

7.3 Reactor Reactivity Control

Reactor reactivity control is accomplished by three safety-control blades and a regulating blade. These blades are raised one at a time by the operator at the control console, which has blade position indicators. The four control blades are driven by magnetic couplings. When the reactor is scrammed, power is interrupted to the magnets and the blades fall by gravity into the core. There is a control blade inhibit system that prevents blade withdrawal under the following situations:

(1) Test switches are not in "operate" position to ensure the monitoring of the neutron level increases as the blades are raised.

(2) There are insufficient neutron source counts to ensure the proper function of the source level instrumentation. A minimum of 2 counts per second is required by the Technical Specifications.

(3) A multiple blade withdrawal interlock is provided to prevent exceeding the reactivity addition rate authorized by the UFTR Technical Specifications.

(4) A period of 10 seconds or faster prevents control blade withdrawal.

(5) Power is raised at a period in the automatic mode faster than 30 seconds. The automatic controller drives the regulating blade down until the period is slower than 30 seconds.

Another facet of reactor reactivity control is the automatic control system. When the operator switches to the automatic mode, the output of the nuclear channel 2 picoammeter is compared with the desired power level and any difference causes movement of the regulator blade through a servo system.

7.4 Core-Cooling-Related Instrumentation

The instrumentation system that ensures adequate cooling of the reactor core consists of the following elements:

(1) A primary coolant flow monitor in the fill line trips the reactor when flow falls below 30 gpm.

(2) A flow switch located in the primary coolant return line to the storage tank serves as a backup to (1) above.

(3) A sight glass in view of the operator indicates core water level. An electric switch located behind this sight glass causes a reactor scram when the water level falls below a preset level.

(4) Thermocouples are located at the discharge of each fuel box and in the bulk coolant lines into and out of the reactor. These temperatures are recorded and any thermocouple indication over 150°F causes an audible alarm; an indication of 155°F causes a reactor scram.

(5) A water level switch at the top of the shield tank causes a reactor scram when the level drops below a preset value.

(6) Flow indicators in both secondary cooling systems scram the reactor at low flow indications.

(7) A relay trips the reactor when power to the secondary cooling system deep-well pump is interrupted when it is being used for secondary cooling.

7.5 Additional Safety-Related Instrumentation Systems

In addition to instrumentation dedicated to safe reactor operation, the following safety-related systems are also installed:

(1) The reactor vent system has a stack monitoring system which consists of a Geiger-Mueller (GM) detector, a log rate meter, and a strip chart recorder. It also provides a log rate meter with an alarm setting capability for the different powers of operation, monitoring the gross activity concentration of radioactive gases in the room effluent air entering the stack.

The GM detector and preamplifier transmit a signal to the control room to monitor the gamma activity of the effluent in the downstream side of the absolute filter before dilution occurs. If the activity reaches an alarm level preset in the control room, the monitor will activate an audible alarm in the control room and the reactor operator will shut down the reactor. The data from this monitor are continuously recorded.

(2) A complete area radiation monitoring system consisting of three independent area monitors with remote detector assemblies and interconnecting cables, strip chart recorders, and count rate meters are available. The signals from these detectors are sent directly to the log count rate meter and recorder, monitoring the gamma activity in the reactor room. Each detector has an energy-compensated Geiger counter with a built-in Kr-85 check source that can be operated from the control room. The stack monitor and three area monitor modules in the control room are equipped with test switches and green "No Fail" lights that go out if the modules do not receive signal pulses from the detectors. Floating battery packs supply power to the units in the event of electrical power loss.

The continuous reactor cell air monitoring system is equipped with a flow indicator, a strip chart recorder, and an audible and visible alarm setting. The monitor is a lead shield, compact airborne particulate Geiger counter. A backup air monitoring system with moving filter capabilities is available for reactor cell monitoring in case the above system is not operable. It also is used for special operations.

The portal monitoring system outside the air lock leading from the reactor cell contains eight channels of Geiger tube detectors providing complete head-to-foot coverage of beta-gamma radiation plus individual alarm lights for each channel. An audible alarm will be activated any time the preset radiation field limit is exceeded.

7.6 Types of Reactor Scrams (Trips)

There are two types of reactor scrams. One is induced by the nuclear instrumentation whereby all control blades fall into the core and the coolant in the fuel boxes is dumped into the storage tank. The second type of scram is induced by process instrumentation. With this type of trip, the control blades fall into the core, but the primary coolant is not dumped.

The conditions that cause a nuclear instrumentation trip are

(1) Fast period (3 seconds or less)

(2) High power, safety channel 1 (125 percent) or safety channel 2 (125 percent)

(3) Reduction of high voltage to the neutron chambers of 10 percent or more

(4) Turning off the console magnet power switch

(5) Loss of electrical power

Process instrumentation scrams are caused by

(1) Loss of power to the reactor vent blower system

(2) Loss of power to the reactor vent diluting system

(3) Loss of power to the secondary system deep-well pump when operating at or above 1 kW and using this system for secondary cooling

(4) Dropping of secondary flow below 60 gpm (normal flow is 200 gpm, alarm at 140 gpm) when operating at or above 1 kW when using the deep well for secondary cooling

(5) Dropping of secondary flow below 8 gpm when at or above 1 kW when using city water for secondary cooling

(6) Drop in water level of the shield tank (about 4 in.)

(7) Loss of power to primary coolant pump

(8) Reduction of primary coolant flow (normal flow is 40 gpm, trip at 30 gpm); flow sensor is located in the fill line

(9) Loss of primary coolant flow (return line)

(10) Reduction of primary coolant level

(11) High-temperature primary coolant return from the reactor (alarms at 150°F, trips at 155°F)

(12) Manual reactor trip button depressed

7.7 Conclusion

The staff concludes that the types of instrumentation included in the UFTR facility, plus the limits and performance requirements of the Technical Specifications, ensure that the reactor can be operated safely.

8 ELECTRIC POWER SYSTEM

The UFTR is a research reactor currently licensed to operate at only 100 kW (thermal), and it does not generate electric power. Since the UFTR does not generate electrical power, there is no impact on the power grid. The reactor is designed to shut itself down safely through operation of the reactor safety systems in case of loss of primary coolant.

8.1 Offsite Power System

During operation, the electric power requirements for the UFTR reactor will be supplied by the regional utilities servicing the University. The reactor facility requires power of 115 V ac at 60 cycles for the reactor console and auxiliary equipment and 230 V ac at 60 cycles for all motors.

Since the system is fail safe, no auxiliary power is needed for the operation of post-shutdown safety systems. The loss of electrical power drops out the scram relays and deenergizes the magnetic clutches to trip the reactor by dropping the control rods under gravity completely into the core. Therefore, there is no need to consider offsite sources of emergency power.

