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NEXT

May 27, 2022

Ms. Andrea Veil
Director, Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

99902088

Subject: **Submittal of the ACU Molten Salt Research Reactor Regulatory Engagement Plan for Construction Permit**

Reference: NEXT Lab Molten Salt Research Reactor Licensing Regulatory Engagement Plan, submitted to the NRC (ML20241A071)

Reference: Abilene Christian University NEXT Lab Molten Salt Research Reactor Preliminary Safety Analysis Report Pre-Submittal Audit Plan (ML22054A140)

Dear Ms. Veil,

Abilene Christian University (ACU) submitted an initial Regulatory Engagement Plan (REP) to the Nuclear Regulatory Commission (NRC), dated July, 24, 2020 (ML20241A071), and requested readiness assessment of the draft Preliminary Safety Analysis Report before ACU submits it for the NRC staff's review (ML22054A140). The initial REP has become dated and does not provide the level of detail necessary to schedule readiness assessment activities in the near term.

Enclosed is the ACU "Regulatory Engagement Plan for Construction Permit." This document provides an updated and more detailed plan for ACU and NRC licensing engagement through fiscal year 2023, including pre-application engagement activities. Per the enclosure, ACU is anticipating submission of a Construction Permit application on August 15, 2022 and requesting NRC resources necessary to complete the acceptance of the application by October 1, 2023.

If there are any questions or a need for additional information, please contact Dr. Rusty Towell at the address below, by telephone at (325) 674-2034, or by email at Rusty.Towell@acu.edu.

Respectfully,

YG01
NRR

Rusty Towell, Ph.D.

Director, NEXT Lab

Enclosure: Regulatory Engagement Plan for Construction Permit

ACU

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Nuclear Energy eXperimental Testing

Regulatory Engagement Plan for Construction Permit

Abilene Christian University

Molten Salt Research Reactor

MSRR-REP-FY23, Rev. 0

May 2022

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Regulatory Engagement Plan for Construction Permit

Abilene Christian University's Molten Salt Research Reactor

MSRR-REP-2023, Rev. 0

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Approved By:	**Signature:**

REVISION HISTORY

Rev	Date	Reason for Revision	Revised By
0	5/31/2022	Initial release	

Contents

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Acronyms and Abbreviations

°C	degrees Celsius
10 CFR	Title 10 of the Code of Federal Regulations
ACU	Abilene Christian University
AEA	Atomic Energy Act of 1954, as amended
Be	beryllium
cm	centimeter
CP	construction permit
F	fluorine
ft	feet
GT	Georgia Institute of Technology
He	helium
kg	kilograms
kW	kilowatt
Li	lithium
MSR	molten salt reactor
MSRE	Molten Salt Reactor Experiment
MSRR	Molten Salt Research Reactor
MW	megawatt
MW_{th}	thermal megawatt
NEIMA	Nuclear Energy Innovation and Modernization Act
NEXT	Nuclear Energy eXperimental Testing
NEXTRA	Nuclear Energy eXperimental Testing Research Alliance
ORNL	Oak Ridge National Laboratory
SERC	Science and Engineering Research Center
TAMU	Texas A&M University
U	uranium
U.S.	United States
UT	University of Texas at Austin

REGULATORY ENGAGEMENT PLAN FOR CONSTRUCTION PERMIT

1 SCHEDULE FOR CONSTRUCTION PERMIT ACTIVITIES

Abilene Christian University (ACU) submitted an initial Regulatory Engagement Plan (REP) to the Nuclear Regulatory Commission (NRC) dated July, 24, 2020 (ML20241A071) and requested readiness assessment of the draft Preliminary Safety Analysis Report before ACU submits it for the NRC staff's review (ML22054A140). The initial REP has become dated and does not provide the level of detail necessary to schedule readiness assessment activities in the near term and to meet overall licensure timeline goals.

This document provides an updated and more detailed plan for construction permit engagement through fiscal year 2023. ACU is anticipating submission of a Construction Permit (CP) application on August 15, 2022 and requesting NRC resources required to complete the approval of the application by October 1, 2023 (Figure 1.1).

