



Materials and Fuels Complex FY-24 – FY-28 Five-Year Investment Strategy

April 2024



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**Materials and Fuels Complex
FY-24 – FY-28
Five-Year Investment Strategy**

April 2024

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ACRONYMS

AFF	Advanced Fuel Facility
AMWTP	Advanced Mixed Waste Treatment Project
ANL	Argonne National Laboratory
ARL	Analytical Research Laboratory
ATF	Accident Tolerant Fuel
ATR	Advanced Test Reactor
BCS	Building Control System
BOP	Balance of Plant
CAMS	Continuous Air Monitoring System
CAS	Criticality Alarm System
CH	Contact-Handled
CHC	Complex Health Committee
CLG	Casting Laboratory Glovebox
D&D	Decontamination and Decommissioning
DEQ	(Idaho) Department of Environmental Quality
DDC	Direct Digital Controls
DM	Deferred Maintenance
DOE	Department of Energy
DOE-NE	Department of Energy Office of Nuclear Energy
DOME	Demonstration of Operational Microreactor Experiments
DU	Depleted Uranium
EBR-II	Experimental Breeder Reactor-II
ECP/EBL	Element Contact Profilometer/Element Bow & Length Machine
EDGB	East Development Glovebox
EELS	Electron Energy Loss Spectrometer
EM	DOE Office of Environmental Management
EML	Electron Microscopy Laboratory
EMM	Electro-mechanical manipulators
EMT	Electrometallurgical Treatment
EOL	End-Of-Life
EPMA	Electron Probe Micro-Analysis
FASB	Fuels and Applied Science Building
FCF	Fuel Conditioning Facility

FIB	Focused Ion Beam
FMF	Fuel Manufacturing Facility
GAIN	Gateway for Accelerated Innovation in Nuclear
GASR	Gas Assay Sample and Recharge
GPP	General Purpose Project
HALEU	High Assay Low Enriched Uranium
HC	Hazard Category
HEU	High Enriched Uranium
HFEF	Hot Fuel Examination Facility
HLW	High Level Waste
HVAC	Heating, Ventilating, and Air Conditioning
IA	Instrument Air
IAEA	International Atomic Energy Agency
IASCC	irradiation assisted stress corrosion cracking
ICERR	International Centre based on Research Reactor
ICP	Inductively Coupled Plasma
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
IFM	Idaho Facilities Management
INL	Idaho National Laboratory
IRA	Inflation Reduction Act of 2022
ISA	Idaho Settlement Agreement
LA	Laser Ablation
LEU	Low-Enriched Uranium
LFTD	Laser-Flash Thermal-Diffusivity
LLW	Low-Level Waste
LOTUS	Laboratory for Operation and Testing in the United States
LWR	Light Water Reactor
MC-ICP-MS	Multi-Collector Inductively Coupled Plasma Mass Spectrometer
MEITNER	Modular Examination Instrument for Transportable Nuclear Energy Research
MFC	Materials and Fuels Complex
MLLW	Mixed Low-Level Waste
MTRU	Mixed Transuranic
NE	Office of Nuclear Energy
NHS	National Homeland Security
NR	Naval Reactors

NRAD	Neutron Radiography Reactor
NRIC	National Reactor Innovation Center
NS&T	Nuclear Science and Technology
NSUF	Nuclear Science Users Facilities
NTP	Nuclear Thermal Propulsion
NU	Natural Uranium
ORNL	Oak Ridge National Laboratory
PFCN	Private Facility Control Network
PIE	Post-Irradiation Examination
RAMS	Radiation Area Monitoring System
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
RDD&D	Research Development, Demonstration, and Deployment
RH	Remote-Handled
RHLLW	Remote Handled Low Level Waste
RLWTF	Radioactive Liquid Waste Treatment Facility
RN	Repair Needs
ROM	Rough-Order of-Magnitude
RWDP	Remote Waste Disposition Project
SC-ICP-MS	Single Collector Inductively Coupled Plasma Mass Spectrometer
SCMS	Sodium Components Maintenance Shop
SEM	Scanning Electron Microscopy
SNF	Spent Nuclear Fuel
SNFWG	Spent Nuclear Fuel Working Group
SPG	Special Project Glovebox
SSC	structure, system, and component
SSPSF	Space and Security Power Systems Facility
STP	Site Treatment Plan
TCM	Thermal Conductivity Microscope
TEM	Transmission Electron Microscopy
TESB	TREAT Experiment Support Building
TIMS	Thermal Ionization Mass Spectroscopy
TREAT	Transient Reactor Test Facility
T-REXC	TREAT Micro-Reactor Experiment Cell
TRIGA	Training, Research, Isotope, and General Atomics

TSDf	Treatment, Storage, and Disposal Facility
U&IS	Utilities and Infrastructure Support
VFD	Variable Frequency Drive
VTR	Versatile Test Reactor
WIPP	Waste Isolation Pilot Plant
WMP	Waste Management Program
ZPPR	Zero Power Physics Reactor

1. INTRODUCTION

The Department of Energy Office of Nuclear Energy (DOE-NE) vision is to “Advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs.” The Materials and Fuels Complex (MFC) serves as the foundation of a nuclear research, development, and demonstration (RD&D) enabling test bed at Idaho National Laboratory (INL) and is an integral part of a National Reactor Innovation Center (NRIC) strategy. MFC leaders focus on developing and maintaining RD&D capabilities that can increase research throughput, reduce barriers to deployment, and facilitate commercialization of new ideas and technologies for clean and secure sources of energy.

The MFC Five-Year Investment Strategy is complementary to the MFC Five-Year Mission Strategy and MFC Operations Management Improvement (OMI) Strategy. The relationships between these documents can be summarized as follows:

- The MFC Five-Year Investment Strategy defines infrastructure needs, estimated costs, and timeline necessary to meet the MFC mission strategy.
- The MFC Five-Year Mission Strategy defines the MFC outcomes and strategies required to meet DOE and INL Laboratory objectives identified in the INL Laboratory Plan and DOE-NE programs.
- The MFC OMI Strategy identifies barriers to MFC success in terms of people, processes, and additional equipment needs not identified in the investment strategy. The OMI Strategy defines actions and timelines to remove those barriers.

Last, annual budget development is done through the Integrated Resource Planning Tool which identifies and allocates resources and funding required to meet mission objectives, within the constraints of annual appropriations. Identified investments required to support continued facility reliability, to recapitalize legacy infrastructure, and to enable mission objectives consistent with these strategies form the basis of MFC out-year budget requests.

1.1 An Investment Strategy for the Materials and Fuels Complex

MFC supports current RD&D missions while enabling new projects and missions working with DOE-NE sponsors, other federal agencies, private industry, and academia. The investment strategy described in this document guides the efforts to build, expand, and sustain DOE-NE research capabilities at MFC, increase access to MFC capabilities by industry and the nuclear RD&D community, and revitalize existing MFC nuclear infrastructure. The strategy also anticipates and guides the preparations necessary for demonstration of advanced nuclear energy technologies in support of NRIC, the DOE Gateway for Accelerated Innovation in Nuclear (GAIN) initiative, and nuclear energy and other related critical outcomes identified in the INL Laboratory Plan.

MFC’s core research and production competencies exist in the following areas:

- Nuclear fuels fabrication
- Fuel characterization
- Materials characterization: Radiation damage in cladding and reactor components
- Fuel recycling and nuclear material management
- Transient irradiation testing
- Radioanalytical chemistry
- Space nuclear power
- Reactor safety in design integration, authorization and licensing (new)

- Test bed engineering and advanced microreactor support (new)
- Focused basic research
- Isotope production
- Nuclear nonproliferation and nuclear forensics.

The investment strategy for MFC addresses building and improving on these core competencies, introducing new and revitalized RD&D capabilities, and maturing the NRIC test bed. MFC is also implementing new business and operations models to help transform MFC into a complex that supports an advanced nuclear technology development test bed. The strategy for MFC is presented in several parts, each focusing on an element needed for success.

Key distinctions for this strategy include the following categories:

- **Base Operations and Maintenance** – This recognizes efficient base operations as a core foundation of RD&D execution excellence, including basic preventive and corrective maintenance of MFC’s nuclear facilities. This supports DOE-NE programmatic objectives by maintaining, as needed, to ensure the safe, more efficient operations of MFC.
- **Plant Health Investments** – Investment in plant health beyond basic preventative and corrective maintenance addresses revitalization and refurbishment of facility systems and equipment for improved reliability and accelerated research throughput. This supports DOE-NE programmatic objectives by improving existing test bed infrastructure and constructing new support infrastructure, as needed, to ensure the safe, more efficient operations of MFC and to establish improved capabilities in support of nuclear RD&D.
- **Mission Operations and Maintenance** – This critical part of the MFC-wide operations model transitions MFC towards a user facility concept by providing predictable and reliable base funding to support a core team of expert RD&D support staff and critical RD&D equipment, instruments, and test bed systems. The term “user facility” denotes a step change transition from providing only stable, reliable single-source funding for compliance-level base operations and maintenance; it also includes funding to maintain RD&D support staff and critical RD&D infrastructure such that staff and systems are ready to support important research missions. This is distinct from base operations which focuses on systems and infrastructure associated with building operations (heating, ventilating, and air conditioning [HVAC], electrical, safety systems, building roofs and shells, etc.) and maintains facility safety bases and compliance requirements. Mission Operations and Maintenance ensures reliable state-of-the-art research capabilities are available to effectively provide RD&D services as envisioned by GAIN and NRIC. Full cost recovery from research programs for costs related to executing mission related RD&D support activities is part of the financial model and includes disposition of research related material and waste.
- **Instrument Science** – The Instrument Science emphasis builds on core strengths in collaboration with INL Nuclear Science and Technology (NS&T) programs, NRIC, the Nuclear Scientific Users Facility, National Homeland Security (NHS) programs, and others to prioritize and pursue funding for construction or enhancement of future or current capabilities where national gaps exist. (This can also include indirect laboratory investment in scientific capabilities.) It recognizes leveraging the key partnerships with other DOE national laboratories such as Oak Ridge National Laboratory (ORNL), Argonne National Laboratory (ANL), and others as well as building relationships and furthering partnerships with DOE-NE’s extended research network to fill capability gaps in locations other than MFC. MFC seeks to improve or establish relationships with U.S. universities to further extend the nuclear research network, provide a pipeline for recruiting future staff, and positively influence educational programs. This also provides additional collaboration pathways with the international community through INL’s designation as an International Centre based on Research Reactor (ICERR) by the International Atomic Energy Agency (IAEA).

This investment strategy positions INL and its sponsor, DOE-NE, to deliver an effective nuclear R&D capability and continue to build an accessible, comprehensive, reliable, and cost-effective nuclear demonstration capability that supports deployment of nuclear technology. This capability will play a key role in developing advanced nuclear technology concepts that can positively impact the ability of U.S. nuclear energy technology to keep pace with a changing world energy market.

This document includes:

- A description of MFC facility infrastructure support needs in Section 2
- A description of MFC scientific infrastructure support needs in Section 3
- A forward-looking vision for development of the MFC campus in Section 4
- Details of specific plant health and RD&D capability target areas in Appendixes A and D
- Descriptions of general infrastructure needs in Appendix C
- Detailed descriptions of Transient Reactor Test Facility (TREAT) investments and instrument capability activities in Appendix B and E.

NOTE: *The cost estimates listed in the tables in Sections 2 and 3 of this document are based upon best engineering judgement at the time the scope was identified by the MFC Directors and staff. In every case the cost estimates will change as work proceeds through planning, design, and execution. The intent of these tables is to provide a strategic context on what areas within MFC facility and scientific infrastructure have been identified as important to address facility reliability, RD&D capability sustainment, and capability growth to support the test bed and NRIC concept.*

1.2 Anticipated Investment Strategy Outcomes

MFC recognizes that implementing this strategy requires significant investment with attendant responsibility for return on the investment. Implementing this strategy results in the following outcomes:

- Increased facility and equipment reliability and availability, reducing the experiment lifecycle of RD&D critical to DOE-NE and other missions
- More efficient operations, increasing the amount of critical knowledge gained per dollar spent on research
- A wider range of RD&D capabilities that support a range of objectives from scientific discovery and model validation to demonstration and licensing
- Increased capability to broaden technology readiness level coverage and support the Nuclear Energy R&D Test Bed concept in a reliable manner
- Compliance with regulatory requirements, ensuring commitments are understood and met.

To mark progress toward these outcomes, MFC performance metrics focus on factors important to enabling and monitoring MFC's nuclear energy RD&D mission. Metrics target the following:

- Reduction of deferred maintenance and repair needs – Documented levels of deferred maintenance in the Facility Information Management System will be reduced
- Increased facility availability – The percentage of time major facilities are available to support RD&D will increase with increased reliability of key operational systems in the R&D facilities
- Increased instrument and equipment use – Use of key RD&D instruments will be tracked to provide data for identifying instrument reliability, performance, and resource issues and to help with future planning for instruments and personnel resources
- Increased ability to meet key RD&D's operational and strategic milestones and objectives – MFC maintains a comprehensive list of RD&D program, key operational, and strategic milestones and objectives and tracks performance to these commitments.

- Quality, relevance, and impact of research output – Metrics used to demonstrate an increase in the contribution MFC is making to nuclear energy knowledge includes the following:
 - Number and quality of peer-reviewed publications and reports
 - Number of external users relying on MFC RD&D capabilities
- Stakeholder Feedback through entities such as the INL Materials and Fuels Complex Strategic Advisory Committee or others (e.g., NS&T, NHS, external industry, small business, and university users).

1.3 Funding Model

MFC is the hub of the DOE-NE test bed and NRIC. The funding strategy below aligns MFC with the overall DOE-NE objective of developing a nuclear energy test bed that can enable innovative nuclear energy technology to pass swiftly through the technology readiness levels. This positions new technology for deployment into the commercial sector as a safe cost-competitive carbon-free energy source.

Figure 1 provides a diagram of the main funding areas addressed in this investment strategy. Elements shaded blue are proposed to be funded by the Idaho Facilities Management (IFM) program and the green shaded element should be supported by multiple funding sources including NE RD&D programs and laboratory indirect investments. Key here is stable, predictable funding to cover the Base Operations, Maintenance and Plant Health and Mission Operations and Maintenance needs described in Section 1.1. Overall funding levels to build an effective test bed and to reestablish DOE-NE as the world leader in innovative nuclear energy technology are identified in Table 1. New construction associated with developing the NRIC/GAIN test bed and demonstration platform described in Section 4 is separate funding from test bed infrastructure operations included here.

INL's ability to perform world class research, development, and demonstration depends on maintaining nuclear RD&D facilities, scientific instruments, necessary scientists and staff to support greater science throughput and shorten the experiment lifecycle

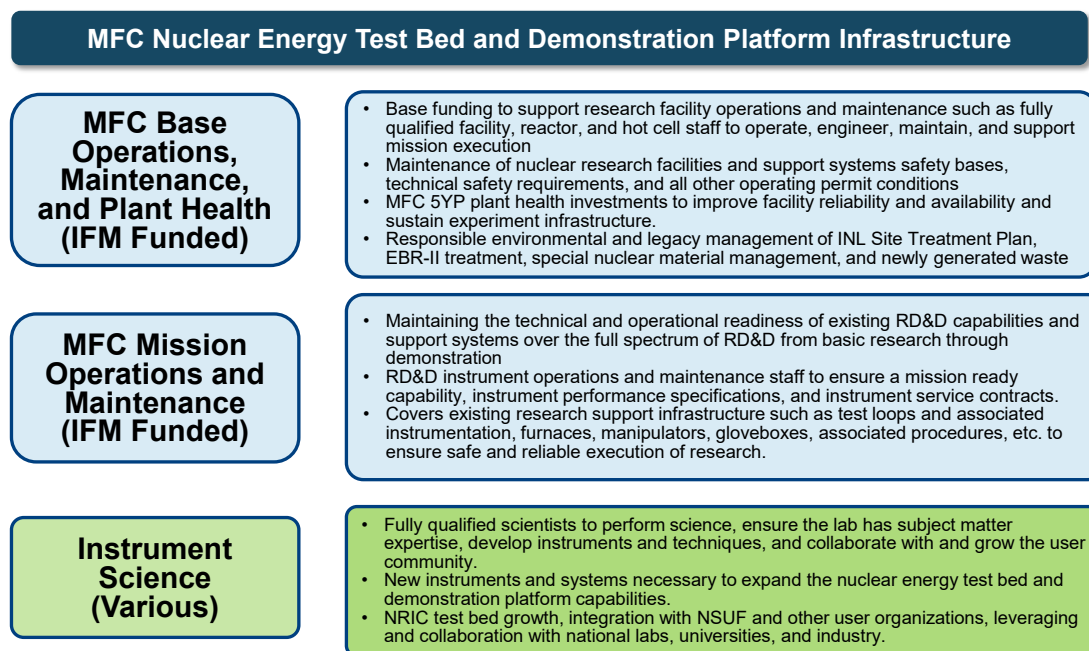


Figure 1. DOE-NE test bed and demonstration platform funding strategy.

2. MFC FACILITY OPERATIONS AND INFRASTRUCTURE

Critical components associated with maintaining and enhancing MFC's facility infrastructure include:

1. MFC Base Operations and Maintenance – This provides compliance-level support to operate and maintain MFC nuclear and radiological facilities in a safe, stable, and compliant state of readiness to accept work. This includes TREAT base operations listed separately in the table below. (Subsection 2.1)
2. MFC Mission Operations and Maintenance – This provides funding above compliance level for the technical staff and material necessary to operate, maintain, and sustain current RD&D capabilities and associated support systems at a mission readiness level to be ready to support RD&D mission execution. (Subsection 2.2)
3. MFC Plant Health Strategic Investments – These are investments in plant systems and infrastructure above historical levels of corrective and preventative maintenance. These investments are focused on refurbishment and replacement of aging plant systems and instruments that can impact facility availability and reliability which can negatively affect mission execution and RD&D outcomes. The selection of plant health activities has been formalized into a prioritization process involving input by facility-specific technical personnel with an MFC-wide evaluation and prioritization by the MFC Complex Health Committee made up of the mission directors and chaired by the MFC Associate Laboratory Director. (Subsection 2.3)
4. Waste and Materials Management – These activities support meeting regulatory agreements between DOE and government entities such as the Idaho Settlement Agreement (ISA) and Site Treatment Plan. This also includes activities executed to reduce the legacy liability of INL. (Subsection 2.4)

A funding profile is shown in Table 1. These funding levels support the reliable infrastructure necessary to provide a mature test bed and demonstration capability.

Table 1. MFC proposed funding levels.

MFC Area	FY-23 Omnibus Level	FY-24 Omnibus Level	FY-25 Proposed Level	FY-26 Proposed Level	FY-27 Proposed Level	FY-28 Proposed Level
<i>MFC Reactor Operations</i>						
NRAD Operations and Maintenance	3,177	5,754	6,434	6,692	6,959	7,238
TREAT O&M	26,921	28,998	30,158	30,324	31,537	32,799
MFC Reactor Operations Total	30,098	34,752	36,592	37,016	38,496	40,037
<i>MFC Facility Infrastructure and Operations</i>						
MFC Base Operations & Maintenance	106,282	109,647	114,033	118,594	123,338	128,271
MFC 5 Year Plant Health Investments	15,663	13,730	30,000	30,000	30,000	30,000
MFC Mission Operations and Maintenance	48,280	50,211	52,219	54,308	56,481	58,740
SNM Program/Processing	4,682	4,869	5,064	5,266	5,477	5,696
SPL OPCs	5,950	6,000	850	0	0	0
Total MFC Facility Infrastructure and Operations	180,857	184,457	202,166	208,168	215,296	222,707
<i>MFC Regulatory Support</i>						
INL Regulatory Compliance	5,000	5,000	5,408	5,624	5,849	6,083
EBR II	8,814	8,814	10,600	11,024	11,465	11,924
MFC Regulatory Support Total	13,814	13,814	16,008	16,648	17,314	18,007
Total MFC Operations	224,769	233,023	254,766	261,832	271,106	280,751
<i>Line Item Construction</i>						
Sample Preparation Laboratory	7,300					
Advanced Nuclear Fuels Fabrication Laboratory		0	5,000	15,000	40,000	50,000
Construction Total	7,300	0	5,000	15,000	40,000	50,000
GRAND TOTAL	232,069	233,023	259,766	276,832	311,106	330,751

2.1 MFC Base Operations and Maintenance

Base Operations and Maintenance funding provides the resources needed to maintain nuclear and radiological facilities in a compliant state of readiness to accept work. This base work scope is not considered discretionary. This state of readiness has historically been defined as maintaining the facilities in a safe, compliant, and stable configuration within the established safety bases and regulatory framework to be available to support RD&D programs (Compliance Level), but it specifically includes the operations, maintenance, and support of nuclear facilities and resources to be ready to enable the conduct of advanced nuclear energy research at MFC.

