UF | UNIVERSITY of FLORIDA

College of Engineering
UF Training Reactor Facility

PO Box 118300
Gainesville, FL 32611-8300
352-392-2104
bshea@ufl.edu

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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

10 CFR 2.109(a) New License
UFTR Operating License R-56, Docket 50-83

Subject: **UFTR Responses to Request for Additional Information (ML113560528)**

Attached are additional UFTR licensing basis documents in response to the RAIs dated January 6, 2012. The attached documents include Chapters 1, 3, 5, 6, 8 and 11 of the FSAR.

The UFTR licensing basis reconstitution efforts continue with remaining FSAR chapters and revised Operator Requalification program to be submitted at a future date.

This submittal has been reviewed and approved by UFTR management and by the Reactor Safety Review Subcommittee.

I declare under penalty of perjury that the foregoing and attached are true and correct to my knowledge.

Executed on February 18, 2014.

Brian Shea
Reactor Manager

cc: Dean – College of Engineering
Reactor Safety Review Subcommittee
Facility Director
Reactor Manager
Licensing Engineer
NRC Project Manager

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CHAPTER 1

THE FACILITY

Chapter 1 – Valid Pages

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1 The Facility

1.1 Introduction

This Safety Analysis Report (SAR) supports an application for license renewal to the U.S. Nuclear Regulatory Commission (NRC) by the University of Florida for the utilization of its modified Argonaut type reactor.

The reactor is owned and operated by the University of Florida for the purpose of training and research including neutron irradiation services for a wide variety of scientific applications. The reactor is known as the University of Florida Training Reactor (UFTR).

The information and analyses presented show that the UFTR can continue to be operated at 100 kW (thermal) rated power without undue risk to the health and safety of the public.

1.2 Summary and Conclusions on Principal Safety Considerations

Possible failures or accident situations have been analyzed and discussed in Chapter 13, including the effects of a rapid reactivity insertion, radioactive fission product release, and loss of coolant flow.

The inherent safety of the UFTR is based on strong negative temperature and void coefficients combined with limited excess reactivity which limit the peak power achievable, thus preventing fuel damage from credible reactivity events.

The operating power level of 100 kW results in a decay heat small enough that loss of cooling water does not result in fuel damage.

For the bounding case of the maximum hypothetical accident where fuel cladding is assumed to be removed, the resulting estimated doses to occupational workers and the general public are well within the annual limits given in 10 CFR 20.

1.3 General Description

The main University of Florida campus is located in the Southwestern quadrant of the greater Gainesville area approximately one mile from the historic center of the city (University Avenue and Main Street).

The Reactor Building is located on the main campus in the immediate vicinity of the College of Engineering and the College of Journalism. The Nuclear Sciences Building is annexed to the Reactor Building.

The UFTR is owned and operated by the University of Florida under the NRC License Number R-56 (Docket Number 50- 83). The UFTR is of the general type known as the Argonaut. The reactor is heterogeneous in design using low enriched uranium silicide-aluminum fuel elements in a two slab geometry. Water is used as a coolant and also as moderator. The fuel is contained in MTR-type plates assembled in bundles. The remainder of the moderator consists of graphite blocks which surround the boxes containing the fuel bundles and the water moderator. The biological shield is made of cast-in place concrete with additional sections of removable concrete shielding. The reactor has an authorized maximum steady-state thermal power of 100 kW.

Significant features of the reactor include:

- four swinging-arm type control blades;
- passive power excursion protection by primary coolant rupture disk; and
- numerous irradiation facilities including horizontal and vertical beam ports, thermal column, shield tank, and pneumatic transfer system utilizing a horizontal throughport.

1.4 Shared Facilities and Equipment

The UFTR is an integral part the Reactor Building and thus shares walls, water supplies, and main electrical supply. The ventilation systems, electrical distribution, and water distribution, are all separate.

1.5 Comparison with Similar Facilities

The UFTR has been operated since 1959 so considerable safe operating experience is available for review.

All similar Argonaut research reactors in the United States have been shutdown; they were located at the University of Washington, University of California at Los Angeles (UCLA), Iowa State University, and at Virginia Polytechnic Institute. Of these, the UCLA R-1 reactor design had the greatest similarity to the UFTR.

1.6 Summary of Operations

The UFTR utilization has been supported by a variety of usages including research and educational utilization by users within the University of Florida as well as by other researchers and educators. The Neutron Activation Analysis (NAA) Laboratory has favorably impacted on all areas of utilization from research projects using neutron activation analysis to training and educational uses for students at all levels.

UFTR energy generation is limited by a codified ALARA constraint on Argon-41 emissions. The maximum annual average availability since the previous license renewal in 1982 was 91.5% for the period from September 1986 to August 1987.

Shortly following conversion to low enriched fuel in 2006, the reactor entered a prolonged outage period. Reasons for this prolonged outage include; personnel turnover, primary piping replacement, security and facility upgrades, and license basis reconstitution in support of license renewal.

Following completion of the prolonged outage, UFTR management expects to increase UFTR utilization back to historic highs while continuing to pursue opportunities for growth in existing and new program areas.

1.7 Compliance with the Nuclear Waste Policy Act of 1982

In accordance with U.S. Department of Energy (DOE) contract with the UFTR, the DOE retains title to the UFTR reactor fuel and is obligated to provide for its long-term disposal following return by the UFTR.

1.8 Facility Modifications and History

The UFTR has been operational since May 1959 when it was first licensed to operate at 10 kW. A brief chronology of the key dates and events in the history of the UFTR is given below.