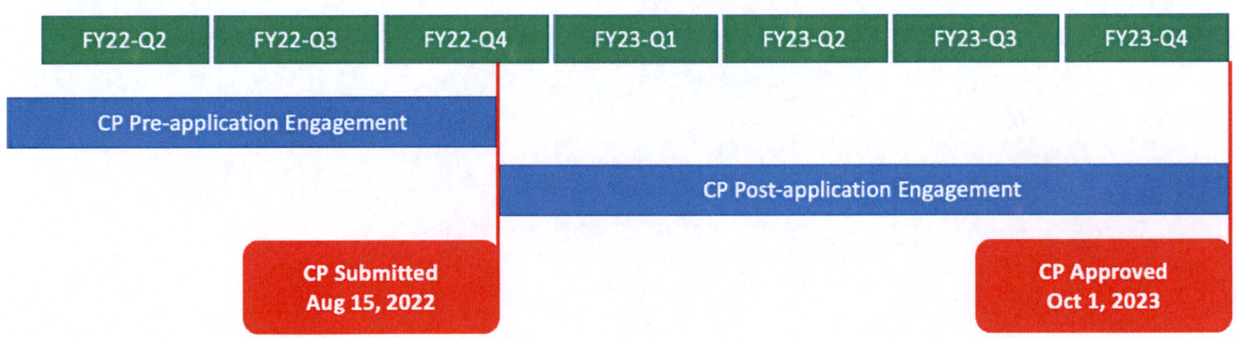

Figure 1.1 Anticipated Construction Permit schedule through FY23.

2 FACILITY DESCRIPTION

2.1 Abilene Christian University

Abilene Christian University (ACU) is a non-profit educational institution that has been in operation since 1906 and is accredited by the Southern Association of College and Schools Commission on Colleges to award associate's, bachelor's, master's, and doctoral degrees. Fall 2021 marks the fourth consecutive year for a record number of students enrolling at ACU. Nationally, ACU achieved top 10 status in three and top 50 in another of eight high-impact categories among 1,500 universities evaluated for the annual "U.S. News Best Colleges" edition. ACU also earned Doctoral/Professional University status, as determined by the Carnegie Classification of Institutions of Higher Education in its latest update, released in December of 2021.

The Nuclear Energy eXperimental Testing Laboratory (NEXT Lab) was established by ACU in

2015 to focus on Molten Salt Reactor (MSR) technology development and deployment. The mission of the NEXT Lab is to provide global solutions to the world's need for energy, water, and medical isotopes by advancing the technology of MSRs while educating future leaders in nuclear science and engineering. The NEXT Lab is a driver in the accelerated expansion of the existing ABET accredited ACU engineering program and is a collaborative hub for the multi-disciplinary research and development activities required to support the mission. NEXT Lab is part of the NEXT Research Alliance (NEXTRA) that includes Georgia Institute of Technology (GT), Texas A&M University (TAMU), and the University of Texas at Austin (UT). All three external collaborators have years of experience with research reactors. TAMU and UT have active licenses. Faculty, staff, and students across NEXTRA are already benefiting from early engagement with this project.

The ACU Science and Engineering Research Center (SERC) is a multi-purpose campus facility designed to house the expanding NEXT Lab activities for decades to come. The SERC is an investment, partially funded by the City of Abilene, that supports integration of the required multi-discipline research and the development of world-class advanced reactor research, training, and educational experiences for students, faculty, and researchers in a convenient campus location. The SERC design also provides NEXT Lab with infrastructure to potentially house a variety of potential radiation-producing systems and has been selected as the site for the ACU Molten Salt Research Reactor (MSRR).

2.2 Purpose and Intended Use of the Reactor

The purpose of the MSRR is to accelerate the development and deployment of MSR systems through foundational research while also developing a new pipeline to a nuclear qualified workforce. ACU's large capital investment in the MSRR will provide a world-class molten salt research facility that will be utilized by large numbers of students, staff, faculty, and outside collaborators. The intended use of the MSRR is to conduct research on molten salt systems, as well as to educate and train a new generation of engineers and scientists who will be uniquely prepared to contribute to the advancement and deployment of molten salt reactors and applications. The research will generate experimental MSR data to advance the understanding of:

- generation and migration of gasses and vapors in a fluid-fueled fluoride reactor,
- the behavior of delayed neutron precursors during normal and off-normal operating conditions,

all of which can be used in the validation and calibration of software for the design, licensing, and regulation of commercial MSRs.