8.2 Onsite Power System

The electrical supply to the reactor and console is supplied by the Regional Utility System of Alachua County. This offsite power is supplied on site to operate the various nonnuclear reactor safety and monitoring instrumentation channels. These channels are all dependent on the utility system ac power for proper operation. However, these channels will only be needed during operation to perform monitoring and nuclear instrumentation trip functions. In a loss-of-power situation, the nuclear instrument channels and the fail-safe nature of the control rod system provide the proper trip and shutdown of the reactor.

Interruptions in power from the regional utilities system are quite common. Although such trips associated with loss of power are bothersome from a training or research standpoint, such a loss of power has no bearing upon the safe operation of the UFTR system. When power is lost, the reactor automatically trips. Since these interruptions in power are usually of short duration, there is no simple remedy for the loss-of-power problem. Therefore, secondary power systems are not considered in this report.

8.3 DC Power Systems

The radiological area monitors and stack monitors are powered by 24-V dc power supplies backed up with a "floating" battery pack. In the event of loss of ac power, the battery packs will automatically power the monitors with the ability to maintain operation for at least 12 hours. This provides the system with an ability to monitor radiation activity in the reactor area at all times. Emergency lighting is located throughout the reactor building and the reactor cell. There is a two-lamp emergency spotlight within the reactor cell to provide light in the event of a loss of power. The security system itself also is equipped with a battery power supply to maintain operation in the event of a loss of all electrical power.

8.4 Diesel Electrical Power

Vital UFTR systems are connected to an ac diesel electric generator located in the rear of the reactor building. The diesel generator will provide automatic backup electrical power for all vital reactor systems, including the radiation monitoring and physical protection systems as well as emergency lighting.

No credit is taken for the backup electrical diesel generator for safety analysis considerations.

8.5 Conclusion

The staff concludes that the primary and emergency electrical power provided to the reactor facility are adequate to ensure safe operation and shutdown of the reactor.

9 AUXILIARY SYSTEMS

The auxiliary systems considered significant in the operation of the UFTR facility are the fuel-handling and storage system, the air conditioning and ventilation system, and the fire protection system.

9.1 Fuel Handling and Storage

Unirradiated fuel plates, as received from the fuel fabricator, are stored in cadmium-lined drawers in a fire-resistant combination safe. No more than 56 plates can be placed in a drawer.

Irradiated fuel is removed from the reactor in a lead transfer cask, using the facility's 3-ton bridge crane, and placed in one of the 27 dry, steel-lined storage pits in the concrete floor of the reactor room. Padlocked shield plugs are installed in the pits over the fuel. If it is necessary to inspect the irradiated fuel, it is placed in the shield tank for inspection and subsequently moved to a fuel storage pit.

9.2 Heating and Air Conditioning System

The reactor cell is completely air conditioned with a recirculating-type system to provide an atmosphere suitable for reliable operation of electronic instruments and for human comfort. The air conditioning unit is rated at 6000 cfm with 130,000 Btu/hr cooling capacity. Although the system is designed to use up to 1500 cfm of outside air, the louvers are closed to maintain a slightly negative pressure in the reactor cell resulting in approximately 200 cfm of outside air intake. The total conditioned air delivery is 4600 cfm to the reactor room and approximately 1400 cfm to the control room. This 6000 cfm of air is delivered in a closed recirculation system at a dry-bulb temperature of 75°F and 50 percent relative humidity, summer and winter.

All inlet and circulated air is filtered through a 2-in.-thick, dry, spun glass, cleanable-type roughing filter capable of removing particles of 5 microns or larger in size with an efficiency of 85 percent or better. The inlet air duct is provided with a motor-operated damper to close the duct whenever the unit fan is not operating.

9.3 Core Vent System

The reactor vent system prevents diffusion of radioactive gases or particulate matter into the reactor room during reactor operation by maintaining a slight negative pressure in the reactor cavity relative to the reactor cell.

The air surrounding the reactor core structure is withdrawn through a rough and an absolute filter and directly discharged to the stack where it is diluted with about 12,000 cfm of outside air before being released to the atmosphere.

The room exhaust air is used to ventilate the reactor structure. The vent flow from the reactor cavity is adjusted within limits conducive to minimization of releases of Ar-41 to the environment and exposures to personnel within the reactor cell.

9.4 Fire Protection

Since the construction materials of the reactor, such as concrete blocks, brick, and floor tile, are predominately nonflammable, a serious fire is considered to be very unlikely.

Conventional smoke and fire detection equipment is available throughout the reactor building. Three CO_2 extinguishers are located in the reactor cell and one pressurized water fire extinguisher in the control room. A fire hose and five extinguishers are located outside the control room in the ground foyer.

An automatic fire alarm system monitors the reactor cell and the reactor building continuously and is provided with emergency battery backup. This system alarms at the Campus Police Station and is made up of two ionization smoke detectors, two heat detectors, seven pull stations, and six horns. Operation of this system will turn on the emergency light in the reactor room (for illumination).

9.5 Emergency Power System

The emergency power system is described in Section 8.4.

The diesel generator is a turbo-charged D-6 Caterpillar-type generator and is available for emergency conditions in case of a power failure. The system is designed to come on line automatically within 10 seconds after the power failure, operating 10 to 11 minutes after power recovery, as a backup power supply in case of repeated failure within this short period of time. The automatic starting system provides for three startup events within a 90-second period, after which it goes into a manual standby condition with the option of a manual startup or a reset mechanism for startup.

Fuel oil storage provisions consist of an underground tank with a capacity of approximately 2000 gal. Fuel oil transfer is accomplished by an electrical motor system with a manually operated hand-pump as a secondary backup. Cooling of the system is provided by a radiator assembly. Inspection of the diesel generator system is carried out on a routine weekly basis by the Plants and Grounds Division of the University of Florida; preventive maintenance is provided by the Ring Power Company-Ocala Division.

9.6 Conclusions

The design of the UFTR auxiliary systems is adequate to ensure safe and reliable operation of the facility and to minimize generation and exposure to Ar-41 production and emissions.

10 EXPERIMENTAL PROGRAMS AND FACILITIES

10.1 Experimental Programs

In addition to being used as an adjunct to other facilities in the education and training program of the university, the UFTR supports various types of experimental programs of the staff and students. Most of the experimental work uses the neutrons available from the reactor to induce radioactivity in various materials. These irradiated materials may be foils or small samples to evaluate reactor parameters or material composition (neutron activation analysis) or as tracers in engineering or biomedical studies.