Table 1-1
Brief Chronology of Key Dates and Events in UFTR History

Date	Event
May 1959	Initial operating license issued. Licensed power limited to 10 kW.
May 1959	Initial criticality of the UFTR.
January 1964	Licensed power level increased to 100 kW.
August 1982	Renewal of the operating license for 20 years
July 2002	License renewal application submitted for new license.
August 2006	Conversion to LEU

CHAPTER 3

DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

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3 DESIGN OF STRUCTURES, COMPONENTS, EQUIPMENT AND SYSTEMS

3.1 Design Criteria

The overall reactor building measures approximately 60 ft. by 80 ft. The current floor plan is primarily aimed for improving area utilization and control. Some relatively minor alterations have been made to the first floor and the second floor of the UFTR building since its first license. All building modifications and equipment additions were in conformance with the building codes in existence at the time. None of these changes is considered to impact reactor safety.

The UFTR principal physical barrier to fission product release is the fuel cladding. Because of the fuel material and core design, the fuel and moderator temperature reactivity coefficients are negative assuring inherent protection. Safe reactor operation is guaranteed by this inherently safe reactor design and by limiting the installed excess reactivity. Calculations presented in Chapters 4 and 13 demonstrate that the safety limit on the temperature of the fuel will not be exceeded and that residual heat removal is not necessary even under loss of coolant moderator.

The scenarios analyzed in Chapter 13 conservatively demonstrate that instrumented shutdown actions and building confinement are not necessary to ensure that radiological doses will not exceed 10 CFR Part 20 allowable limits.

The UFTR coolant works at near ambient pressure and low temperatures. The primary coolant system transfers the heat from the reactor to the heat exchanger. The heat is removed by the secondary coolant system to the storm sewer with no mixing of water between the two systems. The secondary system water pressure is maintained slightly higher than the primary system. Any leakage from the secondary system to the primary system will lead to an increase in the primary water resistivity which is detected by the conductivity cell located before the purification system. Integrity of piping is also checked through flow and level measurement instruments.

Electric power to UFTR is the same one that supplies the whole university. The system is failsafe in design and electrical power is not needed for any active safety function.

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 power. The instrumentation and control systems provide a series of alarms, interlocks and reactor trips preventing the occurrence of operating situations that are outside the bounds of the normal operating procedures. No control or safety system is required to maintain a safe shutdown condition.

3.2 Meteorological Damage

Storm surges and seiches do not occur in Alachua County. Hurricane force winds and tornadoes have a relatively low probability of occurrence in Alachua County and since the UFTR is a self-protected and isolated low-power system with a low fission-product inventory, no further criteria were established for the UFTR structure.

3.3 Water Damage

From accumulated experience at the UFTR site, it has been established that no flooding conditions will exist within the Reactor Cell from an accumulated precipitation of 8" of rainfall in a 24-hour period. In the unlikely event that the National Weather Service gives a significant probability of a hurricane or other severe storm to produce an accumulated rainfall of more than 8 inches of rain in a 24-hour period, UFTR personnel will proceed according to an approved procedure for addressing potential (or actual) flooding conditions.

3.4 Seismic Damage

As stated in Chapter 2, Florida is a relatively inactive area for seismic activity and therefore no criteria for earthquakes have been established for the UFTR structure.

3.5 Systems and Components

The UFTR does not have structures, components, or systems that are safety-related or important-to-safety in the same context as nuclear power plants. For the UFTR, a failure of the protection system or credible event does not have the potential for causing off-site exposures greater than the normal exposure limits of 10 CFR Part 20. However, the UFTR structure was designed to withstand natural phenomena as previously discussed.

CHAPTER 5

REACTOR COOLANT SYSTEMS

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5 REACTOR COOLANT SYSTEMS

5.1 Summary Description

This chapter describes the UFTR cooling system and its various components. Demineralized light water is used in the UFTR to moderate fast neutrons and to maintain low coolant temperatures when it's operating at or near rated power for extended periods. During normal operation, this cooling is accomplished via forced convection through the open primary system with waste heat disposed to the environment via the secondary coolant system. Due to the simplicity of design and low power of the UFTR argonaut type reactor, this chapter is greatly simplified from what is required for a typical reactor.

5.2 Primary Coolant System

The reactor primary coolant water flow path originates from the coolant storage tank through the heat exchanger to the bottom of the fuel boxes, upward past the fuel assemblies to overflow pipes and into a header for return to the storage tank. This is shown schematically in Figure 5-1.

The major components of the reactor coolant system include:

- Coolant Storage Tank - The primary coolant is stored in the coolant storage tank that has a capacity of 200 gallons of water, approximately six (6) times the capacity of the reactor.

- Primary Coolant Pump - Rated at 65 gpm, the primary coolant pump draws suction from the primary storage tank and circulates the water through the heat exchanger before delivering it to the fuel boxes. Normal flow is about 46-48 gpm. Flow from the coolant storage tank is controlled by a ball valve in the pump discharge line.

- Heat Exchanger - The heat exchanger is a 316 stainless steel water-to-water tube and shell heat exchanger, one pass on shell side and 4 passes on primary side, designated to circulate up to 250 gpm of secondary water through the shell side and up to approximately 75 gpm of reactor coolant water through the tube side for removal of up to 500 kW thermal. The tubes are seal welded to the tubesheet to minimize leakage.

- Dump Valve - The Dump Valve is a solenoid-operated valve that opens automatically when actuated by a demand or trip signal, allowing water in the fuel boxes to drain into the coolant storage tank. Prior to reactor operation, the dump valve is shut and the primary coolant pump is started to supply the necessary moderation and cooling for full-power reactor operation.

- Core Water Level Indicator – Core water level is indicated by sight glass. A level switch located with the sight glass is wired to the reactor protection system actuating a reactor trip when the water level in the core falls below the preset limit.

- Rupture Disk - A graphite rupture disk is designed to burst at approximately 2 psi above the normal operating system pressure. Should a pressure excursion occur, this diaphragm would rupture causing the water from the core to be drained into the equipment storage pit.