Specific tasks include:

- Surveillance, maintenance, and operation activities required to control existing material and waste, and to maintain facilities in a safe and stable condition
- Ensuring regulatory requirements are met that relate to health and safety, fire protection, nuclear safety (facility authorization basis), criticality safety, and safeguards and security
- Compliance with state and federal environmental and operating permit requirements
- The engineering for structure, system, and component (SSC) modifications necessary to ensure safety and functionality
- Specific activities such as an equipment reliability program, systems engineering, improving configuration management, and plant health monitoring that efficiently ensures reliability of SSCs and the efficiency and safety in which maintenance and engineering is executed
- Enabling infrastructure such as fuel handling capabilities, a full suite of waste disposition pathways, and integrated cask management is available to support the mission
- Engineering and technical support resources needed to address the technical issues associated with operating multiple shifts in aging facilities to meet mission demands.

2.2 MFC Mission Operations and Maintenance

A sustainable and reliable nuclear RD&D capability requires a funding model that supports effective and efficient management of research instruments and RD&D facilities necessary to execute the current DOE-NE research portfolio and in support of an expanded mission anticipated through NRIC and GAIN. MFC Mission Operations and Maintenance provides the foundation for a comprehensive, reliable, and sustained research capability and a stable environment for recruiting, retaining, training, and improving the expertise of the scientific and support work force.

The proposed MFC Mission Operations and Maintenance activities support technical and operational readiness of RD&D capabilities (equipment and instruments) and the associated support systems including:

- Operation of instruments to develop new methods and techniques while not performing direct program work
- Maintenance of instruments including instrument service contracts (vendor maintenance agreements) to ensure performance specifications are maintained
- Upgrading and developing unique instrument applications to ensure world-class instrument and process performance
- Feasibility and safety evaluations for the use of various fuels and materials configurations
- Preparation of regulatory documentation to support RD&D needs
- Support for general user program relative to experiment setup and data analysis

- Training of staff and users in the operation or maintenance of instruments
- Maintenance, operation, and engineering of support systems such as inert gas, manipulators, experiment loops gloveboxes and furnaces to ensure safe and reliable performance
- Performance testing of integrated instrument systems
- Coordination and logistical support for instrument usage, maintenance, and testing
- Commodity usage such as gas and chemicals that support instrument operation
- Maintenance on in-cell/glovebox utilities and equipment that support instrument and RD&D capabilities such as feedthroughs and process instrumentation
- Maintaining inter-facility transport capabilities
- Operating and maintaining data and control networks.

Establishing a robust, direct-funded mission operations and maintenance platform is a key element in transition to a user facility model that has been successfully deployed in many government-sponsored research facilities and is critical to improve research throughput and efficiency. Steady and reliable mission operations and maintenance funding ensures that RD&D capabilities including instruments and scientific and technical resources are available to support DOE-NE mission execution. This eliminates the uncertainty associated with variable programmatic fund sources and ensures that facilities and instruments are maintained as world-class and mission-ready with the necessary technical expertise to enable mission success. This approach will dramatically increase throughput and reduce the experiment life-cycle time. Additionally, the U.S. ability to lead collaborative efforts is instrumental in reestablishing U.S. leadership in advanced nuclear energy technologies and research techniques.

2.3 MFC 5-Year Plant Health Strategic Investments

MFC plant health investments are a key aspect of a healthy and efficient NE RD&D test bed model required to support NRIC and require dedicated and sustained funding. Plant health investments include targeted major maintenance and repair activities that addresses system and equipment degradation that sustains or increases facility availability and throughput. These investments exceed base operations and maintenance funding levels. These investments will reduce MFC deferred maintenance (DM) and key repair needs (RN).

Targeted major maintenance and repair efforts include hot cell window replacements and next-generation manipulators in the Hot Fuel Examination Facility (HFEF), Fuel Conditioning Facility (FCF), and Analytical Research Laboratory (ARL), FCF Suited Entry Repair Area (SERA) crane replacement, roof repairs for nuclear and radiological facilities, replacement of MFC fire protection and potable water systems, replacement of MFC industrial wastewater systems, and HFEF/FCF in cell handling equipment refurbishment and replacement. This funding enables facilities to sustain multiple shifts and to handle the increased maintenance burden as they operate at increased capacity. The MFC investment strategy identifies the highest priority risks to facility reliability and RD&D experiment throughput and proposes a multi-year strategy to address these risks. The strategy also addresses DM across all MFC nuclear and radiological facilities. Priorities are established by analysis of overall risk to facility availability and system reliability. The total integrated plant health and RD&D capability and sustainment requests are detailed in Table 2 and Table 10.

Annual appropriations available to support plant health investments has been significantly less than the \$30M annual target requested in the investment strategy. These reduced levels require prioritization of funds to projects the MFC leadership team has determined to provide the highest return in terms of facility reliability and research throughput. MFC has implemented a disciplined process to identify and assign a relative priority to plant health issues using an MFC Complex Health Committee (CHC) prioritization process. This process is captured in MFC-ADM-0006, “Materials and Fuels Complex

(MFC), Facilities and Complex Health Reporting Process.” This procedure describes the integrated and coordinated complex wide reliability and health issue management process that MFC uses to identify, evaluate, monitor, maintain, repair, and upgrade site Structures, Systems, and Components (SSCs) important to safe and reliable facility operations and to meeting mission goals. This process utilizes the Long Term Asset Management (LTAM) component of the ER Suite Reliability software tool. It addresses key aspects necessary for the CHC to prioritize MFC plant health needs within available funding. This process is designed to identify and prioritize risks to facility reliability and RD&D mission execution with a goal of ensuring facility reliability risks are identified and addressed before impacts to facility availability or RD&D capability occur. Steady and reliable funding to support a sustained plant health campaign is a critical aspect of the new test bed model and is essential to enable increased RD&D throughput and mission execution success.

The HFEF is DOE-NE’s principal post-irradiation examination (PIE) facility originally commissioned in 1974. Nearly all irradiated samples are processed through HFEF before being sent out to other facilities. This 5YS addresses deficiencies in HFEF systems that currently limit research throughput and ensures that MFC’s support for DOE’s mission is not negatively impacted. Critical HFEF systems and research equipment are being refurbished and replaced to increase facility reliability, and experiment throughput. MFC is focusing in in-cell handling equipment such as manipulator and cranes as well as refurbishing hot cell windows,

The HFEF main cell pressure/temperature, purification, and compressed argon systems use obsolete technology. The argon compressors have been replaced by a new tank system. Key components of the temperature and pressure system are exhibiting increasing failure rates, and many times spares are not available or require a vendor to custom fabricate special-order spares on a limited basis. This approach to patching the system is expensive, time consuming, and does not fundamentally resolve the reliability issues. Current efforts to update these systems will minimize future programmatic impacts due to system reliability.

HFEF electrical systems have, for the most part, remained unchanged and have only had minor modifications performed since HFEF was constructed in the 1970s. System failures are increasing, and spare parts and vendor support is rapidly disappearing; there are no spares available for the breaker panels and motor control centers.

HFEF recently replaced aging back-up power generators relocated adjacent to HFEF from the HFEF basement. This frees up footprint for HFEF to expand test bed capabilities related to the neutron beam lines associated with NRAD while minimizing facility downtime associated with transition to the new generators.

Obsolete equipment within the Met Box system is being to update with modern equivalents. The hoist replacement was completed during FY-23. Various other components that can be controlled by the programmable logic controller (PLC) will be replaced. The project will replace several system valves with modern equivalents capable of communication with the PLC. Gas analyzers, tubing, valves, pumps, and other equipment will be replaced. A purification system and mixing station will communicate with the PLC to control the atmosphere within the Met Box.

The ARL is MFC’s principal facility for obtaining analytical chemistry and related data analysis on nuclear fuels and materials. ARL received its first hot fuel sample from the Experimental Breeder Reactor-II in 1964 and has been in continuous operation since. ARL is a Hazard Category (HC)-3 Nuclear Facility with approximately 10,000 ft² of laboratory space. The ARL HVAC system was no longer capable of supporting additional research or analytical capability. The HVAC system was refurbished and upgraded to support growth in RD&D capabilities and increase facility reliability. ARL is also executing lab renovations and fume hood replacements throughout the facility to modernize the labs and increase operating efficiency. Critical support systems are also being replaced to support more efficient operations and the increased throughput of analytical samples through the laboratory.

The ARL safety and eye wash system utilizes potable water as the flushing water source. Potable water is pumped directly from the ground at approximately 55 degrees. The American National Standard Institute (ANSI) for emergency eyewash and shower requires a minimum of 60 degrees for 15 minutes at 20 gpm for showers, and 0.4 gpm for 15 minutes for eyewashes. These levels are unattainable with the current system and pose a real safety concern during times of distress in abnormal situations. Therefore, the ARL plans to purchase a skid system, circulating piping loop that flows to each eye wash and safety shower station, and back to the skid and install in FY-24.

The ARL currently purchases ultra-pure water each month for use in the laboratory. The ARL is purchasing and installing units to provide water purified and de-ionized to a conventional standard, ensuring native elements in supplied water do not interfere with the quantification of elemental and isotopic analytes in solution during investigation, improving the results of sample analyses in that laboratory.

The HFEF, FCF, and ARL master/slave manipulators and electro-mechanical manipulators (EMM) are key systems that move equipment and material and execute RD&D within the MFC hot cells. These are aging and replacement components are difficult or impossible to acquire. Identification and replacement of the obsolete EMM crane and PaR in FCF and HFEF will improve in-cell capabilities to support ongoing and future mission work. Each set of manipulators services a unique capability(s) within the facility hot cells; manipulator failures remove that particular capability from service and impact mission execution. To address a large portion of this issue, MFC has partnered with a vendor to design and fabricate the next generation of manipulators while ensuring that the existing manipulators can be maintained and serviced. Addressing the manipulators is underway and will continue over several years all manipulators have been replaced with reliable next-generation and more ergonomic equivalents or full refurbishment of all manipulators. New models of manipulators from another vendor have been procured and are being installed in the ARL hot cells. These are significant improvements to the older models and support more efficient sample analysis and improved ergonomics for the staff. Ongoing evaluation of these alternatives to the current suite of manipulators will continue.

The hot cell windows at HFEF and FCF were fabricated over 50 years ago. These windows are four feet thick and comprise tank units filled with alternating layers of glass and mineral oil. Several of the units are leaking mineral oil, which requires resources to manage and mitigate the impacts, increasing cost and decreasing operations efficiency. An ongoing window replacement campaign staged over several years targets HFEF, FCF, and ARL hot cell windows. ARL is also investigating the use of oil-free hot cell windows to reduce maintenance associated with leaking windows.

FCF priorities include addressing the facility control system for hot cell operations and for in-cell process equipment. The first phase, originally funded in FY-19, replaced the small logic controllers for the system. Four new safety significant feedthroughs for FCF's hot cells were fabricated in FY-23. The existing feedthroughs were producing spurious failure notifications decreasing facility reliability and requiring significant time and effort for troubleshoot and repair. Follow-on phases will include incorporation of facility programmable logic controllers and other process control systems without changing functionality. Equipment to eliminate the need for handling legacy EBR-II fuel elements are being designed, fabricated/procured, and installed. The reliability of the high bay crane will be addressed in the future.

Currently, the Radioactive Liquid Waste Treatment Facility (MFC-789) is in the process of being repurposed for upcoming future projects and will no longer be able to process liquid waste from FCF or HFEF. An alternative method of collecting radioactive liquid waste from these facilities is necessary to continue supporting their respective missions. FCF and HFEF drum filling stations will allow transfer of their liquid waste and fill 55-gallon drums for shipment to off-site disposal facilities. A drum filling station is being installed in the basement of HFEF and a separate station will be installed in the truck lock at FCF.

Execution of the in-cell installation and phase-III qualification of the Scraped Cathode Rod Assembly Prototype Equipment (SCRAPE) in FCF is underway, and when complete will support concept development. The scope includes recovery of the prototype components previously fabricated for evaluation and assembly in support of out of cell qualification prior to in-cell installation. In cell operational trials are planned to be conducted in the MK-V electrorefiner and will determine effectiveness, as well as any design changes necessary to mitigate the concept to the MK-IV.

Several facility reliability issues at FCF are now being addressed with additional funding received as part of the 2022 Inflation Reduction Act (IRA). This funding is associated with IRA funding earmarked to address NE infrastructure deficiencies at INL. This includes the process control systems discussed above. Other material handling capabilities such as the SERA crane are also being refurbished. Additional funds may be provided to address scope associated with high assay low enriched uranium (HALEU) production.

Through plant health investment, the criticality alarm systems (CAS) at the Fuel Manufacturing Facility (FMF) and Zero Power Physics Reactor (ZPPR) facilities have been replaced. The ZPPR roof is aging and is being refurbished to address infiltration of precipitation. Identified and ongoing investments support effective and efficient nuclear material management, increased system capacity to support the growing fuel fabrication demand, and resolution of legacy facility structure issues. Additional investment to establish ZPPR as the Laboratory for Operations and Testing in the United States (LOTUS) test bed and the Experimental Breeder Reactor-II dome as the Demonstration of Microreactor Experiments (DOME) test bed in support of advanced reactor demonstrations through NRIC are in-progress as of FY-23.

Deficiencies in fire barriers and penetrations in five separate MFC nuclear facilities (MFC-752ARL, MFC-1702, MFC-765, MFC-709, and MFC-785) are being repaired or replaced. Deficiencies include: wall and ceiling penetrations from various existing or abandoned utilities, that are unfilled or improperly filled, ceiling and wall connections that are not properly sealed and fire doors, windows, and dampers that do not meet the requirements for fire barriers.

Ongoing investment in data communications infrastructure (wired and wireless) is necessary to improve overall effectiveness and efficiency at MFC. Cyber security considerations must also be assessed and managed to support secure execution of the RD&D mission. Continued update and refurbishment of communications and cyber infrastructure enable safety, security, and mission effectiveness and becomes more urgent as technology advances and communication, cyber security, and data management needs increase.

A sustained plant health campaign at proposed funding ensures aging infrastructure at MFC remains reliable and available to support DOE-NE mission execution and can support the additional RD&D capacity and capabilities anticipated as the test bed grows and expands across more technology readiness levels.

Table 2. Prioritized MFC Plant Health investment. Cost in thousands (\$K).

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
1	HFEF/FCF/ARL	Manipulator Refurbishment and Replacement Campaign in HFEF, FCF, and ARL	\$5,059	\$1,264	\$1,413	\$3,000	\$3,000	\$3,000	\$3,000	TBD	\$19,736
2	HFEF/FCF/ARL	Hot Cell Window Replacement Campaign in HFEF, FCF, and ARL	\$1,984	\$268	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	TBD	\$12,252
3	FCF	Multi-Function Furnace #1	\$8,028	\$1,391	\$459						\$9,878
4	HFEF/FCF/ARL	Radioactive Liquid Waste Treatment Facility Process/Storage Tanks Replacement	\$2,843	\$341	\$1,274						\$4,458
5	HFEF	Small and Large Transfer Lock Doors and Drive Control System Upgrade	\$1,228	\$223	\$453						\$1,904
6	HFEF/FCF	Electro-mechanical Manipulator, Cranes, Hoists and Other In-Cell Handling Equipment Refurbishment and Replacement	\$5,072	\$2,906	\$6,224	\$3,201	\$1,115	\$41			\$18,559
7	FCF	Replace FCF SERA/DSC Crane and Control Equipment		\$74	\$1,750	\$4,025	\$6,151				\$12,000
8	FCF	New SCRAPE Cathode Module for FCF Electrorefiner	\$1,733	\$17	\$951						\$2,701
9	FCF	Replace FCF Facility Control System	\$2,483	\$281	\$445	\$1,141					\$4,350
10	ARL	ARL Lab Space Renovations	\$2,354	\$213	\$675	\$2,800	\$2,000	\$2,000			\$10,042
11	HFEF	Argon Regeneration Valve Replacement	\$544		\$500	\$1,500					\$2,544
12	HFEF	MetBox Refurbishment - Purification System Replacement	\$747	\$525	\$68						\$1,340
13	FCF	FCF In-Cell Lighting Feedthroughs	\$871	\$61	\$352						\$1,284
14	TREAT	I&C Obsolescence: Experiment Data Acquisition System (EDACS) Installation/Upgrade		\$290	\$20						\$310
15	MFC	Fire Barrier Refurbishment for MFC Nuclear and Radiological Facilities	\$51	\$473	\$993						\$1,517
16	HFEF	Refurbish Precision Gamma Scanner		\$734	\$791	\$458					\$1,983
17	MFC	Replace MFC Fire Protection and Potable Water System		\$87	\$4,500	\$8,625	\$1,788				\$15,000
18	MFC	Replace MFC Industrial Wastewater System		\$672	\$1,925	\$5,810	\$1,593				\$10,000
19	ARL	Emergency Shower/Eyewash Compliance Updates	\$36	\$576	\$857						\$1,469

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
20	Nuke/Rad Facilities	Roof Repairs for Nuclear/Radiological Facilities		\$556	\$10,220	\$7,500	\$1,724				\$20,000
21	ARL	Ultra Pure Water Stations		\$120	\$180						\$300
22	TREAT	He-3 Injection System Final Design and Hardware Procurement		\$846	\$1,940	\$414					\$3,200
23	TREAT	Reactor Building Exterior Stair Upgrade		\$200	\$126						\$326
24	TREAT	Zone 9 Platform Addition		\$31	\$625						\$656
25	NRAD	NRAD Fuel Procurement		\$750	\$3,200	\$ —	\$1,750	\$1,300			\$7,000
26	HFEF	HFEF Fire Suppression, NRAD East Radiography Station & Preparedness			\$500	\$500					\$1,000
27	FMF	Increase HVAC Capacity to Support Facility Heat Load			\$500	\$1,000					\$1,500
28	FMF	Expand Waste Drum Storage Capacity			\$300	\$300					\$600
29	TREAT	MFC-722 Roof Replacement			\$217						\$217
30	TREAT	Big Buster Facility Support Equipment Upgrades			\$300						\$300
31	FCF	Install FCF Drum Filling Station			\$750	\$750					\$1,500
32	IMCL	IMCL Ventilation Modification			\$500						\$500
33	HFEF	HFEF Hot Cell Chiller Replacement			\$500	\$1,500					\$2,000
34	IMCL	IMCL Laboratory House Chiller System			\$750	\$1,250					\$2,000
35	HFEF	Building Lab Exhaust Fan Replacement			\$500	\$2,500					\$3,000
36	MFC	MFC Glovebox Oxygen Monitors			\$900						\$900
37	FMF	Replace AFCI Glovebox Purification Units			\$1,500						\$1,500
38	IMCL	Establish Backup Power Connection			\$500						\$500
39	FCF	Replace FCF Decon Spray Chamber Chiller Unit			\$500	\$1,500					\$2,000
40	TREAT	Scoping Assessment on I&C Obsolescence			\$200						\$200
41	TREAT	I&C Obsolescence: Reactor Building-to-Control Building Cable Replacement: Engineering			\$550						\$550
42	TREAT	Radiography System Modifications Upgrade			\$200						\$200
43	TREAT	TREAT Reactor Building, Room 108 AC Units Replacement - Engineering Design			\$200						\$200
44	TREAT	TREAT 15-Ton Remote Control System Replacement			\$300						\$300