All proposed new experiments must be reviewed by the UFTR Radiological Safety Officer, who functions as a member of and in cooperation with the Institute's Radiation, Health, and Safeguards Committee to

(1) Ensure that accidents causing changes in composition and geometry of the experiments will not cause positive changes or ramps in reactivity that might place the reactor on unsafe periods

(2) Provide assurance of mechanical integrity, chemical compatibility, and adequate protection against any other potential hazard

The use of explosives is not permitted in the UFTR complex.

10.2 Experimental Facilities

The experimental exposure facilities and instrumentation ports are described below. The overall physical arrangement of these exposure facilities is shown in Figure 4.2. More detailed sketches of the size and orientation of these exposure facilities are presented in Figure 4.7 for the center vertical port and horizontal throughport and in Figure 4.9 for the other major experimental exposure facilities.

Sixteen vertical foil slots, 3/8 in. by 1 in., are placed at intervals in the graphite between the fuel compartments and are used for flux mapping. The foils can be installed by lifting off the top shield, placing the foil holders, replacing part of the shield as deemed necessary for irradiation, and removing it to recover the foils. Shield removal is accomplished by the use of the bridge crane.

There are three vertical experimental holes, 2, 1-3/4, and 1-1/2 in. in diameter, which are centrally located with respect to the six fuel compartments. The maximum neutron flux is available in the vicinity of these ports; therefore, they may be used for irradiating samples or for installing an oscillator. Mated openings are provided in the upper shield for convenience in the use of these holes.

A thermal column is provided in the east face of the reactor having four 4-in. by 4-in. removable stringers. The horizontal thermal column is 60 in. wide by 60 in. long by 56 in. high; the vertical thermal column comprises an area 2 ft in diameter by 6 ft long, filled with H_2O or D_2O as necessary for experimental purposes.

Six other horizontal openings, 4 in. in diameter, are located in the center plane of the reactor as shown in Figure 4.7. These horizontal holes (or ports) may be fitted with collimators to allow neutron beams to escape, or with other equipment for the irradiation of special samples.

A water tank is placed against the west face of the reactor opposite the thermal column and is shielded on the outer three sides by concrete. This 5-ft-wide by 5-ft-long by 14-ft-deep shield tank can be used to perform shielding experiments or for the irradiation of large objects. A horizontal aluminum pipe passes through the shield tank outer wall and is welded to the inner wall; it is provided to allow the extraction of a neutron beam to the reactor west face. The tube allows the insertion of the east-west throughport (EWTP). The EWTP, or horizontal throughport, is a horizontal tube 20 ft long with an inside diameter of about 1.88 in. If the shield tank is not needed for experiments, it can be removed after draining by lifting it out with the crane and other equipment installed in that area.

10.3 Conclusion

The design of the experimental facilities together with the limitations for experiments delineated in the Technical Specifications ensure proper and safe experimental programs.

11 RADIOACTIVE WASTE MANAGEMENT

The principal radioactive waste generated by operation of the UFTR is activated gases (primarily Ar-41). A limited volume of radioactive solid waste, primarily resins, is generated by reactor operations, with some additional solid waste produced by the associated research programs. Limited quantities of radioactive liquid waste are generated by normal reactor operations. In addition, small amounts of radioactive liquid waste are also independently generated in other locations within the Nuclear Science Center and transferred to the liquid waste holdup tanks.

11.1 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. This solid waste generation typically has contained a few millicuries of radionuclides per year.

The solid waste is collected by the Health Physics staff and held temporarily before being packaged and shipped to an NRC-approved disposal site in accordance with applicable NRC and Department of Transportation regulations.

11.2 Liquid Waste

Normal reactor operations produce limited volumes of radioactive liquid waste. In addition, some of the research activities conducted within the UFTR complex are capable of generating such waste. Liquid waste drains in the reactor room and equipment areas drain into holdup tanks; thus, there is no direct flow into the UF sanitary sewer system. All potentially contaminated liquids are collected in these holdup tanks. When nearly full, the individual tanks are isolated, mixed, and sampled. The sample is dried, and the residue is analyzed for radioactive content by standard techniques. If the concentrations of radioactive material in the tank are less than the levels specified by 10 CFR 20, the contents are discharged to the sanitary sewer system, where it is further diluted by an average daily flow of 4.5×10^6 gal of sanitary sewage. The quantity of liquid radioactive waste released from the UFTR and its associated laboratories has been less than several hundred μCi/yr. This facility has the capability to solidify small volumes of highly contaminated liquid for shipment offsite as solid waste.

11.3 Airborne Waste

Airborne waste consists of gaseous Ar-41 and potentially activated dust particles. No fission products escape from the fuel cladding during normal operations.

The radioactive airborne waste is produced by neutron irradiation of air and airborne particulate materials as they are drawn through the reactor.

Leakage of these activated gases and particles into the reactor room is prevented by drawing air from the room, through the reactor, and out the exhaust stack. This air-handling system is equipped with a filter system that collects more than 99.9 percent of the particulate matter. Thus, during normal operations no measurable radioactive particulates will be released into the air effluents from the UFTR stack. These filters are eventually disposed of as solid radioactive waste.

A monitoring system with readout in the control room measures the flow rate and the radioactive gaseous concentration in the effluent. This air stream is diluted with 12,000 cfm of outside air before it is released to the atmosphere. As part of the reactor safety system, any loss of power to the reactor vent or dilution system fan will cause a reactor trip.

Analysis of air samples collected from the reactor vent stream indicates a material having a gamma with an energy of 1.29 MeV and half-life of 110 minutes These values are characteristic of Ar-41. Further analysis indicates a Ar-41 production rate that results in a concentration of 6.7×10^{-6} μCi/cm^3 per kW of reactor power. Thus, at full power (100 kW) the actual concentration at the top of the stack is 1.88×10^{-5} μCi/ml. Applying a factor of 200 to account for dispersion between the release point and the nearest potential receptor reduces the concentration to 9.4×10^{-8} μCi/ml. At the current concentrations of Ar-41 emissions, the reactor is permitted by the State of Florida to operate 235 equivalent full-power hours per month.

This constraint, limiting the number of equivalent full-power hours of operation, ensures that the UFTR cannot exceed the limits specified in 10 CFR 20, Appendix B, Table II, for release to unrestricted areas. It should be noted, however, that with an average of 172 equivalent full-power hours of operation per year (over the last 5 years), that the actual total operation for 1 year is about one-half of that allowed for a single month.

When actual Ar-41 releases are averaged over an extended period of time, such as a year, the Ar-41 concentration then is only a small fraction of the maximum permissible concentration specified in 10 CFR 20 for unrestricted areas. Because the natural tendency of gases is to diffuse and decrease in concentration with distance from the source, combined with the random direction of the wind, the annual exposure to the public will result in only a few millirems to any one individual in the vicinity of the reactor effluent plume.