5.3 Secondary Coolant System

A schematic diagram of the secondary cooling system of the UFTR is shown in Figure 5-2. There are two sources of water for this secondary cooling system: the deep well used for most operations and the city water line used as a back-up system during operation above 1kW (thermal). The well water is pumped by a submersible, 10 horsepower pump.

The deep well is approximately 238 ft deep with a casing diameter of 3" with the static water level approximately 87 ft. below grade. The well pump has approximately 200 gpm pumping capacity for this arrangement. The well water flows through a basket strainer then into the shell side of the heat exchanger and subsequently into the storm sewer.

A flow-measuring instrument located on the input line for the heat exchanger monitors the secondary flow rate. At predetermined setpoints, dependent on the secondary water source and power level, warning signals and trips are transmitted to the control room.

Pressure of the secondary coolant system is maintained higher than the primary system to prevent contamination of secondary water, although secondary coolant is not required until 1 kW. The secondary coolant system is tested for radioactive contamination weekly according to written procedures.

5.4 Primary Coolant Cleanup System

The primary purification system loop is also shown in Figure 5-1. This loop is supplied with a separate pump allowing continuous purification flow. The flow of the primary coolant pump is sufficient to maintain a flow through the purification loop when it is in operation.

The purification system is arranged to provide the reactor with continuous monitoring of the resistivity of the primary water. Nuclear type resin (H-OH; pH control; AMBERLITE^{TM} or equivalent) is used in the purification system demineralizer. An in-line resistivity bridge is set up to accept two conductivity cell signals – one upstream of the demineralizer and one downstream.

5.5 Primary Coolant Makeup Water System

Demineralized water is used as makeup to the primary coolant system and the shield tank through a hose connection. The makeup system consists of demineralizers, connected to the city water system, filled with H-OH nuclear type resin.

5.6 N-16 Shielding

Portions of the primary coolant system that are subject to coolant flow are located in the primary equipment pit or, in the case of the fuel boxes, in the center of the core shielding structure. For operation at 1 kW or above, concrete block shielding is added to the top of the equipment pit. Entry into the equipment pit is permitted no sooner than 15 minutes after shutdown from power operation to allow time for N-16 decay.