2.3 Regulatory Strategy Application Type(s)

The ACU MSRR will be a utilization facility as described in Title 10 of the Code of Federal Regulations (10 CFR), Section 50.21(c) that is useful in the conduct of research and development activities of the types specified in Section 31 of the Atomic Energy Act of 1954, as amended (AEA), and the activities will meet the 10 CFR 50.2 definition of research and development. The MSRR will not be a commercial and industrial facility as specified in paragraph (b) of 10 CFR 50.21 or in 10 CFR 50.22. Based on these activity tests and given that the proposed MSRR is not a testing facility, ACU is seeking to obtain a license under AEA Section 104c pursuant to 10 CFR 50.21(c) as a university research reactor facility with licensed power operation at less than 1 MW_{th}. ACU is aware of the changes made to Section 104c of the Atomic Energy Act (AEA) by the Nuclear Energy Innovation and Modernization Act (NEIMA) and believes that MSRR activities will be consistent with licensing under Section 104c of the AEA as amended by NEIMA.

Additionally, the strategic approach for the 10 CFR Part 50 license application process is intended to follow the appropriate primary guidance provided in:

- NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors - Format and Content"
- ISG-2012, Interim Staff Guidance Augmenting NUREG-1537 Part 1 for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors
- Appendix A, "Part 1, Guidelines for Preparing and Reviewing Application for the Licensing of Non-Power MSRs: Format and Content," of the ORNL/TM-2020/1478 report titled, "Proposed Guidance for Preparing and Reviewing a Molten Salt Non-Power Reactor Application" (ADAMS Accession No. ML20219A771)

ACU intends to embed several activities subject to different Nuclear Regulatory Commission (NRC) requirements in the primary application in accordance to 10 CFR 50.31, "Combining Applications," and 10 CFR 50.32, "Elimination of Repetition." These activities are intended to include at least the following partial list of applicable requirements: 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," to 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material," 10 CFR Part 20, "Protection Against Radiation," 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and related functions," 10 CFR Part 55, "Operators' Licenses," and 10 CFR Part 73, "Physical Protection of Plants and Materials."

2.4 Geographical Location of the Site

The selected site for the MSRR is inside the SERC, located in Taylor County, Texas, on the ACU main campus in Abilene, Texas. The site is situated in North Central Texas and is approximately 142 miles (228 km) west of Fort Worth, 210 miles (340 km) northwest of San Antonio, and 146 miles (235 km) southeast of Lubbock.

2.4.1 The Science and Engineering Research Center

The SERC is located on the southeast corner of the ACU main campus in Abilene, Texas. It is a 28,000-square-foot multi-level structure containing spaces designed to support research in chemistry, physics, and a variety of engineering disciplines. A view of the SERC is shown in Figure 2.1.

Figure 2.1 **Fly-by view of the SERC from the Northeast.**

3 REACTOR DESCRIPTION

3.1 General Description of the MSRR

The MSRR is a single region core, loop-type, thermal spectrum reactor with a fluoride-based fuel salt that flows through a graphite moderator and 316 stainless steel fuel circuit components. A secondary loop with flowing fluoride-based cooling salt, designed to remove 1 MW_{th} of heat, will be used to cool the fuel circuit and expel the heat to the atmosphere. The MSRR is predicated on the 8 MW_{th} MSRE and designed to be passively safe. The MSRR relies on intrinsic properties of molten salts and engineered safety features to ensure safe and reliable operations. The reactor system can be described as a series of interconnected subsystems that include fuel handling, primary salt loop, secondary cooling loop, gas management, biological shielding, and instrument and controls.

3.2 Safety Features/Functional Characteristics of the MSRR

There are a number of inherent safety features built into the design and materials of the MSRR. Given the low power design of the reactor, the overall risk to people and the environment is limited by the small source term and the low fission product inventory. The MSRR is significantly different from the reactors licensed in the past by the NRC and has several unique safety features not found in most solid fuel systems. As an MSR, most of the inherent safety features are a result of the formulation and properties of the salts and the movement of the salts within the system.