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
45	TREAT	MFC-720 East Gate Replacement			\$300						\$300
46	TREAT	MFC-720 / MFC-722 HVAC Upgrades			\$350						\$350
47	TREAT	Replace TREAT Loop Handling Cask Winch System				\$75	\$25				\$100
48	TREAT	I&C Obsolescence: Reactor Trip Logic & Actuator Interface Replacements				\$200	\$1,500	\$1,900	\$1,900	\$1,500	\$7,000
49	TREAT	TREAT Critical Spares for ARCS, DIS, and RTS				\$200	\$200				\$400
50	TREAT	I&C Obsolescence: TREAT Dedicated Microprocessor Tester Development & Installation				\$150					\$150
51	MFC	Compressed Air Supply System for Research Facilities				\$1,000	\$3,000			\$8,000	\$12,000
52	HFEF	HFEF Hot Cell HEPA Replacement				\$1,000	\$3,500	\$500			\$5,000
53	IMCL	New Instrument Room and Mezzanine in IMCL				\$2,000					\$2,000
54	FCF	Replace McQuay Air Conditioner				\$500	\$1,500				\$2,000
55	FMF/ ZPPR	Provide Additional Storage Areas for FMF and ZPPR				\$1,000					\$1,000
56	FCF	High Bay Crane Refurbishment/Upgrade				\$2,500	\$2,500				\$5,000
57	IMCL	Hoar Frost Buildup on HVAC Intake Filters				\$350					\$350
58	RCL	RCL Backup Power				\$1,750					\$1,750
59	HFEF	Decontamination Spray System				\$1,500					\$1,500
60	TREAT	BAR HVAC Duct Remediation & Upgrade				\$300					\$300
61	TREAT	TREAT 15-Ton Crane Replacement				\$2,000					\$2,000
62	TREAT	Replacement Inert Gas Regulators and Valves				\$150					\$150
63	TREAT	TREAT Security Building (MFC-722) Replacement				\$350	\$1,000	\$1,150			\$2,500
64	FCF, FASB	Install Facility-Specific Plant Cooling Water Systems					\$500	\$3,000	\$6,500		\$10,000
65	HFEF	HFEF Intrafacility Pneumatic Sample Transfer Systems Overhaul					\$850	\$2,250			\$3,100
66	MFC	Interfacility Pneumatic Shuttle Transfer System Refurbishment					\$650	\$7,150	\$2,200		\$10,000
67	ARL	Analytical Lab Process Management System Upgrade					\$250	\$1,250			\$1,500
68	FCF	HRA Reactivation					\$500	\$3,500	\$3,000		\$7,000

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
69	TREAT	I&C Obsolescence: Nuclear Instrument Spares & Replacement Chassis					\$200	\$1,000	\$1,000	\$1,000	\$3,200
70	TREAT	I&C Obsolescence: Automatic Reactor Control System Master Clock Spare or Replacement					\$350	\$350			\$700
71	TREAT	I&C Obsolescence: Auxiliary Electronics Spares & Replacement Chassis					\$200	\$600	\$200	\$1,400	\$2,400
72	NRAD	NRS Elevator and Cask Interface Upgrade					\$250	\$1,100	\$2,750		\$4,100
73	ARL	Acid Scrubber Replacement					\$3,000				\$3,000
74	TREAT	Reactor Building Radio Signal Booster						\$100			\$100
75	FCF	Replace FCF Argon Cell North and South Recirculation Blower and Install Purification Instrument						\$300	\$2,200		\$2,500
76	HFEF	In-Cell Compressed Argon Manifold Supply and Associated Controls						\$750			\$750
77	HFEF	Replace HFEF Freight Elevator						\$500	\$1,500		\$2,000
78	FASB	Upgrade FASB Ventilation System						\$500	\$1,500		\$2,000
79	ARL	ARL Hot Cell 5 and 6 Reconfiguration						\$1,200	\$2,000	\$3,300	\$6,500
80	ARL	Waste Volume Reduction Capability (A28)						\$400	\$2,000	\$2,600	\$5,000
81	TREAT	Replace TREAT Control Rod Segments							\$1,250		\$1,250
82	FCF	FCF Material Tracking System and Support Infrastructure Replacement							\$1,000	\$4,500	\$5,500
83	ARL	Replace Backup Diesel Generator								\$3,000	\$3,000
84	ARL	Instrument UPS Installation								\$1,250	\$1,250
85	ARL	ARL Multi-Zone System Overhaul								\$5,000	\$5,000
86	ARL	Decontamination and Demolition of Abandoned Lines and Equipment								\$10,000	\$10,000
87	FMF	FMF HVAC/Suspect Exhaust System								\$2,500	\$2,500
88	FMF/ ZPPR	Implement Uniform SNM Containers and Design Verification								\$3,500	\$3,500
89	FCF	In-cell Periscope and Camera System Replacement								\$2,500	\$2,500
90	ARL	Addition of Pneumatic Transfer Line from AL Hot Cells								\$3,500	\$3,500
91	IMCL	Contamination Control Updates								\$1,500	\$1,500

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
92	Nuke/ Rad Facilities	MFC Private Facility Control Network (PFCN) Critical Infrastructure, Industrial Controls Servers, and Data Repository Storage Facility								\$10,000	\$10,000
93	FASB	Install FASB Vacuum System								\$1,000	\$1,000
94	ZPPR	Install Uranium Process & Synthesis Glovebox in ZPPR Workroom								\$5,000	\$5,000
95	ZPPR/ AFF	Refurbish Concrete Floors								\$250	\$250
96	HFEF	HFEF Building Chiller and Cooling Tower Upgrade								\$3,000	\$3,000
97	HFEF	HFEF Main Cell Exhaust Replacement								\$3,000	\$3,000
98	HFEF	HFEF Cask Cart Control System Refurbishment								\$750	\$750
99	HFEF	HFEF Facility Electrical Distribution System Refurbishment								\$3,000	\$3,000
100	HFEF	Containment Box Temperature Control								\$2,000	\$2,000
101	HFEF	Seal Pot#2 Relief Valve Replacement								\$1,500	\$1,500
102	HFEF	Renovate and Expand Women's Restroom								\$750	\$750
103	ARL	Air Conditioning Unit Condenser Replacement								\$500	\$500
104	ARL	Permanent Cover Over Sodium Wing Stairwell								\$500	\$500
105	ARL	Hot Cells 1, 2, and 3 Reconfiguration								\$2,000	\$2,000
106	IMCL	EPMA Instrument Enclosure within the EPMA SAS								\$500	\$500
107	FCF	Convert Steam Heat to Electric								\$5,000	\$5,000
108	FCF	Refurbish/Replace Vilter Freon Compressors								\$6,000	\$6,000
109	FCF	Additional Argon Supply Tank								\$2,500	\$2,500
110	RSWF	Backup Electrical Supply for RSWF								\$3,000	\$3,000
111	HFEF	Main Cell Gas Chromatograph								\$1,000	\$1,000
112	MFC	Modernization of MFC Data Archival Software System								\$1,000	\$1,000
113	MFC	Industrial Control System Engineering Cyber Requirements Implementation								\$5,000	\$5,000
114	IMCL	Intrafacility Pneumatic Transfer Capability								\$4,500	\$4,500
115	FCF	Satellite Analytical Lab Capability								\$4,000	\$4,000

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
COMPLETED INVESTMENTS											
	FCF	Integrate Bottle Inspection w/Wire Removal Process Improvement	\$2,107	\$13							\$2,120
	HFEF	Argon Cell Temperature and Pressure Controls	\$2,186								\$2,186
	FMF	Replace the Criticality Alarm System (CAS) in FMF	\$1,325								\$1,325
	ZPPR	Replace the Criticality Alarm System (CAS) in ZPPR	\$1,259								\$1,259
	HFEF	Facility Out-of-Cell 40-Ton High Bay Crane	\$3,217								\$3,217
	HFEF/IMCL	Compressed Argon Supply System	\$1,087								\$1,087
	MFC	Legacy Materials Disposition	\$3,764								\$3,764
	RCL	Convert Heating from Steam to Electric	\$647								\$647
	FMF/ZPPR	FMF Roof Replacement/ ZPPR Roof Repair	\$8,100								\$8,100
	IMCL	Noise Reduction Modifications	\$148								\$148
	IMCL	Fixed Air Sampling System	\$575								\$575
	IMCL	IMCL Facility Ventilation System Optimization	\$86								\$86
	IMCL	IMCL Facility Manipulator Repair Capability	\$1,200								\$1,200
	IMCL	IMCL Communications Infrastructure	\$278								\$278
	IMCL	IMCL Material Transfer Optimization	\$556								\$556
	Sitewide	Radiation Monitoring Updates	\$1,500								\$1,500
	ARL	ENU Replacement	\$1,603								\$1,603
	HFEF	Exterior Roof/Stack Access Stair	\$250								\$250
	HFEF	Argon Compressor Removal	\$581								\$581
	HFEF	HFEF Truck Lock Floor Repair	\$250								\$250
	EBR-II	Continued EBR-II Dome Test Bed Platform Refurbishment (carryover)	\$2,853								\$2,853
	HFEF	HFEF Standby Diesel Generator Removal & Replacement	\$5,671								\$5,671
	FASB	Install Equipment Enclosure and North Side Upgrades	\$500								\$500
	ZPPR	ZPPR Vault Cooling System Upgrade	\$390								\$390
	ZPPR	ZPPR Vault Cooling System Upgrade	\$400								\$400

MFC FIVE-YEAR INVESTMENT STRATEGY

MFC Overall Priority	Asset Name	Name	Prior Years	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Outyears	ROM Point Estimate
	ARL	AL EIFS Installation	\$1,104								\$1,104
	ARL	Lab B-103 Refurbishment	\$1,315								\$1,315
	ARL	Replace or Upgrade the AL HVAC System	\$16,613	\$886							\$17,499
	FCF	Design, Fab, and Install Feedthrough in FCF to Support CO ₂ Cold Jet Decon System	\$458	\$122							\$580
	HFEF	Containment Box Lid Seal & Hoist	\$917	\$26							\$943
	AFF	AFF Modifications (HVAC)	\$2,860								\$2,860
Total Actual/Estimated SYS Costs			\$94,350	\$12,276	\$33,418	\$37,698	\$29,840	\$35,841	\$34,000	\$120,800	\$339,356
Total IFM SYS /Request Authorized Funding			\$134,097	\$15,663	\$13,730	\$30,000	\$30,000	\$30,000	\$30,000	\$30,000 annually	\$283,490
Total Actual/Estimated Infrastructure IRA Costs			\$ —	\$1,670	\$18,840	\$27,101	\$11,256	\$ —	\$ —		\$58,867
IRA Infrastructure Funding Authorization			\$64,250								\$64,250
NOTE: Costs/Funding levels reflect actual costs through FY 23 plus estimates at completion for activities still in progress. Remaining funding levels are rough order of magnitude estimates based upon current scope understanding and will be refined as detailed execution planning is completed. Identified SYS funding represents funding applied under AF0202, excluding allocation of carryover funds. Planning basis for SYS project prioritization based on \$30M/yr.											
Green shaded represent scope authorized to proceed Authorized to proceed. Funded by the Inflation Reduction Act of 2022. Includes multiple sub-projects.			The ranking priority of scope in the "Outyear" column is subjective and will change as emergent scope is identified and priorities evolve. Assumes future SYS annual funding of \$30M/yr; annual estimated costs account for planned carryover.								

After 6 years of resumed operation of the TREAT reactor, following over 23 years of non-operational standby, the TREAT team is learning more about maintenance needs for the facility and reactor equipment. Plant Health priorities for TREAT reflect emerging reliability issues with older equipment, such as 1980s-era control chassis or the Digital Microprocessor tester, discoveries of latent conditions with uncertain effects, such as unusual welds on control rod segments, and challenges obtaining obsolete parts.

The TREAT sodium loop involved the entire design and fabrication lifecycle of a reactor-ready NLC. Project execution began by gathering design requirements and historical information to inform the design and operation of a test loop. A prototype loop was fabricated by TerraPower, LLC based on test loop operation and equipment trade studies. Finally, the design, fabrication, and delivery of a reactor-ready sodium loop for transient testing is expected to complete in FY-24.

2.4 MFC General Infrastructure

The MFC Utilities and Infrastructure Systems (U&IS) support department is developing a comprehensive approach to address the overall health of our mission supporting infrastructure. This scope is reflected as part of Table 3. This scope reflects the significant growth in personnel needed to support the research mission at MFC and new facilities and research capabilities such as micro-reactor demonstrations. The approach will position MFC to optimally support a diverse research mission for decades to come and includes consideration for meeting Net Zero objectives, climate change vulnerabilities, and resiliency planning.

- MFC supporting infrastructure systems were installed during the 1960's, with few exceptions. Age-related failures, such as component and piping failures, frequently impact mission accomplishment. In the last several fiscal years MFC experienced three piping failures in the fire main system and two in the plant cooling water system, both of which impacted mission execution. MFC is currently dealing with a failing 13.8K-480v transformer that optimally would be replaced by sectionalizer technology to forgo deenergizing multiple mission facilities to perform predictive, preventative, or corrective maintenance. This is sustainable in the short term but implementing a strategic approach would ensure reliable mission supporting infrastructure for decades.
- Infrastructure examples are included in Table 3 below, and detailed descriptions are provided in Appendix C. This includes maintenance campaigns on general support infrastructure systems such as electrical distribution, water distribution, drainage, and roads. This also addresses energy efficiency needs through roof/window/building skins replacement across the campus, additional office space for TREAT and micro reactor teams and refurbishment of the TREAT office building. Most of this scope is proposed to be addressed through incremental strategic laboratory investments. Examples of some specific systems issues include:
 - Technical obsolescence of electrical distribution system substation breakers, age of transformers, and overall cable condition
 - Age and failure rates of fire main, plant cooling water, potable water – valves, piping, pumps
 - Insufficient septic system capacity for the TREAT office building and control building, which was designed for approximately 20 personnel and is now supporting 60 plus
 - Insufficient capacity for instruments and facility systems data transmission and storage
 - Age, obsolescence, and emissions impact of the standby diesel generator fleet
 - Age and failure rates of general office building HVAC systems, and
 - MFC roads and grounds stormwater runoff control, which needs a holistic approach to improvement.

IRA funding discussed in Section 2.3 has been appropriated to address NE infrastructure. A portion of this funding will address fire protection/potable water systems, industrial wastewater, and nuclear research facility roofs. Detailed planning has commenced in these areas with the majority of the work anticipated to be executed FY-24 – FY-28. This work will be carefully integrated with mission execution to minimize impacts on mission operations.

Table 3. Primary needs for general infrastructure investment.

General Infrastructure Needs	FY-24	FY-25	FY-26	FY-27	FY-28	FY-29	Outyears
MFC-773 Substation Maintenance	\$500	\$1,500					
Building HVAC Maintenance	\$2,000	\$2,000	\$1,000	\$500	\$500	\$500	\$2,500
Asphalt Replacement, Concrete Replacement and Roadway Maintenance	\$2,000	\$2,000	\$2,000	\$1,000	\$1,500	\$1,000	\$15,000
MFC Parking Lot Maintenance	\$1,600			\$1,750			\$2,000
MFC Communications Network Infrastructure Maintenance	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$20,000
MFC Warehouse Loading Dock Reconfiguration	\$1,800	\$500					
Office/Space Modifications	\$1,500	\$2,500	\$1,000	\$1,000	\$500	\$500	\$5,000
Cathodic Protection Maintenance	\$1,500	\$1,500	\$1,500				
Fire Water Protection and Potable Water System Maintenance	\$500 ^a	\$2,000 ^a	\$2,000 ^a	\$1,500 ^a	\$1,000	\$1,000	\$12,000
MFC-786 Substation Maintenance							\$25,000
MFC-752 Substation Repair/Replacement							\$15,000
Re-establish Western Loop of MFC Main Road		\$1,000	\$1,000	\$1,000	\$1,000		
MFC Storm Drain System Maintenance	\$500	\$2,000	\$2,000	\$1,500	\$1,000	\$1,000	\$12,000
MFC Sanitary Sewer System Maintenance		\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$5,000
MFC Industrial Wastewater System Maintenance	\$1,000 ^a	\$3,000 ^a	\$3,000 ^a	\$3,000 ^a			
Roofs - non-nuclear/radiological	\$1,300	\$1,000	\$1,000	\$1,000			
Entrance Gates Repair/Maintenance	\$500	\$1,000	\$100	\$100	\$100	\$100	
MFC Electrical Distribution System	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	\$1,000	
TREAT Modular & Utilities	\$2,200						
MFC-752 HVAC Replacement	\$1,500	\$3,500	\$1,500	\$1,550	\$1,600	\$1,650	
Totals	\$20,400	\$26,500	\$19,100	\$16,900	\$10,200	\$8,750	\$113,500

a. Inflation Reduction Act (IRA) funding being applied to partially address these required investments.

2.5 Waste and Materials Management

2.5.1 Newly Generated Waste Management

MFC manages various newly generated and legacy research materials and wastes as part of the environmental stewardship responsibility and compliance with DOE O 435.1 requirements. Detailed treatment and disposition paths have been established and alternative disposition paths are being evaluated (Figure 2). The approach to disposition of newly generated waste is to leverage actions taken to address legacy liabilities. Off-site treatment is the preferred approach, in consideration of several factors, including how quickly the respective inventories could be dispositioned, realizing efficiencies by focusing on more than one off-site treatment provider, total lifecycle cost savings, and INL capabilities associated with disposition that should be retained, expanded, or retired with respect to the enduring mission of INL.

MFC is working with the research community to ensure full cost recovery for material storage and ultimate disposition is incorporated into every experiment baseline. Disposition costs for all newly generated waste are recovered and managed under an INL service center full cost-recovery program that ensures waste costs are paid for by the generating programs and that funding is available for future disposition of all waste types, or is otherwise directly managed by the program. Material disposition planning and budgeting by research organizations will be required prior to initiating research at MFC. This will be standardized and implemented as part of any new experiment planning and for any research currently being conducted with NS&T. The INL Waste Management Program (WMP) administers nine site-wide service centers. The INL Waste Generator Services (WGS) service center collects revenue and pays disposition costs for waste with a readily available disposition path and supports establishing disposition paths for new waste streams prior to generation. The INL Remote-Handled (RH) waste service center collects revenue for newly generated RH waste that is dispositioned at the INL RHLLW Disposal Facility or for TRU that will be dispositioned to Waste Isolation Pilot Plant (WIPP).

BEA is using the EM ID Idaho Cleanup Project contractor capabilities and WIPP-certified transuranic (TRU) program certification for disposition of contact-handled (CH) and RH-TRU. Advanced Mixed Waste Treatment Project (AMWTP) provides critical characterization, certification, and transportation support for BEA-generated CH-TRU waste. A major capability of AMWTP facilities is waste conditioning and waste repackaging. In 2019, DOE EM decided to close AMWTP. BEA is currently developing a TRU certification program to support ongoing newly generated TRU waste beyond the AMWTP closure that is projected for FY-31. Multi-year Laboratory investments have been made to initiate TRU program development. This plan will address increased waste generation from new and emerging programs such as the NRIC microreactors and high assay low enriched uranium (HALEU) programs, assess support needs for waste certification and characterization, and investigate siting options for this capability. Because of the continued development of BEA's TRU Waste Program, many of the AMWTP capabilities will be performed by BEA. BEA's TRU program planning and development continues to assess the capabilities of the AMWTP facilities and make recommendations regarding retention of characterization and certification equipment and siting of this capability for future program support. For example, co-locating this CH-TRU capability with RH-TRU capability at INTEC may have significant benefit. Development of a BEA High Level Waste (HLW) program is also underway to address future HLW generation and potential disposal paths.

Waste and material management has largely focused on significant legacy liabilities and routine, manageable newly generated waste but is becoming increasingly obvious that additional capabilities are needed to support future generated waste resulting from new mission areas and the Advanced Reactor Demonstration Program as well as some of the more difficult to manage and/or treat legacy liabilities. A strategic plan is under development to outline future needs and capabilities and improvement to processes.