Using the methodology in Regulatory Guide 1.109, the highest dose to population is considered to be a distance of 0.1 mi from the discharge stack. Using an annual release of 129.5 Ci, the β-γ dose is 3.55 mrems/yr. Whole body dose is 1.8 mrems/yr and the skin dose is 2.61 mrems/yr. These are all less than 1/100 of the allowable limits in 10 CFR 20.

11.4 Conclusion

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

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

12 RADIATION PROTECTION PROGRAM

12.1 Summary

The UF has developed a structured radiation safety program with an adequate Health Physics staff and appropriate radiation detection equipment to determine, control, and document occupational radiation exposures at its reactor facility. In addition, the UFTR monitors liquid and airborne effluents at the points of release to comply with applicable regulations. The UFTR also has developed an environmental monitoring program to verify that radiation exposures in the unrestricted areas around the UFTR are well within regulations and guidelines and to confirm the results of calculations and estimates of environmental effects resulting from UFTR research programs.

12.2 ALARA Commitment

The UF administration has formally established the policy that all operations are to be conducted in a manner to keep all radiation exposures as low as reasonably achievable (ALARA). All proposed experiments and procedures at the UFTR are reviewed for ways to minimize 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.

12.3 Health Physics Program

12.3.1 Health Physics Staffing

Independent of the UFTR line of responsibility, full-time Health Physics staff at the University of Florida consists of one professional and three technicians. In addition, the UFTR licensed operators are health physics qualified and perform radiation protection duties, as assigned. One of the full-time reactor operators is assigned the health physics responsibilities and performs the routine surveys of the UFTR.

The onsite staff has sufficient training and experience to direct the radiation protection program for a research reactor. This 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 medical school and many radioisotope laboratories. However, the staff believes that the UFTR Health Physics staff is adequate for the proper support of the research efforts within this facility.

12.3.2 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 UFTR facility. These procedures identify the interactions between the Health Physics staff and the operational 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.

12.3.3 Instrumentation

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

12.3.4 Training

All reactor operators are trained in health physics and certified by the Radiation Control Officer. 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. All reactor operators are given an examination on health physics practices and procedures at least every 2 years. All of the above-mentioned radiation safety training is provided by the Health Physics staff.

12.4 Radiation Sources

12.4.1 Reactor

Sources of radiation directly related to reactor operations include radiation from the reactor core, ion-exchange columns, startup sources, spent fuel, filters in the water and air cleanup systems, and radioactive gases (primarily Ar-41).

The reactor fuel is contained within aluminum cladding. Radiation exposures from the reactor core are reduced to acceptable levels by concrete shielding and a water-filled shield tank.

The ion-exchange resins and filters are routinely changed before high levels of radioactive materials have accumulated, thereby minimizing personnel exposure.

Personnel exposure to the radiation from chemically inert Ar-41 is limited by prompt removal of this gas from the reactor and its discharge to the atmosphere where it diffuses greatly before reaching occupied areas.

12.4.2 Extraneous Sources

Sources of radiation that may be considered as incidental to the normal reactor operation but are associated with reactor use include radioactive isotopes produced for research, activated components of experiments, and activated samples or specimens.

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.

12.5 Routine Monitoring

12.5.1 Fixed-Position Monitors

The UFTR complex uses three fixed-position area radiation monitors, one constant air particulate monitor, and one constant stack effluent monitor. All monitors have adjustable alarm set points and the area radiation monitors and stack effluent monitor readout in the control room on a continuous basis. On special occasions, such as unstacking reactor shielding, a three-channel particulate air monitor with a continuous moving filter is utilized.

12.5.2 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 must be surveyed and tagged by Health Physics personnel.

12.5.3 Special Work Permits

Occasionally, one-of-a-kind, short-term, low-to-intermediate-risk tasks such as simple but nonroutine maintenance activities in potential radiation or contamination areas are performed under a special work permit (SWP). Each SWP requires documentation of the radiation safety review and concurrence of operations personnel. The SWP includes details of any special actions or precautions that are needed to minimize personnel radiation exposures and/or the spread of radioactive contamination.

12.6 Occupational Radiation Exposures

12.6.1 Personnel Monitoring Program

The UFTR 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 pocket dosimeters are used, and instrument dose rate and time measurements are used to achieve administrative occupational exposure limits of 75 mrems/wk to easily comply with applicable limits in 10 CFR 20.

12.6.2 Personnel Exposures

The UFTR personnel annual exposure history for the last 5 years is given in Table 12.1.

Table 12.1 UFTR personnel annual exposure history

	Number of individuals in each range				
Whole body exposure range (rems)	1977	1978	1979	1980	1981
No measurable exposure	4	8	5	2	6
Measurable exposure 0.1	7	2	3	7	2
0.1 to 0.25	1	0	0	1	2
$>$ 0.25	0	0	0	0	0

12.7 Effluent Monitoring

12.7.1 Airborne Effluent

As discussed in Section 11, airborne effluents from the reactor facility consist principally of activated gases. The effluent stream is filtered to remove most particulate material before discharge to the environment through the UFTR stack. The filter installation consists of a roughing filter to reduce the loading of the final filters and a high-efficiency particulate air (HEPA) filter that removes more than 99.9 percent of the solid matter in the air stream.

The stack gas monitoring system measures the radioactive gases discharged from the entire UFTR complex. The only identifiable radioative gas is Ar-41. The system consists of a detector positioned in the duct on the downstream side of the filter (before dilution takes place). The instrumentation readout consists of a meter and strip-chart recorder in the control room. The detector count rate is proportional to the amount of radioactive gases in the chamber and hence to the concentration in the air stream. High concentrations and detector failure activate alarms in the control room. This gaseous monitoring system is calibrated on a quarterly basis by positioning a Co-60 source in a specified location near the detector.

12.7.2 Liquid Effluent

The reactor generates very limited radioactive liquid waste during routine operations. However, leaks in the primary coolant system do have the potential for being released, and experimental activities associated with reactor usage also may generate radioactive liquids. All potentially contaminated liquids are collected in holdup tanks. Before release, each tank is sampled and analyzed, and liquids with low concentration of radioactivity are released directly to the sanitary sewer in accordance with 10 CFR 20.303. Higher concentrations of liquid waste may be diluted before release or held for radioactive decay.

12.8 Environmental Monitoring

The UFTR has developed a program to monitor radiation exposures above natural background radiation levels in the surrounding environment from both reactor operations and the research efforts of the complex.

A perimeter monitoring system of about seven stations has been established in the unrestricted areas around the reactor facility. Film dosimeters provided by a commercial supplier are used to measure the external radiation exposures.

12.9 Potential Dose Assessments

Natural background radiation levels in the Gainesville area result in an exposure of about 100 mrems/yr to each individual residing there. At least an additional 10 percent (approximately 10 mrems/yr) will be received by those living in a brick or masonry structure. Medical diagnostic exposures may add to this natural background.