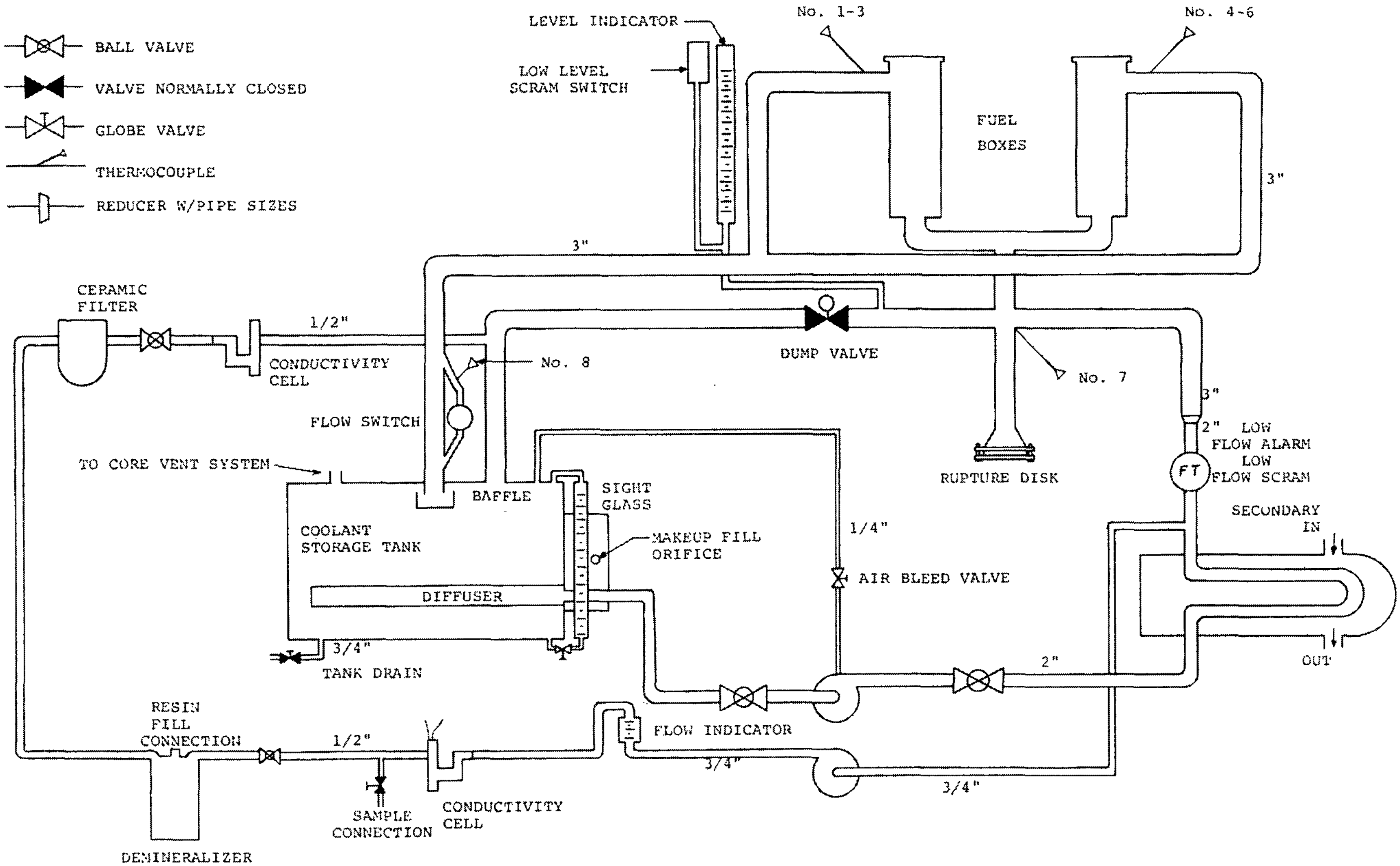

Figure 5-1 **UFTR Primary Coolant Loop and Purification System.**

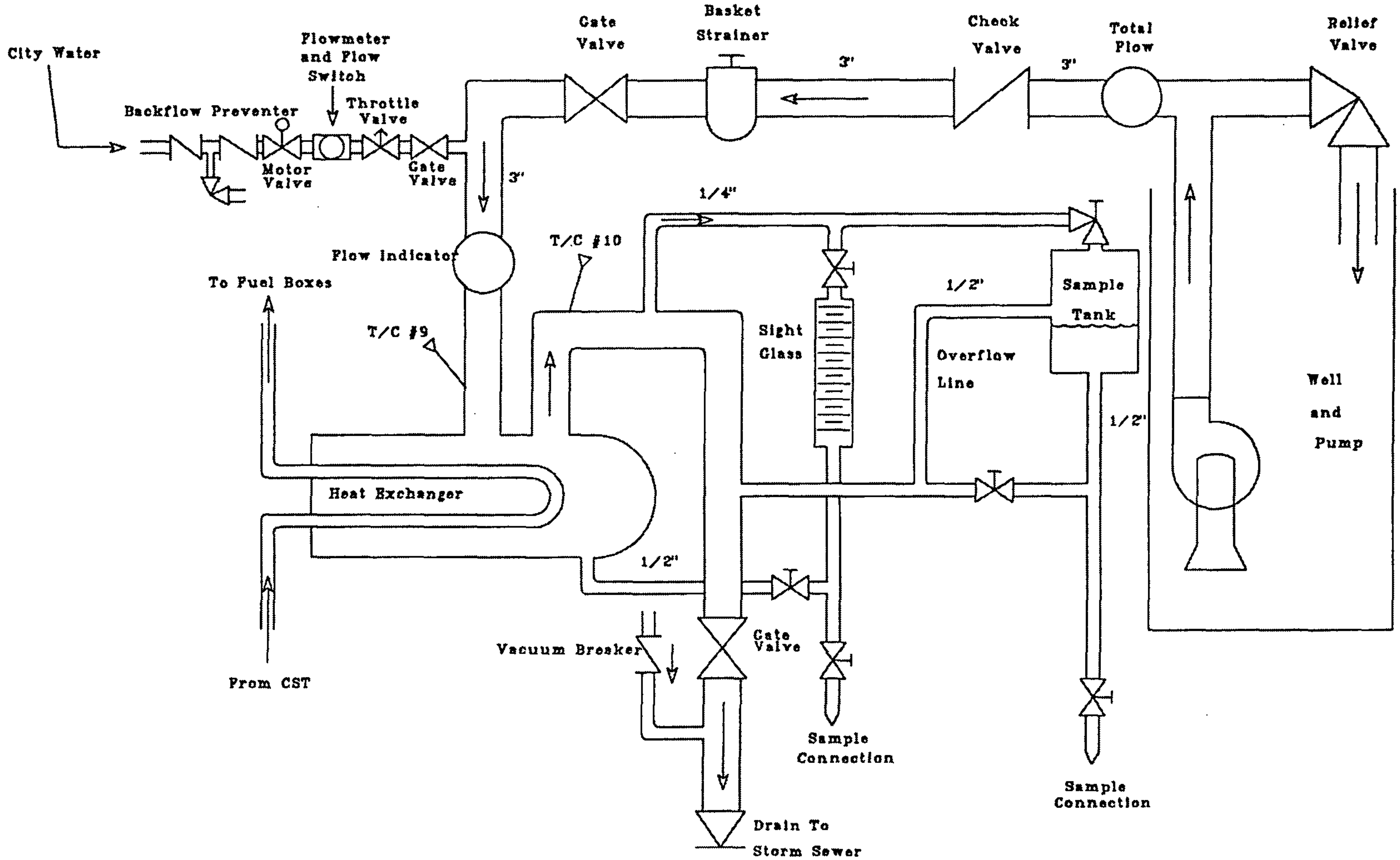

Figure 5-2 **UFTR Secondary Water Cooling System**

CHAPTER 6

ENGINEERED SAFETY FEATURES

(The UFTR does not have any credited Engineered Safety Features)

CHAPTER 8

ELECTRIC POWER

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8 ELECTRICAL POWER SYSTEMS

The UFTR does not generate electric power. Since the UFTR does not generate electrical power, there is no impact on the power grid. The design of the UFTR ensures the reactor is safely shutdown under a complete loss of electrical power. There is no credible accident that would lead to the release of radioactivity in case of loss of power.

8.1 Normal Electrical Power Systems

8.1.1 AC Power Systems

During operation, the electric power requirements for the UFTR will be supplied by the offsite regional utilities servicing the University of Florida. The facility requires power of 115 V-AC at 60 Hz for the reactor console and auxiliary equipment. The facility also utilizes 230 V-AC and 480 V-AC at 60 Hz for various motors.

A loss of electrical power drops out the scram relays and de-energizes the magnetic clutches to trip the reactor by dropping the control blades under gravity completely into the core. Therefore, there is no need to consider offsite sources of emergency power.

Interruptions in power from the regional utilities system occur occasionally. 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.

8.1.2 DC Power Systems

The area radiation monitors and stack monitor are powered by 24 V-DC power supplies backed up with a "floating" battery pack. Emergency DC lighting is located in various locations throughout the reactor building and the reactor cell. Additionally, there are wall mounted rechargeable hand-held flashlights at various locations within the reactor building and reactor cell.