The MSRR salts are highly ionic compounds that are chemically stable, immune to radiolysis, and are compatible with the MSRR structural materials. They do not react rapidly with moisture or air. Their chemical inertness eliminates the risk of fire or explosion due to chemical interaction. Molten salts have been used for years in industry as heat transfer media for their inertness and safety. The MSRR salts are stable to several hundred degrees above temperatures obtainable in the reactor and remain at low vapor pressure. As an inert liquid system at low pressure safety demands are significantly reduced on the MSRR design and the SERC facility.

The MSRR fuel salt has a short and unobstructed path from the fuel loop to a drain tank, allowing the fuel salt to be completely drained in approximately one minute, even under power outages. The geometry and position of the drain tank ensure a noncritical configuration under all conditions when the entire fuel salt inventory is in it.

The reactor vessel is the only location where criticality can be reached and sustained in the MSRR. Unlike existing reactor types, only a fraction of the fuel participates in the sustained chain reaction at any given time, as the remainder is flowing through the rest of the primary circuit. The MSRR core is designed to have very low excess reactivity, which can be made up through occasional fuel salt additions introduced through the access tank. Control rods capable of controlling fission rate are also included in the MSRR design.

The MSRR also includes a shielding system designed to protect people and the environment from radiation.

3.3 MSRR Design Features

3.3.1 Thermal power level & control of heat production

The MSRR is designed to operate up to 1 MW_{th}. Excess reactivity will be minimized and maintained through small uranium salt additions if necessary. The MSRR has a large negative temperature coefficient of reactivity that passively moderates heat production. Thus, the MSRR has a significant "load-following" capability where reduced heat removal through the heat exchanger leads to increased fuel salt temperature and decreased reactivity, or greater heat removal reduces fuel salt temperature and increases reactivity. The MSRR reactivity can be controlled through circulation rate adjustments in the secondary coolant salt circuit when it is being utilized for heat removal, as heat removal may not be required under low power operations. Control rods will be used to compensate, maintain, and stop fission heat production during normal operations. The MSRR drain tank also provides immediate initiation of fuel salt relocation into a non-critical configuration, either on command or under facility loss of external electric power.

3.3.2 Fuel Type and Moderator

The MSRR will be fueled with a uranium bearing fluoride-based salt containing minimal oxidative impurities. The baseline fuel composition is LiF-BeF_2-UF_4. The moderating material is unclad nuclear-grade graphite.

3.3.3 Reactor Loop

All salt facing structural metals in the MSRR fuel loop will be constructed of 316 stainless steel and serve as the primary fuel boundary. The entire reactor loop is mechanically supported inside a steel reactor enclosure, designed to contain all potential radiological releases from the reactor loop (see Figure 3.1). The fuel circuit consists of the reactor vessel, access tank, fuel salt pump, and heat exchanger and are connected by a series of approximately 2-inch internal dimension pipes. Flowing fuel salt enters the reactor vessel from the bottom, flows upward to the access tank, over to the fuel salt pump, down to the heat exchanger, and back to the bottom of the reactor vessel.

The access tank provides a gas head space with fuel salt level control and the only point of direct access to the fuel salt and off gas while the reactor is operating. "Nano-samples" of fuel salt and gasses will be collected from the access tank regularly and taken to the radiochemistry lab in order to monitor the corrosion of the fuel circuit, measure the redox potential of the salt, and collect dynamic isotopic data on the salt and off gas as they evolve over time. The access tank will also be used for small fresh-fuel additions and redox potential adjustments of the fuel salt, if and when necessary.

The fuel salt pump will circulate salt through the loop. The heat exchanger is of the shell and tube type with the fuel salt moving through the shell. Fuel salt leaving the heat exchanger flows back into the reactor vessel.