Conservative calculations by the NRC staff based on the amount of Ar-41 released from the UFTR stack predict a maximum annual dose of less than 2 mrems in the unrestricted areas. The results of the environmental radiation dosimeters located near the reactor facility have been indistinguishable from the ambient background.

12.10 Conclusion

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

The staff concludes that the effluent and environmental monitoring programs conducted by UFTR 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 UFTR 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.

13 CONDUCT OF OPERATIONS

13.1 Organization Structure and Qualifications

13.1.1 Overall Organization

Responsibility for the safe operation of the reactor facility lies within the chain of command shown in Figure 13.1. Management levels, in addition to having responsibility for the policies and operation of the reactor facility, are responsible for safeguarding the public and facility personnel from radiation exposures and for adhering to all requirements of the operating license and Technical Specifications.

13.1.2 Reactor Staff

The reactor facility staff consists of two permanent faculty members, and a permanent five-member technical, technician, and secretarial staff.

13.2 Training

The staff has reviewed the applicant's operator requalification plans and concludes that they meet the requirements of 10 CFR 50.34(b)(7) and (8).

13.3 Emergency Planning

10 CFR 50.54 and Appendix E to 10 CFR 50 require that nonpower reactor applicants/licensees develop and submit Emergency Plans. The applicant submitted a plan that was developed following the recommended guidance in Regulatory Guide 2.6 (1979, For Comment) and guidance in ANS 15.16 (1978 Draft). However, both of these guides have been revised. (Revision 1 to Regulatory Guide 2.6 was issued for comment in March 1982; Draft 2 of ANS 15.16 was issued in November 1981.) The applicant has until November 3, 1982 to revise the Emergency Plan as necessary and submit it for staff review and approval.

13.4 Operational Review and Audit

The Reactor Safety Review Subcommittee reviews and approves new experiments and proposed alterations to the reactor. The subcommittee reviews and audits reactor operations for safety. It is composed of the Chairman of Nuclear Engineering Sciences, Radiation Control Officer, Reactor Manager, and two other members having expertise in reactor technology.

The subcommittee reviews

(1) Proposed changes in equipment, systems, tests, experiments, or procedures and determines that they do not involve an unreviewed safety question

(2) All new procedures and major revisions having safety significance, proposed changes in reactor facility equipment, or systems having safety significance

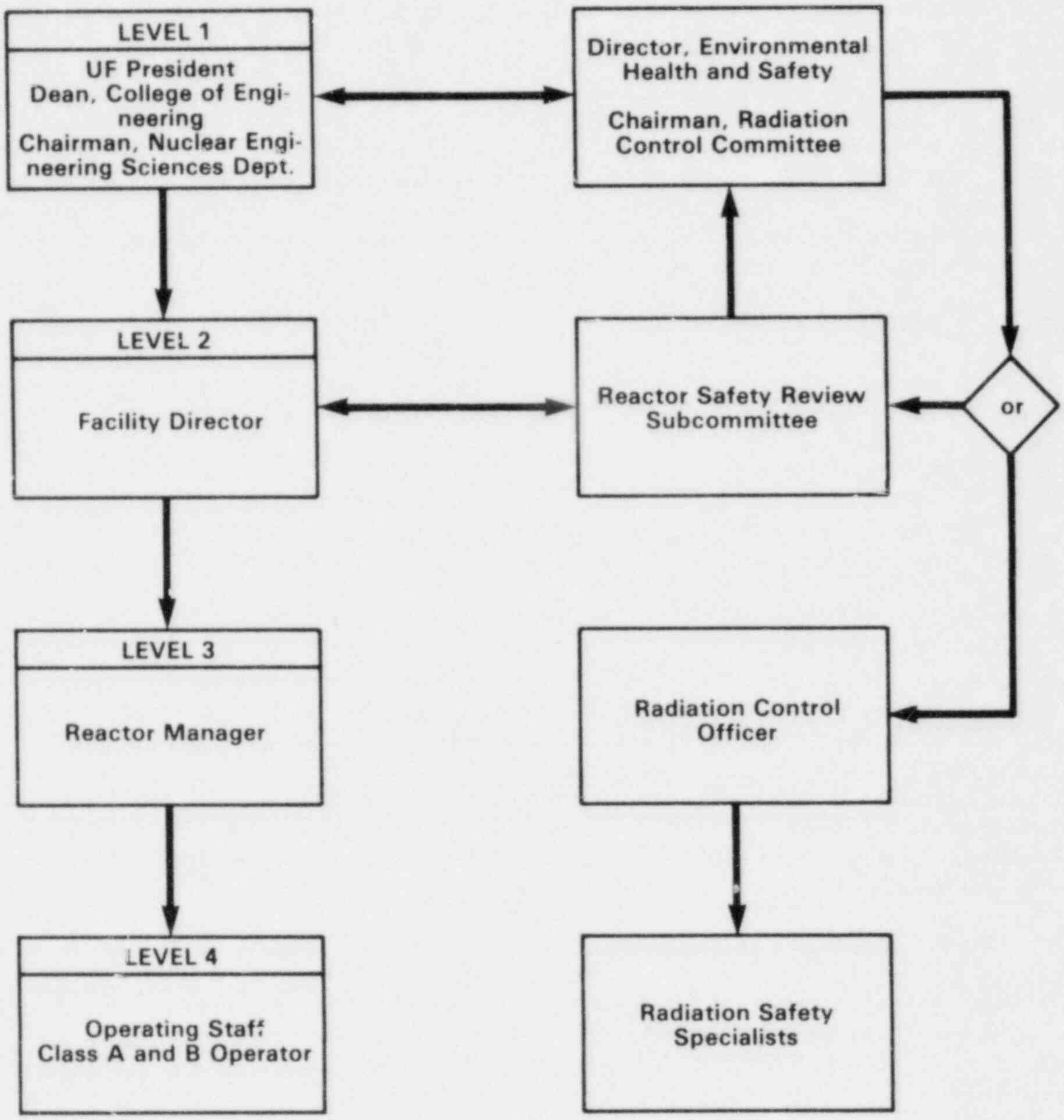

Figure 13.1 UFTR organizational chart

(3) Tests and experiments in accordance with Technical Specifications

(4) Proposed changes in Technical Specifications or license

(5) Violations of Technical Specifications, license, or procedures or instructions having safety significance, and remedial actions to ascertain that the violations do not recur

(6) Operating abnormalities having safety significance and audit reports

(7) Reportable occurrences listed in the Technical Specifications

(8) Audit functions

The subcommittee audit functions include selective (but comprehensive) examination of operating records, logs, and other documents.