8.2 Emergency Electrical Power Systems

The UFTR is connected to a Diesel Electric Generator located in the West fenced lot area of the facility. The Diesel Generator provides backup electrical power for all reactor systems, including the radiation monitoring and physical protection systems, as well as emergency lighting, except for the primary coolant system dump valve. In this way all the monitoring systems are supplied with electric power but the reactor cannot be operated.

No credit is taken for the back-up electrical Diesel Generator for safety analysis considerations. For additional information on the Diesel Generator refer to Chapter 9.

CHAPTER 11

RADIATION PROTECTION AND WASTE MANAGEMENT

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11 RADIATION PROTECTION AND WASTE MANAGEMENT

11.1 Radiation Protection

11.1.1 Radiation Sources

11.1.1.1 Airborne Radiation Sources

As described in Chapter 9, the design of the reactor cell ventilation systems ensure that leakage and accumulation of radioactive gases into the reactor cell is prevented by drawing air from the cell, through the reactor and out the exhaust stack.

The only radioisotope of concern is the Argon-41 produced in the UFTR as a result of neutron activation of the Argon-40 in the air drawn in through the crevices in the concrete and the graphite reflector. The other gaseous components of air are either too rare, have small activation cross sections, or produce activated products having half-lives too short to be of significance.

11.1.1.1.1 Occupational Exposure from Ar-41 During Routine Reactor Operations

The only routine occupational exposure from Ar-41 occurs during performance of stack effluent surveillance measurements involving manual grab samples of stack effluent. This surveillance has a semiannual frequency and surveillance related exposures are kept ALARA and well within 10 CFR 20 limits.

11.1.1.1.2 Estimated Annual Dose in the Unrestricted Area from Ar-41 Released During Routine Reactor Operations

Regulation 10 CFR 20.1101(d) imposes an ALARA constraint on airborne emissions of radioactive material to the environment such that the individual member of the public likely to receive the highest dose will not be expected to receive a total effective dose equivalent (TEDE) in excess of 10 mrem per year from these emissions. This constraint ensures that dose from airborne emissions make up no more than 10% of the 100 mrem per year limit of 10 CFR 20.1301(a)(1) and therefore this analysis will focus on ensuring compliance with the ALARA constraint.

While, in principle, the dose resulting from the release of radionuclides to the atmosphere can be determined by environmental monitoring, at the low levels consistent with the limit of the constraint, it is not reasonable to distinguish the portion attributable to UFTR Ar-41 emissions from that which is due to background radioactivity. Therefore, an expected dose must be determined analytically.

To ensure compliance with the annual TEDE constraint of 10 CFR 20.1101(d), the UFTR limits Ar-41 produced by administratively limiting effective full-power hours of operation (EFPHs). Periodic surveillance measurements of the stack effluent are performed to determine instantaneous Ar-41 concentration. Based on this instantaneous concentration and stack release point parameters, a monthly EFPH limit is calculated to ensure compliance with the annual TEDE constraint of 10 CFR 20.1101(d). Prior to reactor operation, the cumulative EFPHs for the month are compared to this monthly limit to prevent exceeding the monthly limit.

The air concentration at any point in the environment is an extremely complex function of the quantity of the radioactive material released, the configuration of the facility from which the material is released, the distance from the point of the release to the locations of interest, the meteorological conditions, and various depletion processes which remove the radioactive material from the effluent plume as it moves from the point of release to the location of the receptor. To avoid excessive conservatism which result in further constraints on UFTR energy generation, this complexity necessitates the use of a computer code. Additionally, consistent with the low level specified by the ALARA constraint, the UFTR has determined that the effort and expense of implementing a detailed site specific environmental model are not practical or reasonable.

Diffusion and atmospheric turbulence are the primary processes acting to reduce the Ar-41 concentrations in the plume. The degree of dilution resulting from atmospheric turbulence and diffusion depends upon the stability of the atmosphere, the joint frequency distribution of wind speed and direction, and the distance from the point of release to the location of the receptors. Additional factors that influence dilution include the height at which the release occurs, the rise of the effluent plume due to the momentum and/or thermal buoyancy of the gases in the effluent, and the relationship between the height of the release and the heights of the building from which the release occurs and surrounding structures.

When determining average concentrations over a long time period such as the annual average air concentrations of interest, assuming a neutral atmospheric stability is appropriate (Ref 11-4). For the case where atmospheric stability is neutral, the distance from the source to the point of maximum concentration can be calculated (Ref 11-1).

Based on the discussion above, the distance to the most exposed member of the public will be calculated and compliance with the constraint limit will be demonstrated using the NRC endorsed computer code COMPLY (Ref 11-3).

The computer code COMPLY assesses dose from airborne releases using varying amounts of site-specific information in four screening levels. In Level 1, the simplest level, only the quantity of radioactive material possessed during the monitoring period is entered. At Level 4, the COMPLY code produces a more representative dose estimate and provides for a more complete treatment of air dispersion by requiring the greatest amount of site-specific information (Ref 11-3).

The UFTR discharges Ar-41 through an exhaust stack approximately 9.1 meters above ground level. Based on the most recent surveillance measurements in October 2008, the emission rate of Ar-41 in the stack effluent is 1.351E-04 Ci/s (Ref 11-2). A summary of the October 2008 surveillance measurements is provided in Table 11-1.