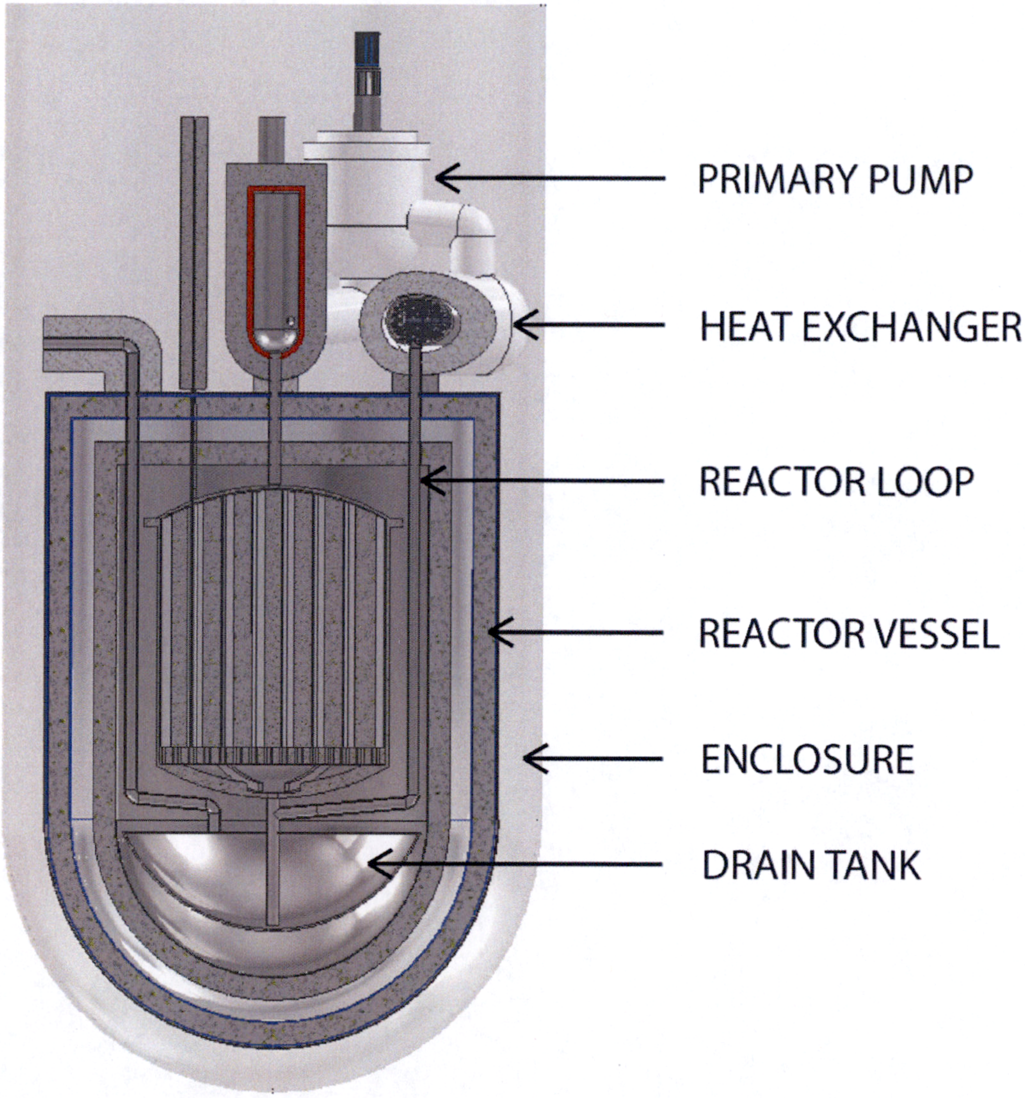

Figure 3.1 **Depiction of the reactor loop inside the reactor enclosure.**

3.3.4 Reactor Vessel

The reactor vessel (shown in Figure 3.1) and internal metal components serve as the primary fuel boundary, as well as the second boundary to radionuclide release, in this section of the MSRR loop. The vessel surrounds and supports the roughly cylindrical graphite core, where the vast majority of fission heat is generated in the MSRR. The core is constructed from a set of closely packed graphite stringers, or blocks, with machined channels that will either form fuel transits or locations for control rod thimbles.

3.3.5 Drain Tank

The MSRR drain tank (shown in Figure 3.1) is the lowest point in the reactor fuel loop, relying on gravity to drain the fuel salt to this location. The tank is designed to ensure a strongly subcritical fuel configuration and to passively manage the decay heat. The drain tank is electrically heated to minimize thermal shock, maintain fuel salt readiness, and re-melt the salt, when necessary. Outside of normal reactor operations, the drain tank system can be configured for bulk fuel salt transfer operations as one component of the fuel handling system. Most of the fuel handling system is located in the fuel handling cell.