13.5 Facility Procedures

The applicant has committed to the development of those procedures that are appropriate for continued safe operation (Application V/6-5). The current procedures are documented and maintained in the control room for ready access by reactor operations personnel.

13.6 Physical Security

The applicant, in accordance with 10 CFR 73, submitted a Physical Security Plan, which was approved in June 1981. The plan has been reviewed and a site visit was made to verify measures with the applicant. Based on its review and site visit, the staff finds that the applicant's Physical Security Plan is acceptable.

13.7 Reports and Records

Annual reports are submitted. The items included are: reactor operating experience; unscheduled shutdowns and corrective actions that have safety significance; changes to facilities, procedures, or experiments or tests that were carried out without prior NRC approval; amounts and nature of radioactive discharges to the environment; and any significant personnel exposures.

Special reports will be submitted as required by the Technical Specifications.

The staff's review of past UFTR violations, as described in the Investigation and Enforcement reports, indicated that none of the violations were safety related; they were all violations of procedural rules, guidelines, or Technical Specifications.

13.8 Conclusion

Based on the above descriptions the staff finds that the applicant's management structure and procedures are sufficiently developed to provide reasonable assurance of safe operation of the facility.

14 ACCIDENT ANALYSIS

As part of its evaluation of several pending license renewal applications for Argonaut research reactors, the staff requested three scientific laboratories to analyze the effects of accidents at those facilities with Argonaut reactors. The analyses included the effects on the core and on public health and safety that resulted from these hypothetical accidents. In addition, the staff considered the accident analyses presented by the applicant which were essentially identical to those presented in the original SAR. The reviews of those original hypothetical events were considered by the Atomic Energy Commission during the evaluation for the original construction and operating licenses.

Among all the accidents considered, the one postulated accident with the greatest effect on the environment and the unrestricted area outside the UFTR building is the dropping of a shield block onto the core resulting in severe mechanical damage to the fuel. For purposes of classification, the staff will call this the "core-crushing accident." In this event, it is assumed that the integrity of the cladding is completely lost from 11 irradiated fuel plates. A less severe accident of a similar nature is the "fuel-handling accident" in which the equivalent of one fuel plate completely loses its cladding. None of the other accidents analyzed posed a significant risk of clad failure. Thus, only the two accidents discussed above could result in the release of the noble gas and iodine fission products into the environment.

As discussed in more detail below, the core-crushing accident will be designated 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 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 described.

The staff requested Los Alamos National Laboratory to provide a thermodynamic analysis and evaluation of an Argonaut-UTR core that was assumed to be severely damaged (NUREG/CR-2198, Appendix B). The postulated damage might be the result of an earthquake or, as in this case, the dropping of a shield block onto the core. In addition, the NRC requested Pacific Northwest Laboratory (Battelle) to conduct an analysis and evaluation of various postulated accidents that could be considered credible for Argonaut-UTR reactors (NUREG/CR-2079, Appendix C). These postulated accidents, which will be discussed in more detail below, are

(1) Insertion of excess reactivity
(2) Explosive chemical reaction
(3) Graphite fire
(4) Fuel-handling accident

14.1 Excess Reactivity Insertion

The maximum rise in the fuel temperature following a reactivity insertion depends on the total energy released during the event and the heat transfer characteristics of the fuel. The maximum power level and, consequently, the total energy released are a function of the reactor period produced by the insertion. In turn, the period is determined by the amount of reactivity inserted and the prompt neutron lifetime.

The applicant's analysis indicates that an instantaneous reactivity insertion greater than 2.4 percent $\Delta k/k$ could raise the fuel temperature high enough to cause concern for fuel melting.

The Battelle study considered the instantaneous reactivity insertion of 2.6 percent $\Delta k/k$ ($3.90) into the core. This accounts for all the excess reactivity authorized by the license (2.3 percent $\Delta k/k$) plus an increase of 0.3 percent $\Delta k/k$ for the conservative assumption that the coolant/moderator is at 4°C, the temperature of maximum density for water. With an assumed prompt neutron lifetime of 0.14 ms, a pulse of 12 MW seconds was determined to be produced based on the SPERT I data. The calculated average fuel temperature was 500°C, and the maximum temperature of the hottest fuel plate was 590°C for the most conservative case. In this case, all of the energy released from the pulse was assumed to heat the fuel plates. It can be seen that these temperatures are well below the melting point of the fuel meat (640°C) and the aluminum cladding (660°C).

Brookhaven National Laboratory also analyzed a reactivity insertion accident. The RETRAN-01 computer code, which was benchmarked against the SPERT I data, was used. Starting with the slightly less conservative assumptions of a 0.188-ms prompt neutron lifetime and a 1.95 percent $\Delta k/k$ ($3.00) ramp reactivity insertion (0.25 second), a peak fuel temperature of 400°C was calculated. This is in good agreement with the Battelle results, allowing for the differences in initial assumptions.

Inasmuch as the UFTR has a prompt neutron lifetime of 0.28 ms and a permissible excess reactivity of 2.3 percent $\Delta k/k$ and the coolant is unlikely to reach 4°C in a Florida reactor, the fuel and cladding temperatures would be less than those indicated above.

Based on the above considerations, and the limitations in the Technical Specifications for excess reactivity not to exceed 2.3 percent $\Delta k/k$, the staff concludes that there is no credible nuclear excursion possible with the UFTR that could lead to fuel melting or cladding failure resulting from high temperature. Therefore, there is no mechanism for fission product activity to be released from the fuel to the environment as a result of a reactivity insertion accident.

14.2 Metal-Water Reaction

The only chemical reaction that can theoretically produce an explosion in the core at this reactor is the metal-water reaction between the aluminum in the fuel and the coolant water and the subsequent potential explosion of any generated hydrogen gas. For this reaction to occur fast enough to produce an explosion, the aluminum would have to be heated to very high temperatures (above the melting point) and/or be in the form of aluminum filings. As there is no mechanism to produce these high temperatures or this degree of abrasion, this situation cannot occur in this reactor.

Based on the above considerations, the staff concludes that there is reasonable assurance that rapid metal-water reactions will not occur in the UFTR.

14.3 Graphite Fire

A self-sustaining graphite fire requires oxygen, high temperature, and an ignition source to initiate combustion. The Battelle report postulated two scenarios that might involve a chain of events satisfying these three conditions.

The first scenario involves the failure of an experimental apparatus. It would be required that the experiment have a continuous flow of gas highly enriched in oxygen, be placed in the center graphite island of the core, and have components made of borosilicate glass. It is then supposed that the glass heats up sufficiently, because of the nuclear reaction within the glass ($^{10}B\ (n,\alpha)$-^{7}Li, Q = 2.8 MeV), to soften, release the oxygen supply, and ignite the graphite.