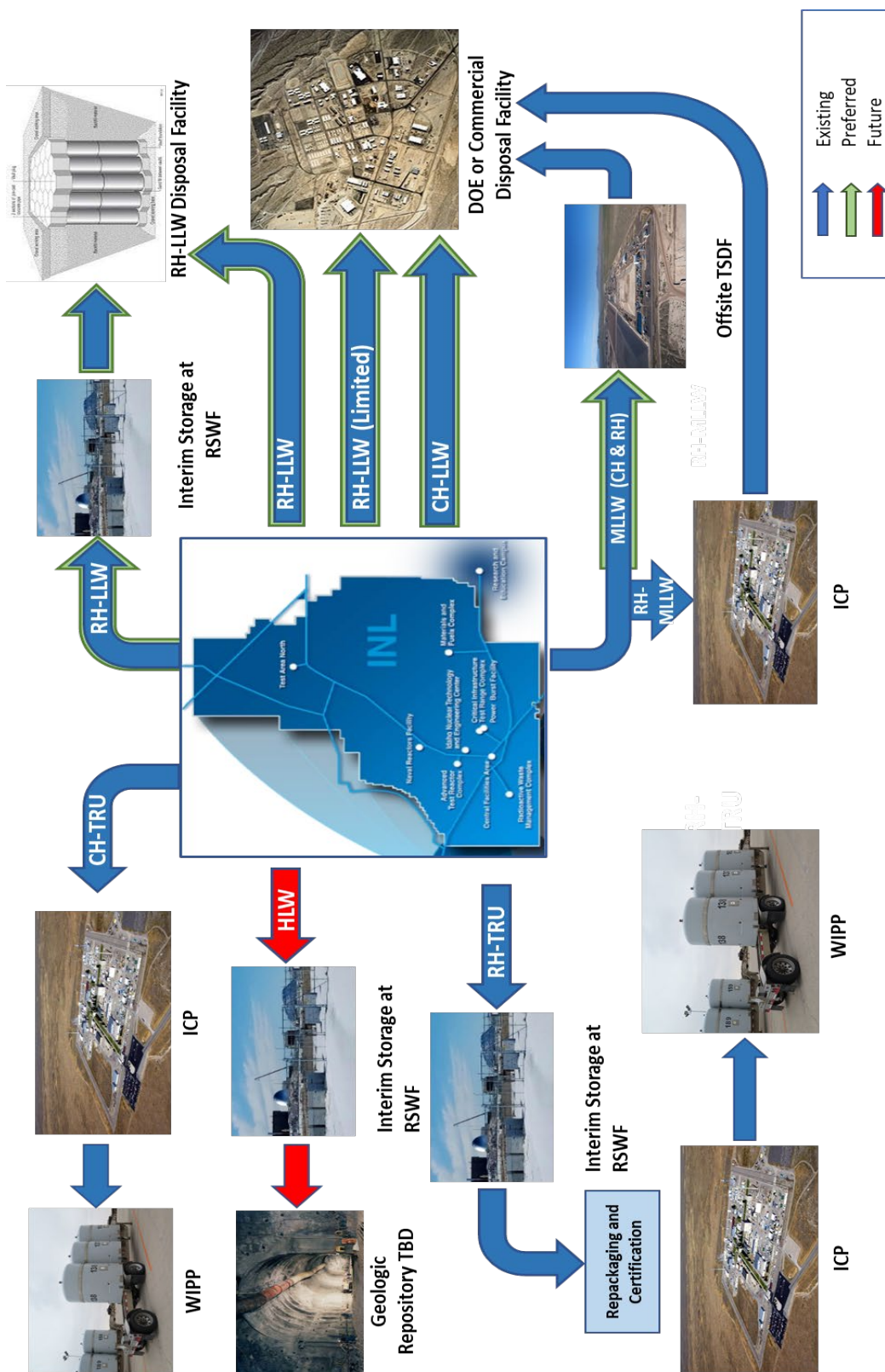


Figure 2. MFC radioactive waste disposition path flowsheet.

2.5.2 Legacy Materials Management

DOE-NE is responsible for the storage, management, and disposition of several legacy waste streams and spent nuclear fuel (SNF) inventories including irradiated sodium-bonded uranium-based material from the EBR-II reactor, sodium-contaminated CH and RH mixed transuranic waste (MTRU), sodium-contaminated and non-sodium-contaminated CH and RH mixed low-level waste (MLLW), EBR-II driver and blanket SNF and material, contact-handled excess nuclear material, and ATR SNF. The majority of these items, with the exception of the contact-handled excess nuclear material, are managed under the INL Site Treatment Plan (STP) as directed by the consent order between DOE and the Idaho Department of Environmental Quality (DEQ) or under the 1995 Idaho Settlement Agreement and subsequent associated agreements. All of these legacy liabilities and associated disposition costs are detailed in the INL Other Legacy Environmental Liabilities Register, INL LST-1149, which is updated each year. See Table 4 for a summary. These liabilities are currently being addressed with several different funding sources as discussed below.

Table 4. MFC-Specific INL Other Legacy Environmental Liabilities, LST-1149 summarized.

Other Legacy Environmental Liability Title (LST-1149)	FY-24 Estimated Cost to Complete (\$M)	Current Status
EBR-II Spent Fuel and Related Materials	\$1,370	EBR-II Na bonded driver fuel SNF (525M) is being treated with incremental annual operations funding. Additional R&D for blanket fuel required to address other materials.
Excess Plutonium	\$1,069	Contact handled SNM being addressed with incremental annual operations funding
Remote Handled Low Level Waste Stored at MFC	\$87	This involves a current total of 267 waste cans/liners containing legacy RH LLW that are currently stored in RSWF at MFC. The waste consists primarily of irradiated metals. Current planning and incremental annual operations funding covers disposition of RH-LLW at the RH-LLW Disposal Facility
Remote Handled Transuranic Waste	\$53	Post-irradiation examination and lab related misc. waste streams (irradiated experimental component debris, HEPA filters, PPE, sample waste, etc.) generated by HFEF and FCF. Waste containers are currently in storage at RSWF and RSWF Staging/Storage Area but additional generation is expected as hot cells and facilities are cleaned out.
Site Treatment Plan Consent Order CH MLLW/RHLLW	\$1,012	CH MLLW – This inventory (SCMS Backlog) consists of primarily sodium and sodium-potassium alloy contaminated irradiated material that must be treated prior to disposition. The current disposition is being addressed with regulatory compliance incremental annual funding. RHMLLW – The waste consists primarily of sodium contaminated irradiated metals and research material that must be treated prior to disposition (RWDP Backlog) and is largely located at RSWF in nested liners with a few items stored in MFC-703. EM will accept responsibility for this liability as EM receives baseline funding needed to perform the treatment and disposition scope. EM typically provided funding to the ICP contractor who, in turn, would fund BEA to retrieve the containers for shipment to INTEC; however, in FY-24 this shifted with BEA funding the retrieval portion of the scope and the ICP contractor funding the treatment and disposition portion only.
Total Estimated Costs (\$M)	\$3,591	

2.5.2.1 NE Funded Other Legacy Environmental Liabilities

MFC manages a substantial inventory of excess contact-handled special nuclear material (SNM). The major quantities of excess contact-handled SNM are associated with ZPPR fuel, unirradiated fast reactor fuel and associated fabrication scrap, and feedstock materials. The overarching nuclear material management objective is to maintain and enhance the capability to efficiently support excess material disposition and programmatic missions while minimizing the number of facilities and locations that are required to manage significant quantities of special nuclear material. MFC supports programmatic planning efforts to ensure nuclear material is available to meet anticipated needs while minimizing the inventory of excess SNM stored at MFC. Prior efforts have resulted in tons of excess SNM and approximately 170 MT of excess source nuclear material being removed from MFC. Current efforts focus on monitored safe storage of the existing material inventory, along with continued processing and shipment of legacy highly enriched uranium (HEU) scrap materials. These efforts facilitate transition of the HEU to beneficial reuse where practical, produce a more stable and better characterized material form, free up vault storage space to support new RD&D missions, and demonstrate continued progress towards responsible removal of excess nuclear material from the state of Idaho. Future efforts will focus on developing new equipment capabilities needed to process and disposition the legacy plutonium-bearing scrap materials.

MFC is currently packaging legacy RH-TRU/MTRU waste located in the HFEF, FCF, and ARL in a manner compatible with characterization capabilities located at INTEC (e.g., externally clean 55-gallon drums) and shipping these to INTEC for eventual final disposition at WIPP. There are also nine containers at RSWF that can be retrieved, as-is, and transported to INTEC when schedules allow and funding is available.

A strategy, consisting of several tactical actions, to address disposition of legacy environmental liabilities for reactivities (typically sodium or sodium-potassium alloy contaminated items) has been developed and implemented. This strategy, documented in PLN-4588, Disposition Plan for Current and Future Reactives and Other Environmental Liabilities, is designed to ensure compliance with the INL STP and 1995 ISA while minimizing DOE-NE budget requirements needed to maintain progress towards compliance agreements. This plan establishes a path for off-site treatment capabilities for the CH-MLLW, and portions of the RH-MLLW, in part, under the Remote Waste Disposition Project (RWDP) backlog, with the potential for application of the treatment capability against future reactive waste or materials on a case-by-case basis. The strategy also includes leveraging industry technology advances, engagement with complex wide activities through active participation with Energy Facilities Contractors (EFCOG) Waste Management Group, DOE National TRU Program Users Group, Spent Nuclear Fuel Working Group (SNFWG) as well as engagement with international consortia and the International Atomic Energy Agency. Off-site treatment capabilities established after years of collaborating with technology and service providers has resulted in significant legacy liability disposition cost reduction. Disposition paths for remaining legacy inventory and potential newly generated waste streams have been established.

Off-site treatment is the preferred approach, with consideration of several factors, including how quickly the respective inventories could be dispositioned, realizing efficiencies by focusing on more than one off-site treatment provider, total lifecycle cost savings, and INL capabilities associated with disposition that should be retained, expanded, or retired with respect to the enduring mission of INL. PLN-4588 also provides the key activities, preliminary cost estimates, and high-level schedules that are required to implement the preferred approach. MFC has taken action to integrate with advanced reactor programs to ensure that off-site and on-site capabilities exist to manage potential waste and SNF generated, in compliance with INL regulatory drivers.

Table 5. NE-Funded environmental liabilities and funding proposed to address them.

Activity	Description	FY-23 ^a	FY-24 ^a	FY-25 ^b	FY-26 ^b	FY-27 ^b	FY-28 ^b	Total (\$K)
EBR-II Sodium Bonded SNF Treatment (NE-3)	EBR-II driver fuel and EBR-II blanket elements in storage at MFC pending treatment prior to disposal at a geologic repository	\$8,814	\$8,814	\$10,600	\$10,900	\$11,200	\$11,500	\$61,828
Site Treatment Plan/Consent Order CH MLLW SCMS Backlog (NE-3)	Identified in the INL Site Treatment Plan as legacy contact-handled mixed low-level waste that contains sodium (Na), sodium potassium alloy (NaK), or a combination of both.	\$5,000	\$5,000	\$5,408	\$5,624	\$5,849	\$6,083	\$32,964
RWDP Backlog-RH MLLW retrievals (NE-3)	RH MLLW stored at MFC is included in the backlog associated with the Remote Waste Disposition Project. (EM funded retrievals and treatment until FY-24 when NE assumed responsibility for funding the retrievals only.)		\$650	\$900	\$927	\$955	\$985	\$4,417
RH TRU/MTRU Repack (NE-3)	Remote-Handled Transuranic Post-irradiation examination and lab related misc. waste streams (irradiated experimental component debris, HEPA filters, PPE, sample waste, etc.).		\$2,000	\$3,000	\$4,000	\$4,000		\$13,000
Contact Handled SNM Management and Disposition (NE-3)	Disposition efforts associated with equipment development, processing, repackaging, consolidation, and shipment of excess plutonium-bearing contact-handled material (dominated by ZPPR clad fuel) from MFC.	\$4,682	\$4,869	\$5,015	\$5,166	\$5,320	\$5,480	\$30,532
Total Proposed NE-3 Funding		\$18,496	\$21,333	\$24,923	\$26,617	\$27,324	\$24,048	\$142,741
a. Actual funding received.								
b. Proposed funding request.								

2.5.2.2 Laboratory Funded Legacy Material Disposition

INL has provided laboratory funding for disposition of excess materials not covered under the ISA or STP and which are located at various locations across MFC. These materials range from excess ZPPR reactive materials to miscellaneous equipment and material utilized by past programs and projects no longer active and no longer needed. The funding profile is identified below in Table 6.

Table 6. Laboratory-funded excess material disposition.

Activity	Description	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Total (\$K)
Excess legacy material and equipment	Excess legacy material and equipment which were used in programs, projects or facilities that are no longer in operation and no longer needed. This does not include excess material or equipment generated by existing programs.	\$750	\$700	\$500	\$500	\$500	\$500	\$3,450
Legacy RH TRU/MTRU Containers	Legacy RH TRU and RH MTRU containers currently located at RSWF that require repackaging and certification prior to disposal.	\$11,131	TBD	TBD	TBD	TBD	TBD	\$11,131
Total Proposed Laboratory Funding		\$11,881	\$700	\$500	\$500	\$500	\$500	\$14,581

2.5.2.3 EM Funded Other Legacy Environmental Liabilities

As management and disposition of the INL Other Legacy Environmental Liabilities is shared with and dependent upon DOE EM, it is critical to maintain a strong relationship with DOE EM. BEA, working with NE ID has developed a strong relationship with EM ID and EM HQ to partner in development of technology solutions and knowledge toward more effective and efficient management of legacy liabilities described in LST-1149. An example of this is BEA, using EM funding, developing and demonstrating a prototype system to improve the RWDP liner retrieval process identified in Table 7. This prototype system has been designed to provide a size-reduced liner thereby improving the efficiency of down-stream waste handling and providing for alternative processing/disposition. The first proof-of-concept demonstration was completed in FY-21 and included a coupled demonstration of the advanced liner retrieval system and new off-site treatment options. Additional retrievals with coupled offsite treatment are planned for FY-24. It is anticipated that this alternative RWDP liner disposition approach will significantly reduce cost and schedule associated with the liability captured in the INL STP.

The conditional transfer of this liability from NE to EM is documented in the memorandum from Ines Triay, EM-1, to Shane Johnson, NE-1, dated May 4, 2009. EM will accept responsibility for this liability as EM receives baseline funding needed to perform the work and disposition the waste. EM typically provides funding each year to disposition a fixed number of the original 168 waste containers and items identified during the liability transfer negotiations. Additional information regarding the NE to EM liability transfer can be found in the memorandum from Shane Johnson to Ines Triay dated February 20, 2009. This waste stream consists of primarily sodium contaminated irradiated metals and research material that must be treated prior to disposal.

UPDATE: A new Memorandum of Agreement (MOA) between DOE-EM and DOE-NE was issued in FY-22 which reflected a shift in funding sources from the historical method as noted in the table below for the RWDP Backlog. Implementation and changes to this plan as a result of this MOA are still being worked and will be fully reflected in the next annual revision.

Table 7. EM Funded Other Legacy Environmental Liabilities dependent upon future funding.

Activity	Description	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Total (\$K)
RWDP Backlog - RH MLLW retrievals (DOE-EM funded retrievals until FY-24)	RH MLLW stored at MFC is included in the backlog associated with the Remote Waste Disposition Project.	\$900	N/A	N/A	N/A	N/A	N/A	\$900
RWDP Backlog – Proof of Concept Demonstration for RH MLLW Advanced Retrievals (DOE-EM funded)	DOE EM Technology Development One-Time Proof-of-Concept Funding	\$500	\$3,500	TBD	TBD	TBD	TBD	\$4,000
Total DOE-EM Funding to Date		\$1,400	\$3,500					\$4,900

2.5.3 Strategy to Accelerate Production of High Assay Low-Enriched Uranium Material

In November 2019, a Supplemental Agreement to the 1995 Idaho Settlement Agreement was established between the State of Idaho and the Department of Energy which provided conditions to support re-commencing research on commercial used fuel at INL. As part of the framework of this Supplemental Agreement, DOE agreed to several terms and conditions related to the treatment of the irradiated EBR-II driver fuel pins into product material for HALEU production, with the most relevant as follows:

- DOE shall treat at least 165 pounds heavy metal of sodium-bonded EBR-II driver fuel pins per year on a three-year rolling-average basis
- DOE shall complete treatment of all sodium-bonded EBR-II driver fuel pins by December 31, 2028
- Except for high-level waste (HLW), DOE shall dispose of any waste materials, including but not limited to fuel-pin cladding material generated during treatment outside of the State of Idaho by no later than January 1, 2035
- Any HLW generated during treatment shall be treated so as to put it into a form suitable for transport to a permanent repository or interim storage facility outside the State of Idaho by a target date of December 31, 2035
- If DOE has not put all the treated product material to beneficial use, DOE will remove all treated product material from the State of Idaho by January 1, 2035.

To comply with the conditions agreed to by DOE, INL plans to accelerate treatment of the EBR-II Driver Fuel beginning in FY-24 beyond current 7d/12h work schedule and has commenced hiring and training additional personnel beginning in FY-22 to support the transition to 24 hours per day operations. Improvements for efficiency and/or alternative processing technologies had previously been identified as necessary to successfully meet the original 2035 deadline agreed to in the ISA. Accordingly, INL continues investigations aimed at identifying potential management alternatives, as well as possible process enhancements to the current system. The goal of the investigation is to identify new technologies and methods for efficiency improvements and cost reductions to successfully achieve the conditions established in the 2019 Supplemental Agreement, as well as those previously developed to comply with the 2035 ISA deadline.

The irradiated sodium-bonded uranium-based material from the EBR-II reactor includes ~25 metric tons of heavy metal. Due to the reactive nature of the sodium component of this material, it is not a candidate for direct geologic disposal under current DOE policy, unless the reactive hazard is mitigated. Consequently, the material has been consolidated and placed into interim storage at INL site for evaluation and processing to address the reactive hazard.

The current processing method is the electrometallurgical treatment (EMT) process for treatment of both the highly enriched uranium driver fuel and depleted uranium-based blanket elements irradiated in EBR-II. The technology has been demonstrated to be effective at simultaneously separating the components of the used fuel and neutralizing the bonded sodium. As part of the EMT process, the metallic uranium used in the original construction of the element is separated from the fission products and transuranic elements produced during irradiation. The enriched uranium separated and recovered during the treatment of the driver fuel elements has been identified as a source of HALEU and industry interest in this material as a potential source of feedstock to support new fuels in advanced reactor concepts has had a significant impact on the strategy for treatment of the irradiated EBR-II elements.

FCF was previously operated 4 days/week, 10 hours/day in accordance with baseline funding of approximately \$8M which supported 25 FTEs and a production rate of 6 batches of driver fuel processed annually. However, due to industry interest in the HALEU product, FCF added personnel and transitioned to a 7d/12h work schedule in FY-19 to support production of a HALEU product that is capable of being used as a fuel feedstock and handled in gloveboxes based on conceptual fuel fabrication scenarios. The work schedule is anticipated to expand further to 24 hours per day starting in 2024. This expanded work schedule is supported by additional annual funding, provided by DOE's office of Nuclear Fuel Cycle and Supply Chain (NE-4) (see Table 9).

The age of FCF and processing equipment, coupled with the harsh operating environment and unique material handling needs associated with the existing batch process, introduces risks to sustained high throughput operations. To mitigate these risks, the plant health process described within this plan includes refurbishment and replacement of the through-wall tele-manipulators and overhead electro-mechanical manipulators (see Table 2). Additional plant health investments have funded process improvements including installation of a new, redundant cathode processor (multi-function furnace), a new remotely operated workstation to consolidate bottle inspection and wire removal, and a new scraped cathode module for use in the electrolyzers. These investments have helped to eliminate existing single-point failures and increase operating efficiencies for the existing processing equipment. Targeted investment to support HALEU production is also being made through the IRA, including movement of the machining capability from FCF, installation of a criticality alarm system, and installation of a second multi-function furnace. These targeted investments, are intended to free up valuable space and establish capabilities that will increase the ability to produce HALEU to support advanced reactor demonstration activities.

2.5.3.1 Funding and Schedule Estimate

To achieve the desired production targets of HALEU, the rate of treatment of EBR-II driver fuel requires incremental acceleration along with utilization of legacy inventory of HALEU ingots recovered from past EBR-II driver fuel treatment.

The strategy is summarized as follows:

- Continue processing EBR-II SNF at an accelerated rate, producing 7kg HALEU regulus as the finished product.
- Continue to integrate recasting of legacy HALEU product inventory using process enhancements to produce a smaller, lower-dose HALEU product in regulus form.
- Increased FCF's working schedule from 7 days/week, 12 hours/day started in 2019, and further increase to 24 hours/day in FY-24.