3.3.6 Thermal Management

Heat generated in the MSRR will be expelled to the atmosphere. Reactor power will primarily be rejected through a heat rejection system, which transfers heat from the fuel salt to a secondary salt loop through the primary heat exchanger and then transfers that heat to the atmosphere through a radiator. Both salt loops will be heavily insulated to provide thermal stability and limit parasitic losses. The secondary salt flows through an air-cooled radiator system that expels the heated air out of the facility. Overall thermal management during power operations is accomplished through flow rate adjustments of the salts and air.

The melting point of the fuel salt is about 500°C and the melting point of the secondary salt is about 460°C. For the salts to remain molten under low-power running conditions, fission heat can be supplemented with an array of heaters that are in direct contact with the steel salt loop components. The heating system will also be used to prepare the salt loops for operation from a cold start and will require approximately 100 kW of thermal power.

The air management system circulates air through the reactor bay to allow for comfortable working conditions. The air management system also supplies air to the enclosures and consists of a number of interrelated systems. There will be large quantities of forced air ranging from fresh to radioactive. There are multiple potential sources of radioisotopes that can be introduced into the air within the facility, including the reactor cell, fuel handling system, secondary cooling cell, and radiochemistry laboratory. Some of the air will be routed to exhaust while others will be routed into controlled locations before release. Air exhausts from the building will be monitored for radiological release.

3.3.7 Helium Gas Management System

The gas contacting the MSRR salts will predominantly be Helium (He). It will be used to cover and pneumatically position salts throughout the systems. The He will become uniquely contaminated by each salt-bearing system and is managed as such, including a level of separation between the He supplies. The three MSRR salt-bearing systems have independent pressurized He reservoirs large enough to support system function through reuse.

3.3.8 Shielding

The MSRR biological shield is a multi-layered system designed to protect people and the environment from radiation and to minimize dose to the SERC systems pit structural concrete, the reactor isolation shielding, and the top plug (see Figure 3.2). The reactor isolation shielding traverses the systems pit from wall to wall on either side of the reactor cell to form a concrete "box" around the reactor cell. The reactor isolation shielding minimizes the radiation dose to the fuel handling cell and the secondary cell. A concrete top plug is placed on the top of the box to minimize the dose into the reactor bay. The systems pit walls, the isolation shielding, and the top plug form a vault around the reactor cell, whose activation needs to be minimized for handling purposes and potential future use. From inside to out, the multi-layered shielding system consists of an internal shield, which is located inside the reactor enclosure and surrounds the reactor vessel, a layer of sacrificial shielding inside the reactor cell to preserve the reactor cell vault components, and then the reactor cell vault itself. This multi-layered radiation shielding system ensures that the dose rate in uncontrolled areas remains below the dose limit allowed for individual members of the public (10 CFR 20.1301), and the dose rate in controlled areas is consistent with the occupational dose limits to individual adults (10 CFR 20.1201).