Table 11-1
Summary of the UFTR Release Point Data Taken During the October 2008 Semiannual Ar-41 Surveillance Measurements

Core Vent Flow	0.10384 m^3/s
Stack Dilution Flow	6.3281 m^3/s
Ar-41 Concentration	2.100E-05 Ci/m^3
Total Stack Velocity	10.896 m/s

The maximum ground level concentration occurs on the plume center line at the downwind distance as follows (Ref 11-1):

$$\sigma_z = \frac{h_e}{\sqrt{2}}$$

where:
σ_z = vertical deviation of plume contaminant (m);

The effective stack height (h_e) can be calculated from the following equation (Ref. 11-1):

$$h_e = h + d(\frac{v_s}{\mu})^{1.4}$$

where:
h = physical stack height (9.1 m);
d = stack diameter (0.876 m);
v_s = stack effluent velocity; and
μ = mean wind speed (m/s).

The distance (x) at which the maximum concentration occurs (d_{max}) can then be determined by solving for 'x' given the vertical diffusion parameter determined previously from the effective stack height using (Ref 11-4):

$$\sigma_z = (0.06x)\,\frac{1}{\sqrt{(1 + 0.0015x}}$$

where:
$x = d_{max}$ = distance from point of release to receptor (m);

A 30-year wind rose is used to describe the average wind speed and wind direction. This wind summary data is provided in Table 11-2.

Table 11-2
Wind Summary for January 1, 1980 to December 31, 2009 for the Gainesville Regional Airport as Reported by NOAA Online Climate Data (Ref 11-5)

Direction - From	Frequency	Speed (m/s)
N	5.90%	3.35
NNE	4.50%	3.50
NE	5.20%	3.65
ENE	5.20%	3.71
E	7.50%	3.60
ESE	4.10%	3.50
SE	3.70%	3.55
SSE	3.10%	3.50
S	4.50%	3.60
SSW	3.30%	3.76
SW	3.50%	3.96
WSW	4.60%	4.32
W	7.50%	4.07
WNW	4.90%	3.60
NW	4.60%	3.40
NNW	3.80%	3.29
Calm	22.60%	0.00
Variable	1.60%	2.11
Mean Wind Speed =		2.81

Using the COMPLY computer code, the maximum expected TEDE, signified as $TEDE_{max}$, received by the most exposed member of the general public located at d_{max} may now be estimated. The result of calculating the annual TEDE to the general public from routine releases of Ar-41 into the unrestricted area is given in Table 11-3.

Table 11-3
Maximum Expected Annual Dose in the Unrestricted Area from Ar-41 Released During Routine Reactor Operations

μ (m/s)	h_e (m)	σ_z (m)	d_{max} (m)	$TEDE_{max}$ (mrem)
2.81	14.9	10.6	202	19.5

It should be noted that in order to receive the dose shown in Table 11-3, an individual would be required to continuously occupy the specified location (202 meters from the release point) for a full year while the reactor operated continuously for a year.

The calculated dose shows that the maximum expected Ar-41 concentration at the location of the most exposed member of the public results in greater than the ALARA constraint of 10 mrem/year but remains well within the 100 mrem/year limit of 10 CFR 20.1301(a)(1).

As discussed previously, the UFTR calculates a monthly EFPH limit based on surveillance measurements to ensure compliance with the annual TEDE constraint of 10 CFR 20.1101(d). Based on the measurements taken during the October 2008 performance of this surveillance and the associated TEDE result in Table 11-3, the UFTR is limited to 375 EFPHs per month.

This choice of ALARA constraint as the analysis limit, in combination with associated Technical Specifications, conservative occupancy assumption, and analysis above, provide reasonable assurance that dose resulting from UFTR Ar-41 emissions will meet the ALARA constraint of 10CFR20.1101(d) and be well within the limit of 10CFR20.1301(a)(1).

11.1.1.2 Liquid Radioactive Sources

Neutron activation product impurities in the primary coolant represent the only liquid radioactive material routinely produced during normal reactor operations. The majority of these impurities are removed from the primary coolant by the purification loop.

11.1.1.3 Solid Radioactive Sources

The solid radioactive sources associated with the normal operation of the UFTR are the fuel, neutron startup sources, fission chambers, solid wastes and activated materials.

11.1.2 Radiation Protection Program

Increased utilization of ionizing radiation at the University of Florida led the administration to establish a University-wide Radiation Control Program in the early 1960's. The primary purposes of this program are to assure the radiological safety of all University personnel, to assure that ionizing and nonionizing radiation sources are procured and used in accordance with Federal and State regulations, and to assure that radiation exposures are "as low as reasonably achievable" (ALARA). To assure these ends, the Radiation Control and Radiological Services Department was established under the Division of Environmental Health and Safety and headed by the Radiation Control Officer (RCO).

The Radiation Control Committee has designed procedures and policies in the form of a document entitled "Radiation Control Guide," in an effort to provide investigators using ionizing radiations with guidelines necessary to maintain their facilities in a manner that keeps exposures ALARA. These procedures are consistent with regulations of the Nuclear Regulatory Commission and the Florida Department of Health; they are applicable to all facilities under the administration of the University of Florida including the UFTR facility.

In addition to University-wide radiation protection policies, the UFTR has embedded radiation protection and ALARA requirements into the UFTR Standard Operating Procedures.

11.1.2.1 Organization of Radiation Control Staff and Working Interface with Operations Staff

Details on the organizational structure, reporting pathways, and working interface can be found in Chapter 12.

11.1.2.2 Radiation Control Procedures

In addition to University-wide radiation protection policies, the UFTR has embedded radiation protection and ALARA requirements into the UFTR Standard Operating Procedures. While not intended to be all-inclusive, the following is a list of typical radiation control procedures incorporated into the UFTR Standard Operating Procedures:

- Radiation Protection and Control;
- Radiation Work Permits;
- Primary Equipment Pit Entry;
- Removing Irradiated Samples from UFTR Experimental Ports;
- Control of UFTR Radioactive Material Transfers; and
- Circulation, Sampling, Analysis, and Discharge of Holdup Tank Wastewater.