- All driver fuel treatment complete by December 2028, recasting of legacy HALEU parent ingots mat continue beyond this.
- Have 5MT of HALEU feedstock available by 2026.

Table 8. Funding for EBR-II Processing ISA 2035 baseline case.

Activity	Description	FY-24	FY-25	FY-26	FY-27	FY-28	Total (\$K)
EBR-II Sodium Bonded SNF Treatment (NE-3) per PLN-6098	EBR-II driver fuel and EBR-II blanket elements in storage at MFC pending treatment prior to disposal at a geologic repository	\$8,814	\$10,600	\$10,900	\$11,200	\$11,500	\$53,014

Table 9. Accelerated HALEU production funding required to support ISA supplemental agreement.

Activity	Description	FY-24	FY-25	FY-26	FY-27	FY-28	Total (\$K)
Proposed Accelerated HALEU Production Funding Level (NE-4) per PLN-6098	Accelerating EBR-II treatment recasting EBR-II spent fuel treatment product to support HALEU feedstock development for advanced reactor fuel. Funded by the NE Materials Recovery and Waste Form Development program (NE-4)	27,000	27,400	28,250	29,100	29,975	\$141,725

Activity	Description	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	
EBR-II HALEU Cumulative Production	Total cumulative estimated HALEU production from both operations	715 kg	1,015 kg	1,315 kg	1,722 kg	2,652 kg	3,852 kg	5,112 kg	6,372 kg	7,632 kg	Approx. 2,115 of legacy HALEU will remain for recast post 2028

2.6 Integrating Reactor Demonstration into Base Operations

2.6.1 Reactor Demonstration Funding Model

The funding model related to reactor demonstration follows the overall funding strategy summarized in Figure 1. These capabilities must be carefully integrated into the NE test bed to ensure continuity of operations. Funding impacts to Base Operations and Maintenance and capability sustainment be well understood and accepted by INL and its NE sponsors prior to developing these new capabilities.

Specific activities are discussed below:

- Establishment of new reactor demonstration capabilities – these can be funded by any of several funding sources. Any benefitting program can establish new research capabilities within the NE test bed. This includes both program and laboratory investments. Typically, this includes facility modification costs, experiment installation, physics testing, costs associated with program specific preparations to execute research (Documented Safety Analysis [DSA] modifications, procedures, training, etc.). Material disposition and research program close-out costs are also the responsibility of the benefitting program.
- Base Operations, Maintenance, and Plant Health associated with reactor demonstration – Base operations and maintenance supporting new permanent capability increases to the test bed such as LOTUS, DOME, and Beartooth require budgetary increases to support increased operations, maintenance, and security. NFM, operators, system engineers, nuclear safety engineering, radcon, security, and maintenance will require more FTEs to adequately support new base growth of research operations. Base O&M is best managed by a single stable funds stream to enable continuity across all aspects of the NE test bed. This will include bridge time funding to maintain research operations expertise (i.e., funding to bridge durations between funding from specific reactor projects). Test bed support will include additional reactor personnel added to base who are essential to experimental

support for mission execution. Trained and qualified nuclear research support staff require a significant investment to be available to support the research mission. As personnel transition from current experiments to support future experiments, funding needs to be available to bridge personnel time as experiments close out and new experiments are readied for operation.

2.6.2 New Reactor Demonstration Infrastructure

New research infrastructure is being developed to expand the NE test bed and NRIC capabilities. Current new infrastructure is described below.

2.6.2.1 Demonstration of Microreactor Experiments (DOVE)

DOVE will be capable of hosting operational modular/mobile nuclear reactor concepts that produce less than 10MW thermal power. Modular/mobile reactors demonstrated in the DOVE will be larger than the LOTUS machines, but still small enough to fit in a standard cargo shipping container. The capabilities of the Experimental Breeder Reactor-II facility are being re-established as the DOVE test bed, through repair and installation of comparable systems that originally existed. Construction activities are projected to be complete in FY-25. Recent accomplishments include:

- Final design was completed in FY-23 and long-lead procurement actions were initiated.
- The Preliminary Documented Safety Analysis was approved by DOE.
- The construction subcontract was awarded, with initial site mobilization at the end of FY-23 and full construction commenced in early FY-24.

2.6.2.2 Laboratory for Operation and Testing in the United States (LOTUS)

LOTUS will provide the physical infrastructure to support demonstration of experimental reactor concepts at the smallest scale practical. This test bed site will be capable of hosting operational nuclear reactor concepts that produce less than 500kW thermal power and that require additional safeguards and security controls. This is being executed as a line-item capital construction project, with Critical Decision (CD)-1, *Approve Alternative Selection and Cost Range*, approved in FY-23. Approval of the projects Performance Baseline and start of construction is anticipated in FY-25. Recent accomplishments include:

- Design subcontract was awarded June 2023.
- Preliminary design and the draft Preliminary Documented Safety Analysis was completed in 2Q FY-24.
- A Technical Independent Project Review, as required by DOE Order 413.3B, was conducted 2Q FY-23.

2.6.2.3 TREAT Micro-Reactor Experiment Cell (T-REXC)

T-REXC is an INL capability needed to demonstrate small reactors and relevant technologies. Establishing T-REXC is a response to the increasing need for advanced reactors in the private sector as well as other DOE programs. INL's unique infrastructure can facilitate this capability as it currently has an operating Category B facility (TREAT). MARVEL will be the first user with other potential users including the General Atomics company, the MCRE project, and Project Pele having expressed interest based on their strategic visions. Modifications made to support this project include installing shield blocks for the north storage pit, industry standard instrument and controls infrastructure, electrical power infrastructure, control room infrastructure, T-REXC HVAC system, fire suppression system, and a reject heat and load bank system. Construction activities are anticipated to commence 4Q FY-24. Recent accomplishments include:

- Final design is in progress, with anticipated completion 3Q FY-24.

- Nuclear safety documentation is in development to support submittal as part of an integrated document that addresses both the test bed and MARVEL (the first T-REXC user).
- The contract for fabrication of T-REXC Be and BeO components has been placed, following approval of a Long-Lead Procurement Request, and fabrication is underway with first shipment expected in FY-24.

2.6.3 Planned Reactor Demonstration and Fuel Cycle Initiatives

There are several new reactor demonstration and fuel cycle support initiatives currently in development. These constitute the first wave of reactor demonstrations utilizing the NE test bed and NRIC infrastructure and are described below. Figure 3 below provides a notional timeline for new reactor demonstration initiatives.

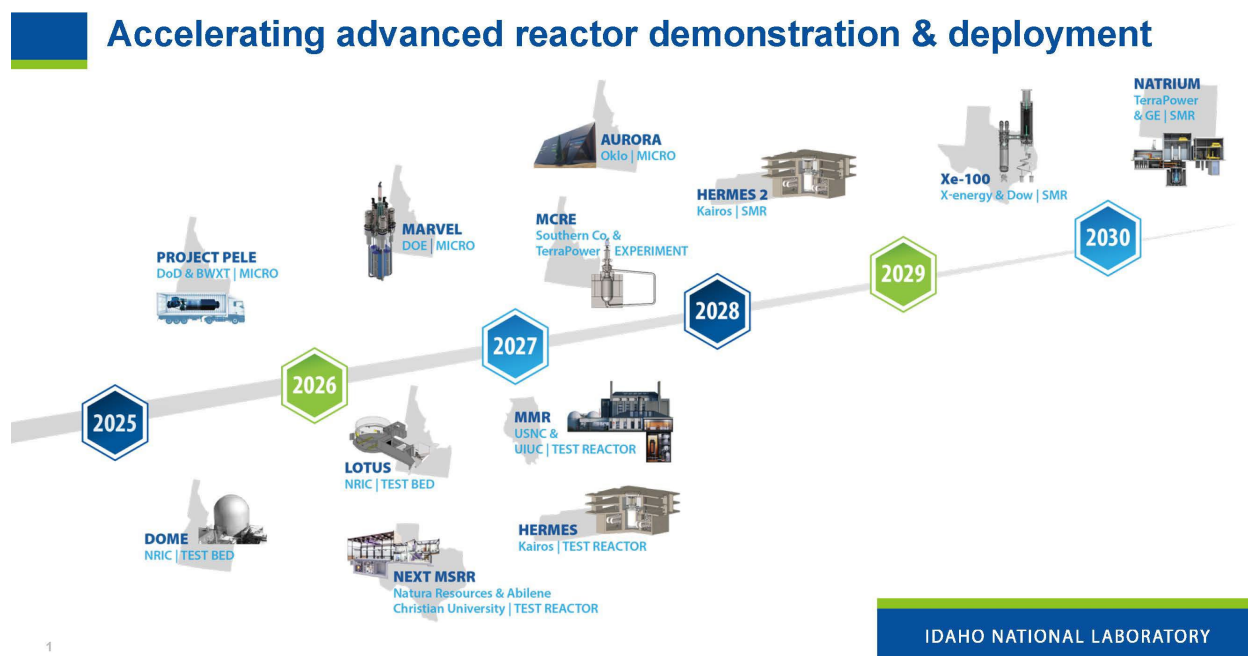


Figure 3. Reactor demonstration initiatives notional timeline.

2.6.3.1 The Microreactor Applications Research, Validation and Evaluation (MARVEL)

MARVEL will provide an opportunity to establish and exercise key capabilities to support future microreactor demonstrations through development of a small-scale reactor for R&D purposes for the first time in nearly 50 years. MARVEL is a platform to test unique operational aspects and applications of microreactors. Envisioned end-users are those with applications of interest to connect to a reactor for testing and ultimate deployment. MARVEL will be the first project to utilize the TREAT Reactor Experiment Cell (T-REXC).

2.6.3.2 Portable Energy for Lasting Effect (Project Pele)

DOE provided BWXT with \$85 million to develop its design for a transportable, TRISO-fueled reactor. In June 2023, the Department of Defense awarded BWXT about \$300 million to deliver a prototype transportable reactor to Idaho National Lab in 2024, where it will be tested for up to three years. Operating at between one and five megawatts, that reactor would be the first operating advanced microreactor in the U.S. This effort will be the first user of the DOME test bed.

2.6.3.3 *The Molten Chloride Reactor Experiment (MCRE) Advanced Reactor Demonstration project*

Selected for funding under the U.S. Department of Energy's (DOE) Advanced Reactor Demonstration Program (ARDP), the MCRE project will advance TerraPower's Molten Chloride Fast Reactor (MCFR) — a technology that could provide low-cost, clean energy for a sustainable future. This project designs and installs the MCRE reactor, a 500-kilowatt reactor that TerraPower and Southern Company will build at DOE's Idaho National Lab. The primary objectives of the project are to demonstrate key physics phenomena associated with fast-spectrum molten chloride-fueled reactor operations, and to develop key technologies necessary for commercial deployment of MCFR's. MCRE will also demonstrate a fuel salt synthesis process using existing DOE fuel and support the MCRE Advanced Reactor Demonstration. The demonstration will be in the NRIC LOTUS test bed.

2.6.3.4 *The Special Nuclear Material test bed capability (Beartooth)*

Beartooth is a R&D test bed that will contain the necessary unit operations for the dissolution, separation, and conversion of special nuclear materials (SNM) such as plutonium (Pu), enriched uranium (EU), thorium (Th) in support of fuel cycle R&D. This is a nuclear glovebox system to be installed at FCF and capable of processing and/or purifying enriched uranium, thorium, plutonium and other special nuclear material (SNM). The test bed will consist of glovebox lines containing the necessary unit operations and associated equipment required to process SNM including dissolution, separations, down-blending, conversion, off-gas treatment, and waste management. Beartooth is capable of processing various SNM feedstocks, including trace minor actinides and fission products.

2.6.3.5 *The Molten Salt Thermophysical Examination Capability (MSTEC)*

MSTEC is a new shielded cell to be installed in FCF. MSTEC is a shielded modular hot cell with an inert argon atmosphere, housing characterization equipment for determining thermophysical and thermochemical properties of high temperature liquids not limited to but focusing on highly irradiated fuel salts. MSTEC will produce critical data needed to design, demonstrate, license, and operate a Molten Salt Reactor.

2.7 Inflation Reduction Act of 2022

Section 50172 of the Inflation Reduction Act of 2022 provided \$150 million dollars to address infrastructure owned by DOE-NE at INL. A significant portion of this is supporting upgrades to MFC infrastructure, including addressing the condition of systems original to MFC. Table 10 below describes the areas where this funding will be applied. Within each area, multiple sub-projects are being established to enable execution. This funding was made available at the beginning of FY-23. It is to remain available until the end of FY-27. Detailed planning is underway in all these areas with execution of work planned to take place through FY-27. This scope will be integrated with facility operations and mission execution to minimize disruption to execution of the research mission. Some of this work addresses facility reliability such as the FCF crane while a significant portion addresses other aging infrastructure such as facility roofs and water delivery/management systems that are beyond service life.

Table 10. Inflation Reduction Act of 2023 NE infrastructure investments.

Facility	Scope Description	Current Allocated Funding (\$K)	Need/Benefit
MFC FCF	Fuel Conditioning Facility (FCF) facility & process control systems replacement	\$8,000	These components were last replaced in the 1990s and are past obsolescence. The old components operate under the Windows XP platform that is no longer supported or maintained by Microsoft. This enables more reliable HALEU production and compliance with Idaho Settlement Agreement commitments.
MFC	MFC research facility roof replacements	\$20,000	Multiple roofs on research facilities are degraded and need to be replaced. Maintenance repairs are quickly becoming less than effective at maintaining roof integrity and the roofs require complete replacement. Cool roofs, where feasible, are the preferred alternative to support energy conservation and better atmospheric control.
MFC	Replace MFC industrial wastewater system	\$10,000	The current industrial wastewater system was installed in the 1970s with approximately 1,500 ft of asbestos cement underground piping and about the same linear footage of open ditches. This investment will serve to replace this legacy piping and improve system functionality while helping to ensure protection of the Snake River Plain aquifer and maintain compliance with state of Idaho regulations.
MFC	Replace MFC fire protection and potable water system	\$15,000	The MFC fire/potable water system consists of approximately 1.2 miles of underground piping and two deep well pumps that were installed as part of the original EBR-II infrastructure in the 1960s. Much of this piping is cast iron and has surpassed service life. Recent piping failures have cost over \$2.5 million to replace. The system will be upgraded to support improved reliability, while conserving water and improving energy efficiency.
MFC	Replace FCF SERA/DSC Crane and Control Equipment	\$12,000	Decontamination Spray Chamber (DSC) and Suited Entry Repair Area (SERA) support maintenance of large items that require hands-on servicing. The DSC has a 5-ton-capacity overhead bridge crane which connects with the crane bridge above the DSC; transfer loads between the SERA and the DSC. The crane is essential to move in-cell equipment such as process equipment and manipulators to and from the repair enclosure. This is critical to performing EBR-II fuel processing and HALEU production mission commitments. The crane has experienced control system failures at an increased frequency and problems with crane bridge latching at the interface of the SERA and DSC. This is a single-point-failure risk.
	MFC Subtotal	\$65,000	

3. MFC MISSION OPERATIONS AND MAINTENANCE

Mission Operations and Maintenance includes the scientific infrastructure (instruments and support systems), dedicated instrument science teams, and new instrumentation that, when coupled with Base Operations, Maintenance, and Plant Health, maintain and expand the test bed and push the boundaries of nuclear energy research. Dedicated predictable funding is required to ensure this capability is available to achieve INL and MFC mission outcomes and provide the ability to fully support the growing research community and industry RD&D needs.

3.1 Scientific Infrastructure

MFC RD&D capability sustainment investments are focused on instrument replacement, refurbishment, and enhancement as analytical capability matures and develops. This emphasis recognizes INL commitment to sustaining world-class nuclear RD&D capabilities, including analytical and PIE systems, across MFC's current areas of expertise. These areas are anticipated to be funded primarily by DOE-NE research programs investment or through strategic laboratory investment. IFM committed to lead support of NE test bed expansion that included completion of the Irradiated Materials Characterization Laboratory (IMCL) thermal properties cell and installing the first suite of instrumentation and establishing the first suite of advanced fuel fabrication capabilities. This established essential new RD&D test bed capabilities that no single research program was willing to fund. IFM appropriations levels have dropped recently and funding above user facility operations levels is focusing on improved facility reliability and strategic plant health investments. This necessitates more laboratory and program investment into scientific infrastructure test bed growth and the NRIC mission.

ARL scientific infrastructure currently includes replacement and addition of mass spectrometry capabilities. Strategy for ARL emphasis is providing more robust and efficient analytical support to RD&D programs with laser ablation-laser induced breakdown spectroscopy and time-of-flight mass spectrometry now operational. A fission gas analysis capability for support to advanced nuclear fuel development has been purchased and is being installed in the ARL. Additional needs include advanced automated sample preparation with robotics and critical updates as current capabilities age out.

Fuel fabrication facilities at MFC have pivoted over the last decade to address the highest priority needs of DOE, DOD, and other commercial partners. Expanded program needs, of a wider range of fuel forms than historically demanded, have necessitated investment in both facility infrastructure and the scientific research and operations equipment within these facilities. These investments have paid dividends in supporting high priority nuclear research such as: fabricating ATF lead test rods, HALEU oxide pellets, NASA NTP fuels, NATRIUM gen II fuels development, Lightbridge fuels development, supporting TREAT and ATR experiment assembly, enabling advanced molten salt fuel research and experimentation, and fuel development for ARDP reactor projects. Sustained investment in both facility infrastructure and scientific equipment will ensure that the US remains at the forefront of nuclear fuel development, enabling our nations goals of deploying advanced nuclear power and supporting national and international climate goals.

HFEF RD&D sustainment activities include refurbishing the NRAD (Neutron Radiography Reactor) East Radiography Station elevator which was still original equipment installed in 1980 and has no spare parts available commercially. Several functions have failed, and an upgraded elevator and control system has been installed to provide more efficient and reliable support for this non-destructive PIE capability. Another priority is restoring and upgrading the north beam line in NRAD. The North Radiography Station is also 1980 original equipment with several out-of-service functions. This effort included removal of old, out-of-service HFEF equipment which increased the available footprint to support expansion of beam line RD&D. Also identified for action are important updates to aging instruments including the precision gamma scanner, visual examination machine, and element contact profilometer.

FCF remains focused on supporting the DOE's commitments documented in the 1995 Settlement Agreement and the 2019 Supplemental Agreement and evolving those capabilities to support the processing of EBR-II spent fuel and development of HALEU fuel feedstock in support of new nuclear reactor concepts. New nuclear reactors may use fuels that incorporate other fissionable materials (e.g., plutonium) and that drive the need for a reactor fuels research capability that has the proper security and radionuclide inventory limits of a HC-2 nuclear facility. The Fuel Cycle R&D workscope at INL is also expanding. Larger gloveboxes, designed specifically for the mission of developing exploratory fuel compositions, forms, and shapes is needed. Use of HALEU feedstock produced from legacy EBR-II used fuel may require further fission product purification to support newly proposed reactor concepts. INL has been developing head-end cleaning processes that can be directly deployed in FCF. Additionally, defense customers need hot cell and laboratory space for their secure missions. INL intends to fulfill some of those missions using FCF, maximizing nuclear research facility capacity and capabilities.

3.2 Scientific Instrument Development Strategy

Many advanced nuclear technologies require new materials and fuels. Efficient development of materials and fuels is enhanced by understanding, starting at the atomic scale, the scale at which radiation damage (or other in-service degradation) occurs. Understanding at this scale, particularly when it is incorporated into modern modeling and simulation methods, reduces the number of trial-and-error experiment cycles required for development. The spectacular scientific and engineering achievements of the last century have followed the same method of transition from basic research to applied science and then to engineering applications, heavily reliant on understanding through instrumentation and testing at each stage of research and development.

Cutting-edge instruments and techniques make the production of knowledge more efficient; they enable us to understand physical phenomena with more precision and speed. The development and application of new instruments and techniques enables research and development teams to ask and answer increasingly complex questions.