The second scenario involves a building fire. It requires that the concrete shield blocks be removed from around the core exposing the graphite, that considerable quantities of flammable material be in the reactor cell, that the reactor is left in this condition for several days, and that a building fire starts over the weekend when the reactor is unattended.

As the enclosed reactor allows only small volumes of air into the core, it is highly unlikely that the requisite of enriched air would be available to support combustion.

Given all the events that must occur before a graphite fire can be started and the magnitude and duration of a fire that would be needed to damage the fuel, the occurrence of a serious graphite fire seems unlikely. It is evident that in order for these scenarios to develop fully, they would have to be the result of deliberate actions and, thus, should not be considered as accidents. Therefore, based on the information above, the staff considers these scenarios to be such remote possibilities that they pose virtually no risk to the UFTR or the health and safety of the public.

14.4 Fuel-Handling Accident

This potential accident assumes that one fuel element is dropped during a core reload or other fuel-handling operation. The reactor would be shut down and drained during these operations so any fission product release would be directly to air.

For this event it has further been assumed that the reactor has been operating at 100-kW steady-state power for 30 days. The fuel transfer operations begin immediately following shutdown of the reactor and the actual fuel transfer accident results in such severe mechanical damage to the fuel element that it exposes fuel surface areas equivalent to stripping the cladding from one plate of an element and exposing its entire surface area.

The applicant has calculated the equilibrium fission product inventory for the core using the radio isotope buildup and decay (RIBD) computer code. It is assumed that 100 percent of the gaseous activity produced within the recoil range of the particles (1.37×10^{-3} cm) or 2.7 percent of the total gaseous activity instantaneously escapes from the fuel plate containing the maximum inventory. A conservative power peaking factor of 1.63 was used by the staff.

In addition, a breathing rate of 3.47×10^{-4} m^3/s and a short-term transport dilution factor of χ/Q of 10^{-2} s/m^3 at the reactor building wall was used.

The doses calculated by the staff to a person standing at the reactor building wall would be 32.7 mrems whole body dose from the noble gases and 4.35 rems to the thyroid from the iodine gases, as indicated in Table 14.1.

The assumptions used in these calculations are believed to be very conservative for the UFTR because

(1) It is highly unlikely that dropping a fuel element would be severe enough to cause the extent of fuel damage that would be equivalent to stripping the cladding from an entire fuel plate.

(2) It is not possible to start fuel transfer operations immediately after shutdown. The 4500-lb shielding blocks first must be removed from the structure to reveal the fuel elements in the core.

(3) The UFTR is not permitted to operate for the length of time needed for fission product equilibrium to be attained. The reactor may operate for a maximum of 23.5 MW-hours per month versus the 72 MW-hours assumed in the analysis.

(4) The UFTR does not normally shut down and immediately begin to manipulate fuel. Typically, the UFTR will shut down on a Friday, be down over the weekend, and commence fuel-handling operations on Monday.

Based on the discussion and analysis above, the staff concludes that if the equivalent of one fuel plate from the UFTR were to release all the noble gas and iodine fission products within the recoil range of the particles, the radiation doses to the public in unrestricted areas would be far below the limits stipulated in 10 CFR 100.

14.5 Core-Crushing Accident

As mentioned above, the core-crushing accident is the MHA for this reactor. In the study conducted by Los Alamos, the core was assumed to be severely crushed in either the vertical or horizontal direction. Some catastrophic event, such as an earthquake, or as postulated here, the dropping of a 4500-lb concrete shield block onto the core, initiates the sequence.

In this analysis, the reactor was assumed to be operating at 100-kW steady-state power with an equilibrium fission product inventory just before the accident. In addition, all the water is assumed to drain out of the core in less than 1 second. The maximum fuel temperatures calculated by Los Alamos are shown in Table 14.2. for various degrees of compaction. As can be seen, there will be no melting of the fuel cladding or fuel meat for any of the conditions considered.

Although the calculations indicate that the fuel or cladding will not melt, it is postulated that there could be severe mechanical damage to the fuel and a significant release of fission products.

Table 14.1 Activity and dose equivalents from maximum credible fuel-handling accident

Nuclide	Curies released[a]	Plume concentration, (Ci/m³[b])	Dose equivalent, (rem)	
^{131}I	0.42	1.2×10^{-6}	2.16	
^{132}I	0.68	1.9×10^{-6}	0.13	
^{133}I	1.09	3.0×10^{-6}	1.51	to thyroid
^{134}I	1.23	3.4×10^{-6}	0.11	
^{135}I	1.02	2.8×10^{-6}	0.44	
Total thyroid dose equivalent from radioiodines			4.35	
^{83m}Kr	0.854	2.37×10^{-6}	5.55×10^{-6}	
^{85m}Kr	0.211	5.85×10^{-7}	3.25×10^{-4}	
^{85}Kr	0.047	1.31×10^{-7}	5.41×10^{-5}	
^{87}Kr	0.409	1.14×10^{-6}	3.24×10^{-3}	
^{88}Kr	0.578	1.60×10^{-6}	3.80×10^{-3}	to whole
^{89}Kr	0.752	2.09×10^{-6}	7.48×10^{-3}	body
^{131m}XE	0.00195	5.42×10^{-9}	1.35×10^{-6}	
^{133m}Xe	0.153	4.25×10^{-7}	1.49×10^{-4}	
^{133}Xe	1.06	2.95×10^{-6}	6.56×10^{-4}	
^{135m}Xe	0.176	4.89×10^{-7}	2.62×10^{-4}	
^{135}Xe	1.06	2.95×10^{-6}	2.46×10^{-3}	
^{137}Xe	1.01	2.81×10^{-6}	8.70×10^{-3}	
^{138}Xe	1.00	2.79×10^{-6}	5.61×10^{-3}	
Total whole body dose equivalent from noble gases			32.7	

[a]Assumes no decay after shutdown and 2.7% release from a single fuel element containing 0.7% of the core inventory following operation for 72 MW-hours.

[b]Assumes 1-hour release time and $\chi/Q = 0.01$.

Table 14.2 Calculated fuel temperatures following an assumed compaction of the core

	Core condition		
Core air flow	Uncrushed	Crushed[a]	Crushed[b]
Natural convection	123°C	205°C	137°C
No airflow	358°C	254°C	187°C

[a]Coolant gap between fuel plates reduced to one-half nominal value (void fraction ≅ 75% of nominal).

[b]Coolant gap reduced to 25 percent of nominal (void fraction ≅ 50% of nominal).

Note: The melting temperature of the fuel meat is 640°C and that of the cladding is 660°C.