11.1.2.3 Radiation Protection Training

Unescorted facility staff and researchers receive training on radiation protection and on the techniques for avoiding, limiting and controlling exposure commensurate with their risk and sufficient for their work or visit. Facility operations personnel are trained and qualified on radiation control through the UFTR Requalification and Recertification Training Program.

11.1.2.4 Audits

The UFTR Reactor Safety Review (RSRS) Subcommittee reviews and audits reactor operations for safety, ensuring radiological safety at the facility. Details can be found in Chapter 12.

11.1.2.5 Radiation Control Records

Details on the records requirements can be found in Chapter 12.

11.1.3 ALARA Program

The University-wide ALARA policy is embedded as an integral part of the UFTR Standard Operating Procedures.

The D-series of SOPs describe the general radiation protection requirements and limits that must be observed to assure radiation exposures are kept ALARA per the University-wide ALARA policy. Specific procedures to be followed during maintenance operations are included in the E-series of SOPs. Specific procedures and radiation limits related to fuel handling operations are included in C-series SOPs. Radioactive waste handling and shipment are also addressed in D-series SOPs.

11.1.4 Radiation Monitoring and Surveying

11.1.4.1 Radiation Monitoring Equipment

UFTR radiation monitoring equipment is summarized in Table 11-4. This equipment is updated and replaced as needed and therefore this equipment list should be considered representative only.

Table 11-4
Radiation Monitoring Equipment

Item	Location	Function
Stack Monitor	Effluent Stack	Airborne particulate and gas
Area Radiation Monitors	Various locations in Reactor Cell	General area radiation fields
Air Particulate Detector	Reactor Cell ground floor	Airborne particulate
Portable Air Sampler	Various	Airborne particulate
Portal Monitor	Reactor Cell entrance	Personnel contamination
Portable Ion Chamber Survey Meter	Various	Beta/Gamma exposure rates
Portable GM Survey Meter	Various	Beta/Gamma exposure rates
Portable Pancake Probe GM Survey Meter	Various	Beta/Gamma contamination
Portable Neutron Survey Meter	Various	Neutron dose rates
Portable Micro-R Survey Meter	Various	Gamma exposure rates
HPGe Gamma Spectroscopy System	NAA Lab	Gamma spectroscopy
Gas Flow Proportional Counter	NSC Rm. 106 / NAA Lab	Alpha/Beta activity
Self-Reading Pocket Dosimeters	Various	Gamma exposure estimates
TLDs	Various	Environmental and personnel exposures

11.1.4.2 Instrument Calibration

Technical Specification required radiation monitoring systems are calibrated in accordance with Technical Specification requirements. Other radiation instruments, such as portable survey meters, are calibrated using local procedures based on ANSI N323-1978. Instruments not calibrated locally are sent to an appropriate calibration facility.

11.1.4.3 Routine Monitoring

The radiation survey program is structured to make sure that adequate radiation measurements of both radiation fields and contamination are made commensurate with the amount and type of work being performed with radioactive material. The intent of such surveys is to prevent uncontrolled release of radioactive material and to minimize exposure. This program includes, but is not limited to:

Surveys performed on a weekly basis include swipe surveys, air and water samples, and gamma radiation field surveys. Surface contamination in the room is determined by means of portable instruments and smear tests. Particular attention is given to the equipment pit, experimental areas and the irradiated fuel storage pits during each survey. There is an ongoing program by the Radiation Control Office and the UFTR facility staff to monitor radiation levels outside the UFTR building in the nearby vicinity.

Periodic surveys are performed to check for leakage around beam plugs and through the stacked-block reactor shield; periodic air samples are also taken and analyzed providing a check on the proper functioning of the continuous air monitoring (CAM) system which uses one or more air particulate detectors. The coolant is checked by evaporating a sample to dryness and counting with a gas flow proportional or equivalent counter.

11.1.5 Radiation Exposure Control and Dosimetry

The UFTR facility is of the modified Argonaut type, designed to minimize radiation exposure to all individuals. Since the reactor is used as a teaching tool and for research operations, a more stringent safety program has been developed to ensure radiation exposures meet the ALARA criterion; UFTR Standard Operating Procedures (SOP's) are designed to facilitate the minimization of exposure rates and to ensure the health and safety of the people in and around the facility.

11.1.5.1 Shielding

During normal operation at the 100 kWth rated power level, the shielding is sufficient for the entire "core" and activation (biological shield) sources of radiation discussed. At full-power, typical radiation levels within the reactor cell are 1 to 2 mR/hr or less.

Additional shielding is available in the form of cast concrete blocks, lead bricks, shield casks, small concrete blocks and sheet shielding materials which can be used as shielding during experiments, maintenance activities, and around activated sources. Radiation surveys are conducted for routine experiments to determine whether special shielding configurations are needed to meet the ALARA standard.

When experimental requirements necessitate operation of the reactor with a shield plug removed, strict health physics supervision is required. All such experiments are approved in advance by the Reactor Manager and the UFTR RSRS if deemed necessary based on experiment class. Adequate shielding must be provided as specified in the applicable procedures, to assure that ALARA criterion and safety considerations are satisfied.

All samples activated in the reactor are removed as specified in applicable procedures. Additional shielding in the form of lead bricks and concrete blocks is available for any activated sources removed from the exposure facilities. In addition, a hot cave with remote handling facilities is available in the radiochemistry laboratory outside the reactor cell.

11.1.5.2 Ventilation

The UFTR ventilation systems are described in FSAR Chapter 9.

11.1.5.3 Entry Control and Posting Requirements

In accordance with the regulations found in 10 CFR 20, the UFTR has multiple locations posted and controlled as radiation areas. Other areas within the UFTR are designated restricted areas. Should radiation or facility conditions change, the entry controls and postings will follow the requirements in 10 CFR 20.