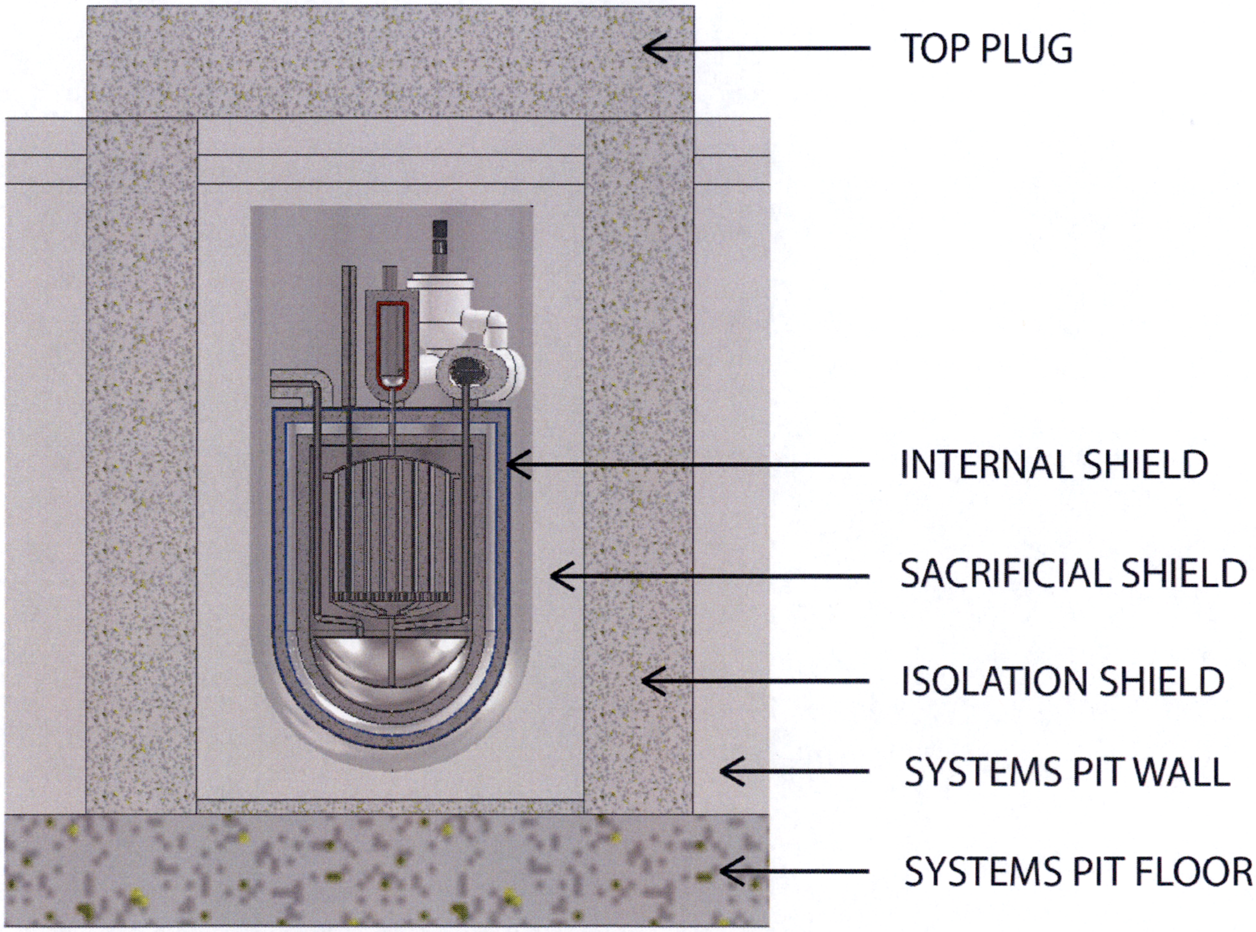

Figure 3.2 **Biological shield cross-section.**

4 SUMMARY

The mission of the NEXT Lab is to provide global solutions to the world's need for energy, water, and medical isotopes by advancing the technology of MSRs while educating future leaders in nuclear science and engineering. The purpose of the MSRR is to accelerate the development and deployment of MSR systems through foundational collaborative research while also developing a new pipeline to a nuclear qualified workforce. The MSR will provide the opportunity to significantly advance the understanding of:

- generation and migration of gasses and vapors in a fluid-fueled fluoride reactor system,
- the behavior of delayed neutron precursors during normal and off-normal operating conditions,

all of which are valuable for validation and calibration of software for the design, licensing, and regulation of commercial MSRs.

The MSRR is a single region core, loop-type, thermal spectrum reactor predicated on the 8 MW_{th} MSRE and designed to remove up to 1 MW_{th} of heat. The MSRR relies on intrinsic properties of molten salts and engineered safety functions to ensure safe and reliable operations and includes:

- Small source term (low power, low burnup)
- Very low excess reactivity
- Strongly negative reactivity coefficient
- Redundant control rods to control criticality during normal operations
- Unobstructed path for fuel salt to drain tank during power outage
- Passive decay heat removal from the drain tank
- Defense in depth through multiple barriers minimizes release, if any, to the public and environment
- Located in a below-grade vault, under a massive shielding system, that also adds a significant layer of protection from external event

This document provides an updated and more detailed plan for construction permit engagement between ACU and the NRC through fiscal year 2023 in order to schedule readiness assessment activities in the near term and to facilitate overall licensure timeline goals for the MSRR project.