Instrumentation specific to nuclear fuels and materials science is not widely available. Of the hundreds of scanning electron microscopes in the United States, a relative few are available for use on radiological materials. Those instruments that are available for use on radiological materials are almost universally limited to materials with low activity. These materials have either been cooled for long periods, have not been exposed to high neutron fluence, or have not been irradiated in a prototypic neutron environment and thus are often of limited relevance. Rapid, routine, and efficient analysis of high dose-rate fuels and materials using state-of-the-art instrumentation is required if nuclear technology is to advance at a rate similar to other energy technology sectors.

Instruments that enable rapid, routine, and efficient analysis shorten that nuclear development cycle, increase the chance for breakthroughs, and lower the cost of development. Because development of advanced nuclear fuels and materials cannot occur without the capability to fabricate nuclear fuel samples, fabrication capability is included in the MFC instrumentation strategy.

Planned investment in instrumentation at MFC will focus on making nuclear-capable instruments widely available to the research community. The strategy presented here is based on current known program needs and current instrument capabilities and will evolve with increasing engagement of industry and academia. Continuous improvement in instrumentation and data analysis methods, driven by user needs, is a key component of this strategy.

3.2.1 MFC RD&D Capability Sustainment

Use of instruments at MFC is rapidly trending upward as new capabilities are installed and new characterization techniques are assimilated by the user community. Current operating FIB, SEM, and EPMA instruments now have a backlog of 3-9 months. The availability of high-resolution TEM and shielded FIB, SEM, and EPMA capability has resulted in a further increase in use.

Replacement or upgrade of instrumentation on a regular basis is required. Major improvements in instrumentation occur approximately on a 3-5 year cycle. Most instrumentation becomes technologically obsolete after 8-10 years. After 10-15 years of service, replacement parts become difficult to find, and vendors may stop supporting service contracts. Replacement of instruments on an 8-10 year cycle ensures that a subset of instruments provide state-of-the-art capabilities to the nuclear research community at all times.

Examples of instrument science needs for 2024 – 2028 include:

- Neutron diffraction that provides information critical to understanding the internal crystallographic structure of fuels and materials.
- Advanced manufacturing fuel fabrication capability that enables fuel RD&D critical to the development of many advanced reactor concepts. (Several new capabilities are productions ready with others ordered.)
- An advanced non-destructive post-irradiation examination system that greatly reduces the time required for a complete examination while providing higher quality data than current methods.
- Digital neutron tomography in development that will allow routine three-dimensional imaging of fuels and materials.
- Small cask systems that allow efficient transfer of high activity material specimens on-site, nationally, and internationally.
- Gloveboxes that provide material handling, fabrication, and preparation capability.
- Funding for instrumentation is proposed at levels of approximately \$10-15M annually over the next five years. This is a combination of direct program investments and lab investments. MFC is now equipped with a solid base of research instrumentation readily available to the broad nuclear energy research community, so (given diminished funding levels for implementing the 5-Year Investment Strategy) the primary focus of IFM funding has shifted to plant health and facility reliability with. Steady-state funding as proposed will expand the DOE-NE test bed capability and ensure that the suite of instruments remains current, reliable, and upgraded to meet user needs.

Table 11 provides a list of the instrumentation needs. This list will be reviewed annually and may be updated based on the needs of DOE-NE-funded programs, external users, updated NSUF gap analysis, instrument use, and development of new instrument technology.

The descriptions of each instrument or support system are provided in Appendix D.

Table 11. Summary of instrument development strategy and ROM cost estimates (\$K). (The items listed at the end of the table and shaded in gray are now complete.)

No.	Facility Name	Capability	Direct/ Indirect Funding	Prior Years	FY-24	FY-25	FY-26	FY-27	Outyears	Point Estimate
1	ARL	Fission Gas Mass Spectrometry	Indirect	\$2,786	\$175					\$3,000
2	FMF	Multi-program U/Pu Synthesis Glovebox	Indirect	\$5,856	\$2,300					\$8,200
3	AFF	AFF High Temperature Furnace	Indirect	\$513	\$1,100					\$1,500
4	FASB	HIP Upgrade	Direct		\$700					\$700
5	NRAD	NRAD Imaging System Upgrades	Indirect	\$1,316	\$450	\$100				\$1,900
6	HFEF	HFEF 2nd Manipulator Repair Glovebox	Indirect	\$2,012	\$2,450					\$4,500
7	NRAD	Upgrade NRAD North Beam Shutter to Include Aperture and Filter Drum	Indirect	\$1,276	\$1000	\$400				\$2,700
8	AFF	Oxy-Gon Hot Press Furnace	Indirect	\$316	\$150					\$500
9	EFF	EFF Radiological EDM Capability Upgrade	Indirect	\$58	\$500					\$700
10	HFEF	CNC for experiment disassembly and sample preparation throughput increase at 3M	Indirect	\$489	\$1,800	\$250				\$2,600
11	AFF	Spherodizer	Direct		\$650					\$650
12	AFF	Rolling Mill	Direct		\$850					\$850
13	AFF	Sodium Room Upgrade	Direct		\$850					\$850
14	FASB	UO2 Precipitation Capability (1666)	Indirect		\$300					\$300
15	FASB	JOEL Benchtop SEM (1674)	Indirect		\$175					\$175
16	HFEF	Improved Electronic Interface for Hot Cell Scales and Balances	TBD			\$250	\$200			\$400
17	ARL	Automated Sample Prep/Dissolutions	TBD			\$250	\$500			\$750
18	IMCL	Atomic Force Microscope	TBD			\$250	\$750			\$1,000
19	HFEF	Visual Mount Inspection System in the HFEF Containment Box	TBD			\$1,000	\$500			\$1,500
20	FCF	Multi-Function Furnace #2	TBD			\$1,000	\$2,500			\$3,500
21	NRAD	Develop Neutron Diffraction Capability in HFEF (NRS)	TBD			\$1,000	\$1,000	\$500		\$2,500
22	IMCL	IMCL High Throughput Sample Preparation Capability for Nuclear Fuel (Laser Ablation)	TBD			\$1,100				\$1,100
23	IMCL	Pneumatic Transfer System	TBD			\$4,300	\$3,200			\$7,500
24	NRAD	Design & Install a Rotation Stage in the ERS Elevator to Enable Neutron Tomography of Fuels	TBD			\$750				\$750
25	HFEF	ECP/EBLM Refurbishment	TBD			\$1,000	\$1,000			\$2,000
26	HFEF	Digital Imaging Studio	TBD			\$500				\$500
27	RCB	Hydrogen, inert, and vacuum atmosphere furnace for creep testing systems	TBD				\$475			\$475
28	AFF	Powder Bed Additive Manufacturing	TBD				\$1,000		\$1,000	\$2,000
29	IMCL	Argon Atmosphere in Shielded Sample Preparation Area (SSPA)	TBD				\$1,500			\$1,500
30	NRAD	NRS Elevator Replacement	TBD					\$2,000		\$2,000
31	NRAD	Sample Preparation Glovebox	TBD					\$500	\$2,500	\$3,000
32	ARL	Robotics Design and Install	TBD					\$500	\$4,500	\$5,000
33	ARL	ARL Liquid Scintillation Capability	TBD					\$600		\$600
34	HFEF	Integrated Gas Supply, Collection, and Distribution System in HFEF for Mechanistic Source Term and Component pressure testing at HFEF	TBD					\$250	\$5,750	\$6,000
35	ZPPR	ZPPR multi-purpose uranium processing and synthesis glove box chain	TBD					\$6,000		\$6,000

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No.	Facility Name	Capability	Direct/ Indirect Funding	Prior Years	FY-24	FY-25	FY-26	FY-27	Outyears	Point Estimate
36	FMF	FMF multi-purpose glovebox and fume hood combination	TBD					\$5,000		\$5,000
37	NRAD	NRAD Automated Computed Tomography System	TBD						\$2,400	\$2,400
38	NRAD	NRS Control Console Replacement	TBD						\$1,000	\$1,000
39	ARL	ARL HR ICP-MS	TBD						\$1,500	\$1,500
40	FASB	FASB multi-purpose uranium glove box chain	TBD						\$4,000	\$4,000
41	NRAD	NRAD Fuel for 1 MW Upgrade	TBD						\$5,100	\$5,100
42	ARL	Replace CNOH Glovebox and Instrumentation	TBD						\$5,500	\$5,500
43	ARL	Inert GB installation in ARL Lab B-147	TBD						\$4,000	\$4,000
44	ARL	Inert GB installation in ARL Lab A-102	TBD						\$4,500	\$4,500
45	ARL	Replace ARL Thermal Ionization Mass Spectrometer (TIMS)	TBD						\$3,000	\$3,000
46	HFEF	Upgrade the Visual Examination Machine (VEM) Camera Controls	TBD						\$250	\$250
47	AFF	High Capacity, High Temperature Furnace	TBD						\$3,000	\$3,000
48	EFF	EFF Radiological Machining Capability Enhancement	TBD						\$5,500	\$5,500
49	AFF	Weld Characterization Suite	TBD						\$300	\$300
50	AFF	Cold Hearth Furnace	TBD						\$1,000	\$1,000
51	AFF	Envelope Pycnometer	TBD						\$75	\$75
52	AFF	Muffle Furnace	TBD						\$300	\$300
53	EFF	High Capacity Press	TBD						\$1,500	\$1,500
54	IMCL	Replace IMCL SEM 7600	TBD						\$2,500	\$2,500
55	IMCL	Replace IMCL Shielded Ga FIB	TBD						\$2,500	\$2,500
56	IMCL	IMCL Simultaneous Thermal Analyzer (STA) Mass Spectrometer (MS) Replacement	TBD						\$300	\$300
57	IMCL	IMCL Thermal Conductivity (and Diffusivity) Microscope (TCM) Upgrade	TBD						\$350	\$350
58	IMCL	IMCL Laser Flash Analyzer (LFA) Laser and Power System Replacement	TBD						\$250	\$250
59	ARL	ARL Laser Flash Analyzer (LFA) Laser and Power System Replacement	TBD						\$250	\$250
60	IMCL	IMCL TPC shielding for reducing exposure to personnel	TBD						\$100	\$100
61	IMCL	User-facility Data Analyses Station for FIBs, SEM, TEM, XRD, PGS, Thermocalc, and Aviso license	TBD						\$1,000	\$1,000
62	IMCL	Remote Control and Advanced Data Analytics for PIE and Advanced Characterization	TBD						\$5,000	\$5,000
63	IMCL	Replace IMCL Shielded Electron Probe Microanalyzer (EPMA)	TBD						\$6,000	\$6,000
64	IMCL	IMCL LEAP5000 APT Major Components Replacement	TBD						\$500	\$500
65	IMCL	Replace IMCL Shielded G3 PFIB	TBD						\$2,500	\$2,500
66	IMCL	IMCL ZEISS X-ray Microscope X-ray Source Replacement	TBD						\$500	\$500
67	IMCL	PI-98 Nanoindenter Upgrade for Micro-mechanical Testing for IMCL	TBD						\$70	\$70
68	IMCL	High Temperature Laser Flash Apparatus	TBD						\$600	\$600
69	IMCL	Micro-XRD Analyses Upgrade	TBD						\$100	\$100
70	ARL	ICP-AES (A-wing)	TBD						\$1,000	\$1,000

MFC FIVE-YEAR INVESTMENT STRATEGY

No.	Facility Name	Capability	Direct/ Indirect Funding	Prior Years	FY-24	FY-25	FY-26	FY-27	Outyears	Point Estimate
71	ARL	ICP-ToF-MS	TBD						\$1,500	\$1,500
72	ARL	ICP-MS (B154/B159)	TBD						\$1,000	\$1,000
73	ARL	LA-LIBS	TBD						\$1,500	\$1,500
74	ARL	MC-ICP-MS	TBD						\$2,000	\$2,000
75	ARL	Gas Chromatograph	TBD						\$400	\$400
76	ARL	Gas Mass Spectrometer	TBD						\$100	\$100
77	EFF	Large Casting Furnace	TBD						\$2,500	\$2,500
78	FMF/AFF	Irradiation Experiment Equipment	TBD						\$300	\$300
79	EFF	Powder Testing Center	TBD						\$310	\$310
80	FASB/ EFF/AFF	Nuclear Material Inventory Storage Enhancements	TBD						\$2,500	\$2,500
81	AFF	Pelletizing Equipment	TBD						\$250	\$250
82	FASB/ EFF/AFF	Inventory Tracking System (non-rad)	TBD						\$250	\$250
83	FASB	CryoMill	TBD						\$250	\$250
84	AFF	SLS Nylon Printer	TBD						\$110	\$110
85	AFF	Brazing Equipment	TBD						\$175	\$175
	HFEF	Eddy Current Head for Oxide Determination in HFEF - Complete	Indirect	\$235						\$235
	IMCL	Install Thermal Properties Cell and Glovebox (laser flash, DSC, thermogravimetric, and dilatometry) - Complete	Direct	\$3,400						\$3,400
	AFF	Expanded Fuel Fabrication Capability - Complete	Direct	\$4,014						\$4,014
	ARL	Mass Spectrometers for ARL (Quad/ToF-MS/LA-LIBS/Counting Room) - Complete	Direct	\$4,515						\$4,515
	HFEF	Complete GASR and Polisher/Grinder Refurbishment - Complete	Direct	\$4,600						\$4,600
	HFEF	TREAT Experiment Handling Support at HFEF - Complete	Direct	\$1,153						\$1,153
	HFEF	HFEF East Radiography Station Elevator Repair - Complete	Direct	\$902						\$902
	HFEF	North Radiography Station Footprint Repurpose - Complete	Direct	\$1,203						\$1,203
	ARL	Multi-Collector ICP-MS - Complete	Direct	\$2,400						\$2,400
	FCF	Establish NDA capabilities in FCF - Complete	Direct	\$625						\$625
	ARL	B-116 Gas chromatograph - Complete	Direct	\$289						\$289
	IMCL	Secondary Ion Mass Spectrometry (Lab Investment) - Complete	Indirect	\$600						\$600
	IMCL	Atom probe tomography instrument (Lab Investment) - Complete	Indirect	\$3,759						\$3,759
	HFEF	Replace LEICA metallograph - Complete	Direct	\$300						\$300
	IMCL	In-situ mechanical testing for Titan TEM - Complete	Indirect	\$842						\$842
	IMCL	Second Plasma FIB in IMCL - Complete	Indirect	\$3,070						\$3,070
	EML	Replace Quanta Focused Ion Beam - Complete	Indirect	\$1,225						\$1,225
	ARL	Expanded CNO capability - Complete	Indirect	\$930						\$930
	FASB/HFEF	Digital Image Correlation for Mechanical Testing - Complete	Indirect	\$170						\$170
	HFEF	Replace Leitz Metallograph in MetBox with SEM - Complete	Direct	\$1,500						\$1,500
	ARL	Triple Quadrupole ICP-MS - Complete	Indirect	\$750						\$750

MFC FIVE-YEAR INVESTMENT STRATEGY

No.	Facility Name	Capability	Direct/ Indirect Funding	Prior Years	FY-24	FY-25	FY-26	FY-27	Outyears	Point Estimate
	IMCL	Comprehensive Mechanical Testing Capabilities for Light Water Reactor Fuel - Complete	Indirect	\$935						\$935
	IMCL	Plasma cleaner for IMCL - Complete	Indirect	\$375						\$375
	IMCL	Benchtop optical microscope for IMCL - Complete	Indirect	\$240						\$240
	FASB	Replace dilatometer in FASB - Complete	Indirect	\$155						\$155
	FASB	Leak Checker - Complete	Indirect	\$17						\$25
	AFF	Compact Hopper for LENS Additive Mfg System - Complete	Indirect	\$38						\$50
	FMF	Commission Casting Furnace - Complete	Indirect	\$117						\$150
	IMCL	IMCL TITAN TEM 4D STEM Detector Upgrade - Complete	Indirect	\$242						\$500
	TREAT	Re-establish TREAT Na Loop Capability - Complete	Direct	\$13,035						\$13,035
	FASB	Optical Microscope Replacement - Complete	Indirect	\$140						\$150
	FASB	FASB Arc Melter Replacement - Complete	Indirect	\$13						\$80
	ARL	B-wing ICP-OES (non-rad) - Complete	Indirect	\$353						\$300
	EFF	Laser Powder Diffractometer - Complete	Indirect	\$86						\$150
	IMCL	ZEISS X-ray Source Upgrade - Complete	Indirect	\$626						\$750
	HFEF	Sample Preparation Equipment for IMCL - Complete	Indirect	\$547						\$570
	EFF	EFF X-Ray Diffractometer - Complete	Indirect	\$159						\$200
	HFEF	Replace EML SEM (Electron Microscopy Laboratory, Scanning Electron Microscope)- Complete	Indirect	\$825						\$1,000
	FASB	FASB Equipment Replacement (Red Devil Furnace) - Complete	Indirect	\$883						\$995
	IMCL	In-situ testing stage for Titan and Talos transmission electron microscopes - Complete	Indirect	\$1,100						\$1,100
	TREAT	Multi-program Experiment Assembly Equipment for TREAT Experiment Support Building (TESB) - Complete	Indirect	\$1,265						\$950
		Totals		\$72,255	\$13,450	\$12,150	\$12,625	\$15,350	\$93,340	\$219,982
		Total IFM Authorized Funding		\$37,936	\$3,050					\$40,986
		Total Authorized Laboratory Investment		\$34,319	\$10,400	\$12,150	\$12,626	\$15,350	\$93,340	\$178,185

Indirect funded lab investments, prior year carryover, or other non-IFM program funding support many of these investments. Extremely dependent on IFM appropriation levels.

Green shade represents authorized scope.

Costs reflect estimates at completion. Remaining costs are rough order of magnitude.

Gray shade represents completed scope.

The ranking of remaining items will change as scope is identified and priorities evolve.

3.2.2 MFC RD&D Capability Replacement Planning

Over the last 5 years, significant efforts have dramatically expanded the NE test bed capabilities available to execute the NE mission. Many of these revolve around advanced characterization of nuclear materials and advanced fabrication technologies. Many of these high precision instruments are not designed specifically for operation in high radiation environments or designed specifically to work on high radiation samples. Instrument lifecycles in lower-exposure radiation environments are typically 5-7 years. Operating in high radiation environments or on high radiation material can accelerate instrument degradation. Many of these instruments have service contracts that support preventative and corrective maintenance which can slow degradation but not prevent it.

The INL is working with research programs leadership and federal program sponsors to develop an integrated research capability replacement strategy to address replacement of instruments before catastrophic failure occurs impacting the research mission. MFC senior leadership is engaging with research programs and developing a 5-year strategy to replace the current suite of research capabilities. No final funding determination has been made yet and all areas will be evaluated.

3.2.3 TREAT Experiment Infrastructure Strategy

The Resumption of Transient Testing Program (RTTP, or colloquially the TREAT restart project) was remarkably successful in achieving restart ahead of schedule and under budget. But, purposely, it did little to establish experiment infrastructure. Since TREAT restart, program funding and expressed interest has aligned with 5 “product lines” for the Transient Testing Program:

- Light Water Reactor fuel safety
- Sodium Fast Reactor fuel safety
- Nuclear Thermal Propulsion fuel testing
- Microreactor testing and support
- National security testing.

In general, the types of tests and experiments needed to support these product lines include 1) capsule-scale tests using relatively affordable static-environment experiment vehicles and 2) loop-scale tests in experiment vehicles using active thermal-hydraulic manipulation. (Some tests, such as those in consideration for national security applications, will use specialized applications of static capsules.) The original intention was for the DOE Advanced Fuels Campaign (AFC) to fund and establish experiment infrastructure as a matter of course for its own R&D needs, with the understanding that subsequent programs and users would benefit from that established infrastructure. Year-by-year evolution of annual appropriations increasingly reduced AFC funds available for TREAT experiment infrastructure, primarily due to constraining earmarks for industry to develop accident tolerant fuels. As a result, TREAT experiment infrastructure projects are finding constrained or even unfunded.

Despite funding constraints, a great amount of the infrastructure is in hand, or nearly so. Roughly 65% of estimated experiment infrastructure cost has been funded thus far, establishing a nearly complete capsule-scale testing capability. But most of the experiment vehicles and associated infrastructure (such as equipment and fixtures needed to handle, load, and unload fueled tests in HFEF) remain unfunded or partially completed, with the notable exception of the Mark-IIIR sodium test loop itself, which is funded and within months of delivery to INL. Even with completion of the test loop, use of the loop will not be possible without additional investments in experiment infrastructure (currently funded by NRIC). For TREAT to have the impact envisioned, these remaining capabilities and experiment infrastructure must be completed.