The staff assumed the damage to the core would be sufficient to expose fuel surface areas equivalent to stripping the aluminum cladding from 11 fuel plates (an entire fuel element). As was assumed in the fuel-handling accident, 100 percent of the gaseous activity pr[illegible]within the recoil range of the particles was immediately released fro[illegible] damaged plates. The breathing rate and χ/Q values again were assumed to be 3.47×10^{-4} m^3/s and 10^{-2} s/m^3, respectively.

Because 11 fuel plates are now assumed to be damaged, the activity released and, therefore the doses, are 11 times higher than in the fuel-handling accident. The doses calculated by the staff to a person standing at the reactor building wall would now be 0.36 rem whole body dose from the noble gases and 47.8 rems to the thyroid from the iodine gases.

Factors that make the above analysis conservative are:

(1) As mentioned above, the reactor would not attain the 100-kW equilibrium fission product inventory. Therefore, the actual decay heat and activity available for release would be smaller than that assumed.

(2) A high degree of structural damage was postulated with subsequent elimination of convection cooling. In all probability the core would not be uniformly crushed, so 100 percent of all channels will not be blocked to convective airflow. In this case the core temperatures would be even less than those calculated.

(3) The analysis assumes that the coolant in the core and plenums would drain in 1 second. Any delay in draining the core and any evaporation of water remaining in the core (either collected in crevices or clinging to the fuel or structure by surface tension, and so on) will provide additional heat sinks and further reduce temperatures below those calculated.

(4) It was assumed that the heaviest block was removed last and dropped onto the unprotected core. However, the shield assembly requires that the heaviest block be removed while the core is still structurally well protected. In any case, it is unlikely that this event would cause the extent of fuel surface area exposure postulated.

Based on the above conservative analysis, the staff concludes that a core-crushing accident will not cause melting of the fuel or the fuel cladding. In addition, it is concluded that the fission product release from such an accident will not result in radiation doses to the public in excess of the 10 CFR 100 limits.

14.6 Conclusion

Based on the references and analyses presented in the preceeding sections, the staff concludes that the possible credible accidents involving the UFTR do not pose significant hazard to the public or to the environment. The event with the greatest potential impact to the public is the loss of integrity of the cladding of one or more fuel plates, coupled with the loss of function of the room containment systems. No credible operational conditions of the reactor, including a rapid loss of all coolant, will lead to fuel-cladding failure. The conservative analyses discussed above give reasonable assurance that the operation of the reactor for the 20-year renewal period does not pose significant risk to the health and safety of the public.

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.

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 offnormal or accident events.

16 FINANCIAL QUALIFICATIONS

In support of the license renewal application, the UF supplied financial information which described sources of funds necessary to cover the estimated cost of operation plus the estimated costs of permanently shutting down the facility and maintaining it in a safe condition. The staff reviewed the financial information in the application and concluded that the UF possesses or can obtain the necessary funds to meet the requirements of 10 CFR 50.33(f).

Therefore, the applicant is considered financially qualified to operate the reactor for the time period requested.

17 OTHER LICENSE CONSIDERATIONS

17.1 Prior Reactor Utilization

The previous sections concluded that only a postulated fuel-handling accident or damage to the core could cause the failure of fuel and the consequent release of fission products. As explained in previous sections, the design of the reactor, the small amount of fuel, the low-power level and part-time reactor utilization prevent serious consequences of multiple failures, simultaneously or sequentially. Failure of two or more channels might prevent the shutdown of the reactor, but the inherent safety features of the Argonaut reactor do not provide a mechanism which can lead to catastrophic fuel-cladding failure.

The staff considered the effects of the past 20 years of reactor use on continued safe operation of the facility.

Significant factors that minimize the effect of past use are:

(1) The average UFTR utilization for the past 20 years has been less than 10 percent of the normal available time, and much less than experienced by some other reactors containing similar components (for example CP-5). Accordingly, operating parts received comparatively low wear. (It should be noted that power reactors' licenses are usually issued for a term of 40 years of full-time operation.)

(2) The operators of the UFTR perform regular preventive maintenance to discover potential failures or to preclude the failure of components. At appropriate times, components with degraded performance are replaced before failure occurs.

(3) The modifications described in Section 1.7 upgraded the reactor facility and ensure continued safe operation.

As the reactor has had such an infrequent use factor, and as the Technical Specifications are performance specifications and require periodic testing and/or calibration of components, there is no reason for concern about age of the reactor or the performance of its components.

17.2 Corrosion

The staff also considered changes in the rate of corrosion that may, for some unidentified reason, become a problem because of the age of the reactor.

As stated in the Technical Specifications, reactor coolant water is maintained at a very high purity of not less than 400,000 ohms of conductivity. Conductivity is monitored continuously and is checked each day before reactor startup. Corrosion products that may be circulating in the core and activated are removed by ion-exchange equipment. Inordinate or changing rates of buildup of this source of radiation in the core circulating system would be noted in the cleanup system monitors. Section 4.0 of the Technical Specifications stipulates a rate of testing and calibration that will ensure the operability, validity, and reliability of the equipment or instrument between testing and calibration intervals.

Moreover, the Technical Specifications, besides indicating intervals of testing and calibration, reflect the performance requirement of the equipment or instrumentation. If the performance of the reactor safety components do not meet the requirements in the Technical Specifications, the reactor is not permitted to operate or the reactor is shut down.

The combination of primary coolant water purity, testing frequency, instrumentation, purification equipment, and performance requirements in the Technical Specifications precludes corrosion products becoming a safety factor or detrimentally affecting performance of the reactor.

17.3 Multiple or Sequential Failures of Safety Components

Of the many accidents hypothesized for the UFTR, none produce consequences more severe than the postulated accident wherein the core is crushed and fission products are released into the reactor room. The only multiple mode failure possible would be all the rods stuck out of the core and the dump valve stuck closed. This would merely cause the water in the fuel boxes to boil and evaporate and, thus, reduce the reactivity until fission stops. Accordingly, other multiple or sequential accidents were not analyzed.

18 CONCLUSIONS

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

(1) The application for renewal of Operating License R-56 for its research reactor filed by the University of Florida, dated October 21, 1977, as amended, complies with the requirements of the Atomic Energy Act of 1954, as amended (the Act), and the regulations of the Commission set forth in 10 CFR, Chapter 1.

(2) The facility will operate in conformity with the application as amended, 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 AND INDUSTRY STANDARDS

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16. ABSTRACT (200 words or less)

This Safety Evaluation Report for the application filed by the University of Florida (UF) for a renewal of operating license number R-56 to continue to operate their Argonaut-type research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U. S. Nuclear Regulatory Commission. The facility is owned and operated by the University of Florida and is located on the UF campus in Gainesville, Alachua County, Florida. The staff concludes that the reactor facility can continue to be operated by UF without endangering the health and safety of the public.

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