11.1.5.4 Protective Clothing

Anti-contamination clothing designed to protect personnel against contamination is used and specified when recommended or required by work conditions.

11.1.5.5 UFTR Occupational Radiation Levels

Exposure measurements show that both thermal and fast neutron contributions to radiation levels in the reactor cell are typically negligible. Typical gamma radiation levels during full-power operation are shown in Table 11-5.

Table 11-5
Typical Gamma Radiation Levels in the Reactor Cell at Full-Power

Location	Typical Radiation Level (mR/hr)
Top of shield tank	15
Control Console	< 1
North ARM	1
East ARM	1
South ARM	< 1
Area just West of Rabbit system	2

11.1.5.6 Personnel Dosimetry

The UFTR provides personnel dosimetry to occupational radiation workers to ensure compliance with the dose limits of 10 CFR 20. Whole body badges are worn for this purpose with additional dosimetry such as extremity or ring badges if warranted due to the radiological conditions.

The Radiation Control Office maintains permanent records of dosimetry readings.

11.1.6 Contamination Control

Radioactive contamination is controlled at the UFTR by using standard operating procedures and radiation control techniques for radioactive contamination monitoring along with proper work methods. Routine radiation monitoring is used to detect and identify contamination. The UFTR procedures contain provisions to control contamination such as:

- Personnel are required to monitor their hands and feet for contamination when leaving contaminated areas or restricted areas that are likely contaminated.
- All personnel entering the reactor cell are required to utilize the portal monitor or hand-held frisker to check for potential contamination upon leaving the reactor cell.
- Materials, tools and equipment are surveyed for contamination before removal from contaminated areas or restricted areas where contamination is likely.
- Contaminated areas and restricted areas where contamination is likely are surveyed routinely for contamination levels.
- Potential contaminated areas are periodically monitored, consistent with the nature and quantity of the radioactive materials present.
- Radiation Work Permits (RWPs) are required to assure proper radiological protective measures are available and used during work which has actual or potential radiological hazard with its accomplishment and to provide appropriate documentation of the radiation control measures.
- Anti-contamination clothing designed to protect personnel against contamination is used and specified in the RWPs when recommended or required by work conditions.
- Contamination events are documented in reports.
- Staff are trained on the risks of contamination and on the techniques for avoiding, limiting and controlling contaminations commensurate with their risk.

11.1.7 Environmental Monitoring

The UFTR Environmental Radiological Program is conducted to ensure that the radiological environmental impact of reactor operations is as low as reasonably achievable (ALARA); it is conducted in addition to the radiation monitoring and effluents control. This program is conducted by the UFTR facility staff under the supervision of the Radiation Control Office, to monitor radiation levels in unrestricted areas surrounding the UFTR facility.

Monitoring is conducted by measuring the gamma doses at selected fixed locations, with acceptable personnel monitoring devices. The Luxel, TLDs or other radiation monitoring devices are then collected by the UFTR staff or Radiation Control personnel and evaluated monthly by a qualified processor. Typically these radiation monitoring devices show no significant indications above background for the UFTR site.

11.2 Radioactive Waste Management

11.2.1 Radioactive Waste Controls

Radioactive waste is generally considered to be any item or substance which is no longer of use to the facility and which contains, or is suspected of containing, radioactivity above the natural background radioactivity. Radioactive waste handling and shipment are addressed in D-series SOPs.

The objective of the radioactive waste management program is to ensure that radioactive waste is minimized, and that it is properly handled, stored and disposed of. The UFTR is a low power research reactor and generates very small amounts of radioactive waste.

11.2.1.1 Gaseous Waste Management

As described in Chapter 9, the design of the reactor cell ventilation systems ensure that leakage and accumulation of radioactive gases into the reactor cell is prevented by drawing air from the cell, through the reactor and out the exhaust stack.

The only gaseous radioisotope of concern produced during normal operation of the UFTR is Argon-41, classified as an effluent rather than waste. Therefore, as in many other non-power reactors, there are no special gaseous waste systems necessary at the UFTR.

11.2.1.2 Liquid Waste Management

While normal operation of the UFTR does not produce liquid radioactive wastes, liquid resulting from HVAC operation and sampling activities are routed to an aboveground tank in the Northwest corner of the reactor cell. Periodically the water is pumped to the above-ground Waste Water Holdup Tank, sized to hold 1,000 gallons of liquid and located outside the reactor building in the West fenced area. Most of the water held up in the tanks comes from the air conditioning system with a small amount coming from sampling water collected from the primary system, shielding tank, and secondary sample points. Periodic samples of the collected liquid waste are taken by the reactor staff and assayed to determine the total activity level present. If, as expected, activity levels are within acceptable levels for release, then the contents of the tank are released into the University of Florida Sanitary Sewage System.

The D-Series of UFTR Standard Operating Procedure establishes the standard protocol for the circulation, sampling, analysis and discharge of wastewater to assure releases to the sanitary sewer are within the limits set forth by the 10 CFR 20.

11.2.1.3 Solid Waste

Solid waste is typically generated at the UFTR from irradiated samples, packaging materials, contaminated gloves and clothing, used primary coolant demineralizer resin beads, filter traps on the waste water holdup tank and other similar sources. All solid wastes are collected in accordance with approved Radiation

Control techniques. These solid wastes are typically very low level. Solid wastes are periodically transferred and shipped in accordance with approved UFTR Standard Operating Procedures.

References:

11-1 Slade, D.H. Meteorology and Atomic Energy – 1968, TID-24190
11-2 UFTR S-4 Argon Measurement Surveillance completed on October 14, 2008.
11-3 Regulatory Guide 4.20
11-4 EPA 520/1-89-001
11-5 NOAA Online Climate Data Center