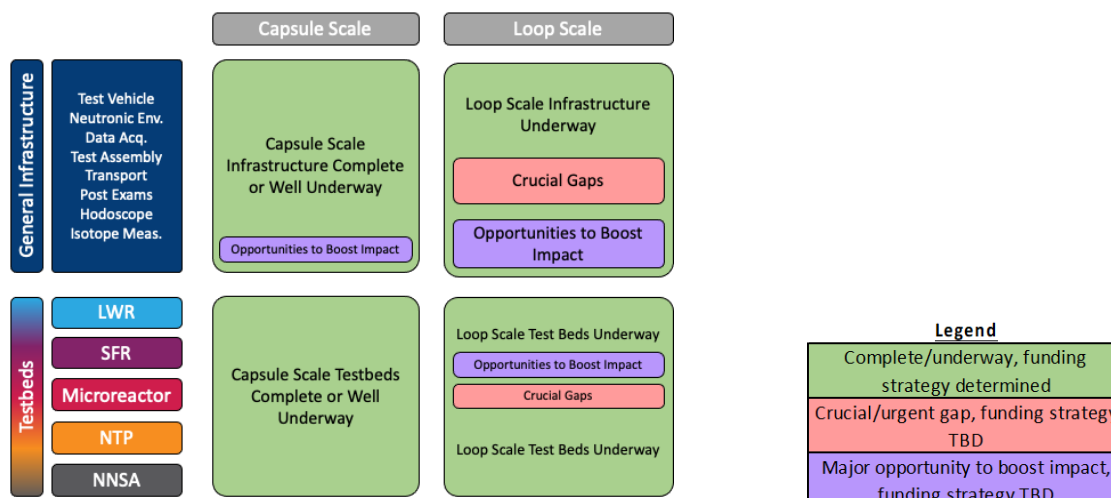


Figure 4. TREAT funding strategy.

Additional capabilities, such as advanced fuel motion monitoring (an advanced neutron hodoscope) and an experiment fission product release monitoring system have been identified as opportunities to further increase TREAT program impact.

INL-LTD-15-33324 provides an overview of the capabilities required for conducting experiments in TREAT, with recent updates and clarifications provided in SOW-18688, “HFEF Infrastructure to Support the TREAT Sodium Loop Cartridge (NLC),” and TEV-4357, “TREAT Infrastructure to Support the Mk-IIIR Sodium Loop Cartridge (NLC).” These capabilities are to be incorporated sequentially as the complexity of transient testing increases and as scope of test programs increases from light water reactor (LWR) fuels to also include advanced fuels. Simpler, capsule testing capabilities were established coincident with resumption of TREAT reactor operations. The capsule testing capabilities are providing the initial transient testing services required for near-term program needs (e.g., for the Accident Tolerant Fuels (ATF) Program and NASA’s Nuclear Thermal Propulsion program). Such capability includes equipment, facilities, and expertise to perform basic transient tests using static capsules. However, the complexity of needed testing is increasing significantly to include prototypic environments (pressure, temperature, and recirculating coolant) and state-of-the-art in-pile instrumentation. For that reason, additional investment over the 5-year period from FY-24 to FY-28 must continue for INL to meet nuclear fuel technology development objectives.

The TREAT Experiment Infrastructure Strategy as described in this document focuses on the following capabilities because they currently present the biggest challenges:

- TREAT Multiprogram Experiment Support Infrastructure
- LWR/ATF Fuel Testing
- Fast Reactor Fuel Testing
- Other Test Program investments.

TREAT experiment infrastructure funding needs and proposed funding sources are provided in Table 12. The descriptions of each instrument or support system are provided in Appendix E.

Table 12. Summary of TREAT and transient experiment infrastructure strategy and ROM cost estimates (\$K).

Transient Testing Experiment Scientific and Enabling Infrastructure		Funding Source	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Totals	Comments
TREAT Multi-mission Experiment Support Infrastructure	TREAT Experiment Support Building (TESB)									
	TESB: Building Modifications for Habitability	INL Indirect			\$1,300				\$1,300	Building HVAC, life safety systems & rad monitoring, door sealing
	TESB: Building Modifications for HC-3 experiment prep.	NE-3 (IFM)				\$2,500			\$2,500	Reinforce concrete floor; modular containment with localized HVAC; HC-3 authorization
	TREAT Multi-mission Experiment Support Equipment									
	Multi-mission experiment – closure seals of capsule experiments	INL Indirect			\$750	\$1,750			\$2,500	Laser welding inert atmosphere enclosure, fume hoods, radiography equipment, machining tools
	He-3 system (HENRI) final design and hardware procurement	NE-3 (IFM)	\$846	\$1,445					\$2,291	He-3 injection system necessary to narrow transient pulses (to ~45 msec FWHM)
	Large Experiment Capability fixtures and modifications in the TREAT facility	NE-3 (IFM)		\$1,150					\$1,150	Storage fixtures, neutron radiography stand modifications
	Sodium Loop-related additions to Large Experiment Capability	Natrium ARDP	\$110	\$2,330	\$2,020	\$300			\$4,760	TREAT equipment and modifications to the Large Experiment Capability to support the Sodium Loop
	Transport and Storage Casks									
	HFEF-15 Transfer Cask Modification for Large Experiments	NE-5 (NRIC)	\$150	\$1,850					\$2,000	TREAT large diameter experiment outer container to accommodate large-dia. experiments for multi missions. Includes HFEF modifications to support upgraded cask. FY-24 to use FY-23 carryover funds.
	Provide instrumentation to monitor core and fuel behavior during transients									
	Fuel Motion Monitoring									
	Hodoscope Operations and Maintenance	NE-42 (AFC)	\$450	\$400	\$500	\$500			\$1,850	
	Full View Hodoscope (Refurbish all 360 channel system)	NE-42 (NSUF)		\$750					\$750	
	Develop Next-Generation Fuel Motion Monitoring System	NE-42 (AFC)		\$0	\$1,000	\$1,000	\$1,000		\$3,000	Project funded for FY-19 through FY-21 by NE-42 (AFC); unclear going forward
	TREAT in-pile instrumentation									
	Advanced Transient Instrumentation Development	NE-42 (AFC) & NE-5 (ASI)	\$2,100	\$2,000	\$2,000				\$6,100	

Transient Testing Experiment Scientific and Enabling Infrastructure		Funding Source	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Totals	Comments
LWR/ATF Fuel Testing	Experiment Vehicles									
	Capsule Devices									
	TWIST experiment vehicle (LOCA testing in capsules)	NE-42 (AFC)	\$3,000	\$3,000					\$6,000	For time-at-temperature LOCA testing in water. Will also replace SERTTA as RIA test vehicle for irradiated fuel.
	TWIST vehicle enhancements (pumped, steam, etc.)	NE-42 (AFC)	\$2,000	\$1,000					\$3,000	Includes contribution from NNSA Nonproliferation
	Flowing Loops									
	TWERL: TREAT Water Environment Recirculating Loop	NE-42 (AFC)			\$500	\$1,000	\$2,000	\$3,000	\$6,500	For prototypic temperature and coolant conditions for RIA and LOCA testing
	Experiment Support Systems and Equipment									
	Capsule handling system in HFEF (TWIST)	NE-42 (AFC)	\$750	\$1,500					\$2,250	HFEF fixtures & tooling design, assembly, and installation to support TWIST experiment vehicles
	Loop handling system in HFEF (TWERL)	NE-42 (AFC)			\$750	\$1,000	\$750		\$2,500	HFEF fixtures & tooling design, assembly, and installation to support TWERL experiment vehicles
	Shielded Experiment Preparation and Inspection Cell (EPIC) – Procurement and installation into TESB	NE-42 (AFC)			\$2,300	\$4,000	\$1,500		\$7,800	For installing instrumentation on previously irradiated fuel rods for testing in ATR and TREAT
	Testing of Pre-irradiated LWR Fuel Rods									
	Advanced Fuel Rod Instrumentation Bench at TESB	NE-42 (AFC) & NE-5 (ASI)	\$1,500	\$1,500					\$3,000	Contract with Halden to implement and commission system in TESB shielded cell (ASI supporting out-of-pile testbed facility)

MFC FIVE-YEAR INVESTMENT STRATEGY

Transient Testing Experiment Scientific and Enabling Infrastructure		Funding Source	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Totals	Comments
Fast Reactor Fuel Testing	Experiment Vehicles									
	Static Capsule Devices									
	THOR development and commissioning	NE-42 (AFC)	\$2,500	\$1,000					\$3,500	For JAEA and DOE (AFC) joint test program and for other FR-type fuel testing
	Flowing Loops									
	Mk-IIIR Reactor-Ready Sodium Loop	NE-3 (IFM)	\$1,693	\$700					\$2,393	\$12.6M spent in FY-19 through FY-23. Executed in collaboration with TerraPower. TP ARDP is first user.
	Sodium loop commissioning test	NE-42 (AFC)			\$2,500	\$1,000			\$3,500	Preparation for first test using sodium loop to shake out all loop handling and operations through test lifecycle
	Experiment Support Systems and Equipment									
	Sodium loop support infrastructure									
	HFEF sodium loop equipment and preparation	Natrium ARDP	\$1,050	\$4,340	\$2,450	\$90			\$7,930	HFEF fixtures & tooling design, assembly, and installation; SAR revision; procedure dev & mock-up (SOW-18688)
	Sodium loop out-of-pile prototype installation	NE-42 (AFC)	\$1,900						\$1,900	See TEV-4357
Other Program Investments	Sodium loop sodium loading equipment	NE-42 (AFC)	\$1,000						\$1,000	See TEV-4357
	TREAT MicroReactor Experiment Cell (T-REXc)									
	TREAT facility modifications for microreactor demonstrations (T-REXC)	TREAT facility modifications for microreactor demonstrations (T-REXC)	INL Indirect	\$2,005	\$5,900	\$2,130			\$10,035	
	Flowing Hydrogen Test Loop									
	Hydrogen Supply and Exhaust System	NASA	\$2,388	\$450					\$2,838	For NASA NTP fuel testing. Construction and Installation of system FY-21-FY-24. FY-24 spending is carryover from FY-23. There is an additional \$100K set aside for future disposal. Subsequent application of design and ancillary hardware to other users.

MFC FIVE-YEAR INVESTMENT STRATEGY

Transient Testing Experiment Scientific and Enabling Infrastructure		Funding Source	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Totals	Comments
Other Infrastructure Investments	TREAT Office Building Modernization									
	MFC-721 Office Building Renovation – Engineering	INL Indirect			\$200				\$200	Interior modernization is needed to address building deficiencies.
	MFC-721 Office Building Septic Replacement	INL Indirect			\$282				\$282	Current septic system supports 20 personnel, but the current need is to support as many as 50 people at a time.
	MFC-721 Office Building HVAC and MFC-724 Power Upgrade	INL Indirect				\$2,200			\$2,200	Replacement needed due to obsolescence (coolant, spare parts) and to eliminate propane heating fuel. Requires power upgrade for MFC-724.
	TREAT Reactor Area Power Upgrade	NE-3 (IFM)			\$1,633				\$1,633	Replacement load distribution panel to update from the current and to bring additional power into the fence for TESB.
	TREAT Guard Shack Replacement (MFC-722)	NE-3 (IFM)						\$1,500	\$1,500	Current TREAT security building has structural problems.
	TREAT O&M and Training Modular Building	INL Indirect	\$2,187	\$2,225					\$4,412	Modular space for operations training and maintenance planning, to support increased mission needs at TREAT such as MARVEL, PELE, etc. Reactor building spaces not designed for current O&M desk occupancy. Cost shown includes purchase, site prep, and installation
Scientific and Enabling Infrastructure (\$K)			\$23,624	\$27,645	\$24,085	\$17,470	\$5,250	\$4,500	\$102,574	

Funding source	FY-23	FY-24	FY-25	FY-26	FY-27	FY-28	Totals
NE-3 (IFM)	\$2,539	\$3,295	\$1,633	\$2,500	\$0	\$1,500	\$11,467
NE-42 (AFC)	\$11,600	\$6,900	\$7,550	\$8,500	\$5,250	\$3,000	\$42,800
NE-42 (NSUF)	\$0	\$750	\$0	\$0	\$0	\$0	\$750
NE-42 (AFC) & NE-5 (ASI)	\$3,600	\$3,500	\$2,000	\$0	\$0	\$0	\$9,100
NE-5 (NRIC)	\$150	\$1,850	\$0	\$0	\$0	\$0	\$2,000
INL Indirect	\$4,192	\$8,125	\$4,662	\$3,950	\$0	\$0	\$20,929
Natrium ARDP	\$1,160	\$6,670	\$4,470	\$390	\$0	\$0	\$12,690
NASA	\$2,388	\$450	\$0	\$0	\$0	\$0	\$2,838
Total	\$25,629	\$31,540	\$20,315	\$15,340	\$5,250	\$4,500	\$102,574

4. MFC CAMPUS VISION

MFC is a central part of the NE test bed and NRIC mission, and their future growth. To support advanced nuclear technology development, nuclear energy technology RD&D must broaden the technology readiness level scale towards the demonstration and deployment phases. The MFC campus vision comprises a refurbishment and replacement campaign within the facilities that enables new capabilities along with a strategy to expand, replace, and relocate capabilities to support growing test bed needs. These new facilities are described below and range in maturity from capital and line-item construction underway to conceptual planning beyond the current five-year window. These encompass the need for expanded research and infrastructure capabilities anticipated to support growth related to maturing NRIC test bed capabilities.

The campus vision includes a revised overall layout of MFC, locating research facilities and support facilities into separate geographic areas of the campus to increase efficiency of the flow of research execution and decrease congestion and logistical conflicts. Post-irradiation examination (PIE) RD&D facilities HFEF, IMCL, and SPL are co-located in the northwest quadrant of the MFC site. Current and future fuel fabrication RD&D facilities are located primarily in the southeast quadrant near FMF. Current and potential future analytical laboratory research and support capabilities will remain in the central or southwest portions of the campus to support all research areas. Industrial support services will move to the northeast quadrant. Traffic will be rerouted around the perimeter of MFC to reduce industrial vehicle and equipment interaction with research and support staff and provide more direct access to industrial portions of MFC.

Additional elements that complement the proposed new facilities will also be addressed as part of the campus vision. Footprint reduction will provide additional expansion space within the fence and reduce resources required to manage and maintain aging infrastructure beyond intended service life. Facility support infrastructure such as electrical and transportation infrastructure, utility loops, and general facility systems refurbishment and replacement are being addressed as funding allows. Deferred maintenance backlog and repair needs are targeted as appropriate. Transportation flow, site drainage, parking, and general roads and grounds are reviewed with respect to the future campus design. Sustainability activities such as xeriscaping and LED light replacement is implemented as funding allows.

There are three primary means for campus development at MFC:

1. Direct DOE-NE funding for capital asset projects that can include General Purpose Project (GPP) construction and line-item construction projects of new facilities or refurbishment of existing nuclear and radiological facility systems.
2. Direct operating funded plant health related efforts such as updating or refurbishing existing nuclear and radiological facilities and their associated structures and systems (e.g., structural, electrical, or HVAC-related activities), and efforts such as sustainability, legacy material disposition, and footprint reduction.
3. Laboratory-funded investments including general-use buildings, structures, and support infrastructure. Examples include building roofs and skins, utilities and HVAC, lighting replacement, sidewalks and pavement, and other sustainability efforts.

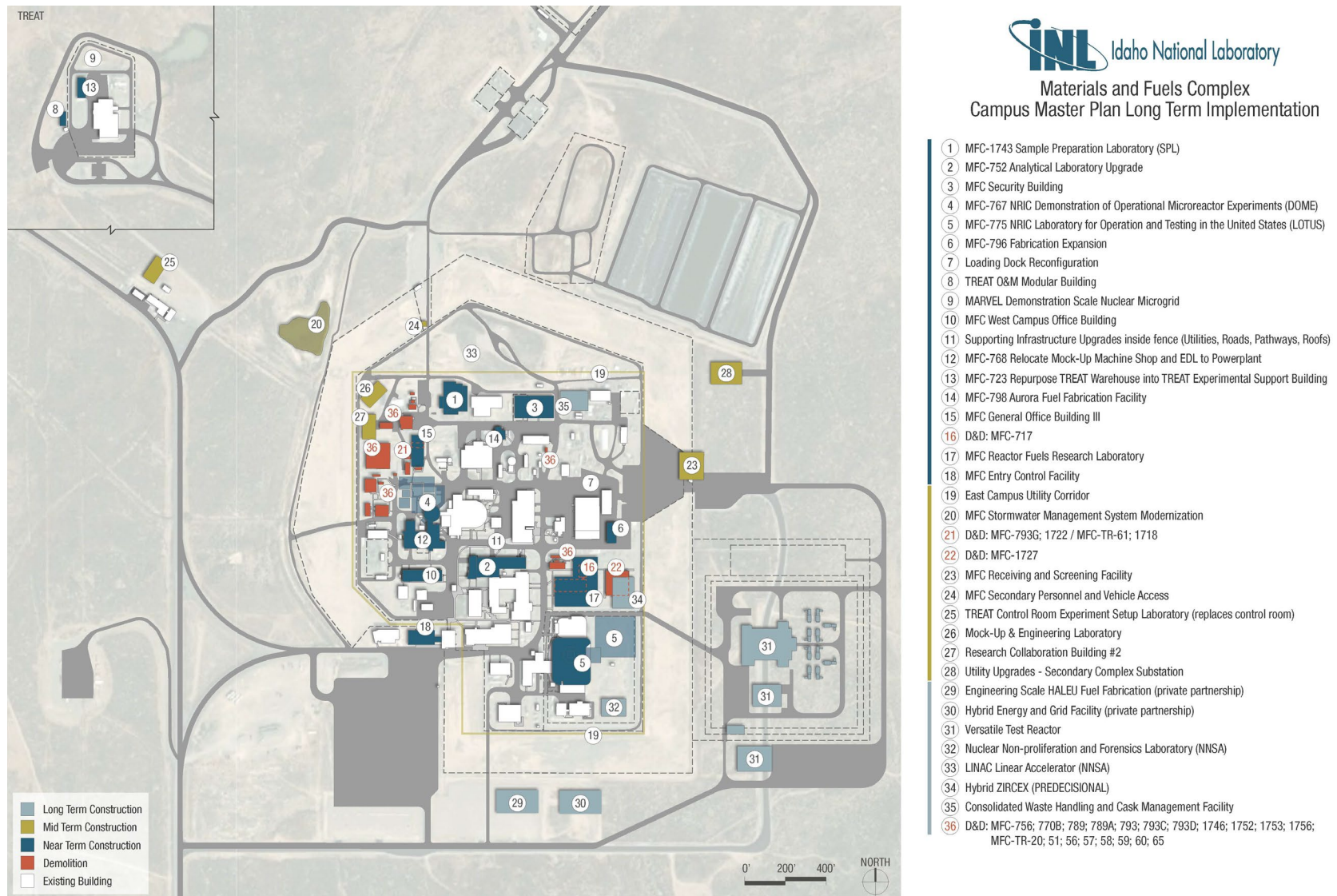


Figure 5. MFC campus vision conceptual time frames for test bed and demonstration platform development.

4.1 Sample Preparation Laboratory

Description

The Sample Preparation Laboratory (SPL) mission is to provide for analysis of irradiated structural materials. It closes an identified nuclear energy research capability gap by greatly increasing sample throughput and nanoscale research capability. SPL will provide a central hub for DOE-NE research collaborations because of its world-class instrumentation and ability to prepare, analyze, and ship alpha-free materials to universities, industry partners, and other DOE user facilities for research. This network provides specialized capabilities and access to a greater portion of the national intellectual capital.

Benefit

The proposed laboratory will include capabilities that will allow high-hazard materials to be routinely prepared and tested in a safe, secure, and environmentally controlled environment. SPL provides a key link between DOE-NE's core research functions at MFC and ATR and the broader nuclear energy research community. Materials free from alpha contamination can be sized appropriately, packaged, and transported to other national user facilities, universities, commercial, and international sites. In addition, this laboratory will complete the suite of facilities fulfilling near-term advanced post-irradiation examination (along with HFEF and IMCL) needs that will serve as a center for advanced fuels and materials characterization, as well as development of new processes, tools, and instruments to further research.

Facility Risk

This facility is needed to continue test bed expansion in line with NRIC and DOE programmatic objectives. RD&D capabilities associated with non-alpha mechanical testing of nuclear materials cannot be established without new hot cell space that this facility will provide. SPL will provide world-class structural material analysis capabilities focusing on non-fuel sample preparation, mechanical properties and failure modes, and micro/nano structural materials characterization. This capability is crucial to growing the DOE-NE test bed capabilities, to support advanced reactor RD&D up through demonstration, and to ensure LWR life extension.

Estimated Cost/Status: \$166M. Construction completion: FY-24; Operational Readiness: FY-25.

4.2 MFC Analytical Research Laboratory Upgrades

Description

The Analytical Research Laboratory (ARL) was constructed in the late 1950s and has been operational since that time. The facility was expanded in the 1970s to add sodium chemistry and nondestructive analysis capabilities. There was a major refurbishment of the hot cells in the early 1990s. Throughout its history, ARL has been primarily focused on providing chemical and isotopic analyses in support of experimental programs. In addition, ARL supports the analytical infrastructure needs of other MFC facilities. While additional capabilities have been added over the years, the support infrastructure and scientific instrumentation has not kept up with current technology. ARL has several single-point failures that could have a major negative impact to MFC's mission if they occurred. The current effort remodels separate laboratories within the ARL to include replacing aging or out-of-service fume hoods and refurbishing cabinets and floors. An exterior insulation finishing system and new windows were installed in FY-20/21 to support regulating interior temperature and pressure which had historically impacted operations. A significant HVAC upgrade was completed in FY-23 that supports improved air flow and environmental conditions that support modern instrumentation. As part of this effort, two laboratories were completely remodeled to provide modern research capabilities. The major recapitalization effort continues with modification of additional laboratories to support the significant demand on the laboratory, which has increased significantly proportionate to the increase in programmatic work at MFC.

Benefit

Growing test bed needs will continue to impact mission support operations and limit efficient response to these needs. Given its current infrastructure and space limitations, ARL will be unable to address the needs associated with its position as a central part of the DOE-NE test bed and future growth associated with capabilities at MFC unless its analytical capabilities and infrastructure are expanded. Expanded footprint coupled with re-purposing and refurbishment enables ARL to incorporate modern infrastructure technologies and install state-of-the-art analytical capabilities that would address upcoming mission needs while attracting world-class talent and users.

Facility Risk

A recapitalization program has been implemented to ensure the laboratory is able to meet its near-term mission by addressing critical infrastructure needs. This effort addresses several current potential single-point failures and alleviates the need to continue in a high-maintenance mode using scavenged and harvested parts. It also lessens the facility reliability risks associated with single-point failures and production bottlenecks that jeopardize the production and efficiency of MFC. However, it does not expand the facility footprint to support additional analytical capabilities to meet anticipated advances in the nuclear mission.

Estimated Cost/Status: ARL HVAC upgrades are complete and turned over to operations. Modification of individual laboratory rooms is ongoing, with costs estimated at \$1.5 – \$2.0M.

4.3 MFC Security Building

Description

Funding for a new MFC security building was identified in FY-20 within the NE Safeguards and Security appropriation.

Benefit

MFC-714 is the current MFC security building. It is a temporary modular office acquired in 1992 and in poor condition. A new MFC security building is required to replace the existing building MFC-714 to house necessary female and male security personnel at MFC. The project will demolish and replace the MFC-714 building and tenants have been temporarily relocated. The new building will include both female and male sleeping quarters, showers, and locker rooms. This solves providing facilities of equal quality and access that were not available to female Pro Force personnel. Also included will be Special Response Team (SRT) and Security Police Officer (SPO) storage rooms; muster/classroom; classified storage and communications; kitchen and weight room; and office/computer stations.

Facility Risk

The current security building is a converted temporary office building never intended to house security personnel overnight. It is less than 700 square feet and not suited for the security mission at MFC as operations increase and the test bed continues to grow and mature. This can impact the effectiveness of security personnel at MFC.

Estimated Cost/Status: \$15.6M. Demolition of MFC-714 was completed in FY-22; construction of the new building was initiated in FY-23 and is nearing completion, with beneficial occupancy of the building forecast 1Q FY-25.

4.4 NRIC Demonstration of Operational Microreactor Experiments (DOME)

Description

A key component of the NRIC strategy is to provide a network of independent test beds and sites (research infrastructure) that can accommodate a wide variety of experimental reactors. Based on its unique capabilities (i.e., containment dome, configuration, location at MFC), the EBR-II facility has been identified as one of the NRIC test beds. Specifically, the NRIC Demonstration of Operational Microreactor Experiments (DOME), which will re-establish reactor demonstration/experiment testing capabilities at the EBR-II facility, has been identified as a facility for testing of reactor concepts up to 10 MW thermal. To support advanced reactor demonstration activities, the containment capabilities of the EBR-II structure must be re-established to include the freight access door, personnel airlock, and support system penetrations. Re-establishment of containment functionality of the dome is consistent with its original function. Identified capabilities for the test bed were defined based on preliminary discussions with potential reactor demonstrators and refined through final design based on ongoing coordination between NRIC and reactor developers. The project will be executed as an operationally-funded activity, re-establishing original test bed capabilities and repairing the existing infrastructure.

Benefit

Re-establishing reactor demonstration test bed capabilities at NRIC is foundational to the goals of providing research infrastructure to promote scientific progress and enable users from academia, the National Laboratories, and the private sector to make scientific discoveries relevant for nuclear, chemical, and materials science engineering; and enabling the private sector to partner with the National Laboratories to demonstrate novel reactor concepts.

Estimated Cost: \$77.5M; Final design was completed in FY-23, procurements placed for long-lead items, and the construction subcontract award with initial subcontractor mobilization. Construction is ongoing with forecast completion 4Q FY-25.

4.5 NRIC Laboratory for Operation and Testing in the United States (LOTUS)

Description

The Office of Nuclear Energy (NE) has a mission need to establish a Safeguards Category I demonstration test bed capability to support the development and deployment of advanced reactor concepts. NRIC has identified a test bed capability known as LOTUS.

The purpose of the test bed capability is to enable and support the development and deployment of advanced nuclear systems by providing the infrastructure for advanced reactor developers to test and operate demonstration and experimental reactors that utilize Safeguards Category I materials. The capability would also provide necessary support systems and components (e.g., reactor cooling, backup power, instrumentation and control, material handling) for safe operations and testing.

LOTUS repurposes existing space at MFC. Multiple missions are being considered for the former ZPPR reactor cell. The reactor and ancillary support systems were removed several years ago. This created several thousand square feet of Hazard Category 2 research space available to repurpose to support new advanced reactor development and demonstration. The ZPPR facility consists of a workroom, cell area, and material storage vault. The ZPPR cell is cylindrical in construction with a usable 40-ft diameter and 25-ft height. The facility can provide safety-class confinement supporting the operation of nuclear reactors. Current facility activities are material inspections and packaging in the workroom/vault, National and Homeland Security testing and detection training in the cell area, and material storage in the vault. Demonstration of reactor concepts has not been conducted since the early 1990s. The project will be executed as a line-item capital construction project.

Benefit

Re-establishing reactor demonstration test bed capabilities at NRIC is foundational to the goals of providing research infrastructure to promote scientific progress and enable users from academia, the National Laboratories, and the private sector to make scientific discoveries relevant for nuclear, chemical, and materials science engineering; and enabling the private sector to partner with the National Laboratories to demonstrate novel reactor concepts.

Estimated Cost/Status: \$98.2M (upper end of CD-1 cost range). CD-1 was approved 3Q FY-23. Preliminary/final design is in development with CD-2/3 approval and start of construction forecast in FY-25.

4.6 MFC-796 Fabrication Expansion

Description

This project will convert from warehouse to a manufacturing shop, providing additional fabrication capabilities and capacity at MFC. Fabrication expansion is a multi-year effort, with re-location of SSPSF materials out of the northside of Building 796 up to the Security Building 736 on the hill. In order to accommodate storage in MFC-736, MFC-736 scanning equipment was disassembled and new shelving and warehousing type of storage was installed. The MFC-796 wall divider was removed and life safety systems, HVAC power drops, and an overhead crane with approximately 2 ton capacity added. A modular office has been installed inside of the Warehouse Building 796 for fabrication personnel. Modern quality storage racks, material handling equipment, and a laser cutter and other sizing machinery have been installed. The fabrication and assembly area in the current fab shop will be moved out into that warehouse making space for new mills and lathes. Execution of this expansion is being executed as an operating activity (relocation of SSPSF) and an Institutional General Plant Project (two projects (re-configuration of MFC-736).

Benefit

Additional fabrication capabilities are required to keep up with increasing demand. Additional footprint is needed to accommodate new capabilities. This expansion will position MFC Fabrication to support fabrication needs for test-train assemblies and projects lab wide as well as enhancing delivery and turn-around times to customers.

Facility Risk

Without the additional fabrication capabilities, MFC's ability to meet commitments to researchers will be impacted.

Estimated Cost/Status: \$5M. Final construction activities will be completed in FY-24, allowing fabrication personnel to move into the new expanded space.

4.7 Loading Dock Reconfiguration

Description

The existing warehouse loading dock configuration provides for a north south semi-truck access, conflicting with the primary MFC ingress/egress traffic flow to the East gate. All vehicular traffic to MFC travels east-west right in front of the warehouse. The new loading dock configuration will have trucks parking facing west backing up to a new loading dock jetty. This project will also correct drainage issues in front of the loading dock and a bad low spot in the road that is being exacerbated by the routing of all traffic through the East gate. The project is being executed as an Institutional General Plant Project.

Benefit

Reconfiguring MFC warehouse access optimizes traffic flow into MFC from the new East Gate. This enhances safety and operational efficiency.

Facility Risk

The loading dock for the existing MFC warehouse (MFC-781) is configured such that trucks are parked in a north-south orientation, blocking the roadway in front of the building. This configuration makes it difficult for the large trucks to maneuver into the dock parking and results in congestion and blocks the flow of traffic on the road in front of the docks. With establishment in FY-21 of the East Gate at MFC as the primary access point for in-plant vehicle access, the road in front of MFC-781 now serves as the primary ingress/egress roadway for MFC with an average of 125 vehicles accessing the facility daily.

The existing configuration of the MFC-781 loading dock creates not only a logistical issue with routine flow of traffic, but it also presents a safety hazard for personnel supporting operations at the warehouse as well as personnel accessing MFC. With continued growth and construction activities at MFC, it is anticipated that the impacts of the current loading dock configuration will continue to increase. Additionally, the grading of the existing dock configuration results in drainage running directly into the dock parking spaces, creating muddy/icy conditions that represent further hazards to employees.

Estimated Cost/Status: 2.5M. Design was completed in early FY-24, the construction subcontract award, and construction initiated spring FY-24.

4.8 TREAT O&M Modular Building

Description

The TREAT O&M Modular Office Building will provide space for TREAT operators and maintenance personnel as well as micro-reactor staff to be added as use of the TREAT area expands, accommodating approximately 36 to 40 people. The building is being placed northwest of the TREAT guard station and will have full services; water, power, fiber, life safety systems. This project is being executed as an Institutional General Plant Project.

Benefit

Current operations are impacted by a lack of space to house staff. Staff are forced into double or triple occupancy in some cases during research mission execution. Additional facility space can more effectively house current TREAT staff as well as new microreactor staff supporting MARVEL and future initiatives. This will improve working conditions and operational efficiency for all personnel located at TREAT. Existing MFC-721 office space is above reasonable capacity with the available space optimized to the furthest degree possible to hold current staff. In addition to current TREAT staff, we are hiring operators and maintenance staff for MARVEL, operation in T-REXC (see Section 2.6.2.3), who will be assigned to the MFC Reactors division. These personnel will be trained along with the TREAT crew in TREAT accommodations, which will only exacerbate the current space issues.

Facility Risk

There will be no available expansion capability to house additional staff for MARVEL or other projects to be placed in T-REXC. Substandard conditions will continue to exist for TREAT personnel, affecting employee morale and productivity. A lack of training and conference room space will result in delayed qualifications. Further hiring, required to support TREAT programmatic goals, means doubling up the remaining 3 manager's offices with additional workstations. Conditions will affect the TREAT experiment schedule and will force us to slow hiring for micro reactor programs.

Estimated Cost/Status: \$2.4M. Construction completion forecast 3Q FY-24.

4.9 MARVEL Demonstration Scale Nuclear Microgrid

Description

The Microreactor Applications Research Validation and Evaluation (MARVEL) project will install and operate a prototype test reactor at INL's Transient Reactor Test (TREAT) Facility. MARVEL will encompass a 100-kW thermal fission reactor inspired by an existing design and technology with TRIGA fuel, which has a high safety pedigree, that can be designed, fabricated, and started up within approximately 2-3 years. The reactor will be a sodium-potassium cooled reactor with natural circulation cooling and an operating temperature of 500–550°C. Off-the-shelf Stirling engines will convert thermal energy to ~20kW electrical power. The system is anticipated to operate for approximately 2 years. MARVEL will be the first new reactor at INL in more than four decades. MARVEL is being executed as an operations-funded R&D activity.

Benefit

MARVEL development provides an opportunity to establish and exercise key capabilities to support future microreactor demonstration by addressing:

- The need identified in engagements with potential end users of microreactor systems wanting more information about how microreactors meet their application needs.
- Development of a small-scale reactor for R&D purposes for the first time in nearly 50 years.
- Engagement and outreach with end users and stakeholders to perform research and development on the integration of microreactors with a range of anticipated applications, such as load-following electricity demand, process heat, hydrogen production, and water purification.
- Research and development to investigate and address issues and challenges related to the fabrication, assembly, rapid installation, deployment, authorization, and operation of microreactors to facilitate end-user adoption.

Risk

Development of MARVEL serves to exercise processes (engineering, regulatory, procurement, manufacturing) necessary to develop, demonstrate, and deploy small, factory-fabricated, transportable reactors to provide power and heat for decentralized generation in civilian, industrial, and defense energy sectors. Development of MARVEL will reduce the risks associated with new technology performance and manufacturing readiness of microreactors, helping to ensure that microreactor concepts can be licensed and deployed by commercial entities to meet specific use case requirements.

Estimated Cost/Status: TBD. The estimated cost for MARVEL is being established following completion of final design in FY-23. Fabrication of the guard vessel was initiated in FY-24 and a subcontract has been established for fuel fabrication.

4.10 MFC West Campus Office Building

Description

Modernizing the MFC Test Bed Campus remains a priority for INL. INL recently completed construction of a new office building including a new cafeteria in 2021. A second office building is needed to replace aging modular office infrastructure. This ensures there are facilities available to support the anticipated growth of research and technical support staff. Ensuring adequate office space also supports attracting and retaining personnel critical to support the growth of the test bed. A second office building has been designed to replace capabilities that are well past their design life. This building is a key component of a modern nuclear energy research test bed at INL. The project is being executed as an Institutional General Plant Project.

Benefit

Many MFC personnel are still housed in aging modular offices, some without basic necessities such as plumbing. Code compliance is also at risk with this aging infrastructure. Completion of the West Campus Office Building will provide for more professional office capacity for MFC employees, tour groups, and visiting dignitaries. This facility will also provide at least 60 additional office spaces that will support mission growth as well as replace the aging modular facilities that are approaching 40 years old.

Risk

New support infrastructure is required to replace aging and less than adequate modular structures currently exceeding capacity to house existing staff. MFC is currently over 100% capacity for office space. Many of the office buildings are decades beyond their intended design life. For example, MFC-717 was acquired in 1985, MFC-713 was acquired in 1978, and MFC-714 was acquired in 1977. There are also numerous smaller trailers such as MFC-TR-56 and MFC-TR-57, located at MFC in the mid-2000s that were originally leased and used by the Idaho Cleanup Project contractor to support operations at MFC. None of these degrading facilities were ever intended to provide long-term permanent offices for MFC personnel and do not have water or sewer.

Expected RD&D growth at MFC will further burden housing that is over capacity. There is no room for the additional personnel required to support the growing mission at MFC.

Estimated Cost/Status: \$25M. Design and construction, under a design-build subcontract, commenced in FY-23, with building occupancy anticipated mid-year FY-25.

4.11 Supporting Infrastructure Upgrades Inside Fence (Utilities, Roads, Pathways, Roofs)

Description

Much of MFC's supporting infrastructure is original to the complex. This work scope represents an ongoing effort to recapitalize MFC's supporting infrastructure (utilities, roads, pathways, roofs), much of which has been significantly degraded. The work represents a continuing, multi-year effort to ensure that this infrastructure is in place to support MFC's mission activities. Available fund sources, direct and indirect, are being utilized, as appropriate, to support multiple project activities.

Benefit

Continued operation of MFC's nuclear facilities, which are critical to enabling programmatic objectives, require that supporting infrastructure be in place, and provide reliable service.

Risk

Failure to invest in supporting infrastructure would lead to continued degradation of systems critical to safe and efficient nuclear operations. Reliable utilities (electrical, water, wastewater, industrial waste, compressed air, etc.) with sufficient capacity are critical to operational continuity; failure of these systems can and does result in un-planned outages, impacting mission work. Failure to invest in aging roads and pathways increases safety concerns for personnel and vehicular traffic that must traverse the facility. Failed roofing systems result in water infiltration that can negatively impact facility operations, and decreases building energy efficiency.

Estimated Cost/Status: >\$100M. This is a multi-year, continued need. Current investments include institutional investments in roads and pathways, as well as utilization of IRA infrastructure funds for nuclear facility roof replacements, fire/potable water piping replacement, and industrial wastewater piping replacement and improvements.

4.12 MFC-768 Relocate Mock-Up Machine Shops and EDL to Powerplant

Description

The current mock-up capability occupies critical Hazard Category II research footprint within FCF. Mock-up, engineering, and testing needs continue to grow every year with no ability to increase footprint to support these activities. A new mock-up capability is proposed to be located in the NW quadrant co-located near the primary research facilities IMCL, SPL and HFEF. This enhances mission execution by providing co-located resources and more efficient mock-up and testing capabilities closely aligned with the research facilities. Co-locating capabilities currently located in the EDL for non-radiological experiments, enhances integration of similar activities and will establish the MFC-768 power plant as the central hub at MFC for mock-up and research-enabling planning and development.

Benefit

Providing additional non-radiological footprint in the NW research corridor supports more effective integration. This co-locates important engineering, development, and mock-up functions increasing mission integration efficiency, while freeing up valuable Hazard Category II research footprint for expansion of programmatic/mission activities.

Facility Risk

Access to the mock-up area is needed by multiple facility and engineering personnel creating traffic within FCF that is not productive for FCF operations. The size of the mock-up area is not adequate to support current MFC mission execution creating delays in mock-up and testing that impact mission execution progress. The need for mock-up capabilities is increasing every year as the MFC mission continues to grow.

Estimated Cost/Status: Initial activities to relocate the machining capability of the existing mockup shop have been authorized through IRA HALEU funding at an estimated cost of \$10M. Design is ongoing, with D&D anticipated to commence 3Q FY-24. Movement of EDL capabilities to the turbine deck of MFC-768 are estimated at ~\$3M. Design activities, authorized as part of an institutional investment, commenced FY-24.

4.13 TREAT Experiment Support Building

Description

Additional equipment is needed to support experiment assembly at the Transient Reactor Test (TREAT) facility at MFC. Experiment assembly is needed for nearly all TREAT test programs, including those funded by NASA, DOE-NE for advanced fuels and accident tolerant fuels, NSUF projects, NNSA projects, and possibly DOD and DARPA. INL is repurposing an existing building for installation of an initial complement of experiment assembly equipment, including an inert atmosphere glovebox for closure of inerted experiment capsules.

Benefit

To address expanded experiment preparation needs, the TREAT Experiment Support Building (TESB, MFC-723, the repurposed TREAT Warehouse) is being prepared for additional work associated with TREAT experiments. A glovebox has been installed into the building and experiment assembly is placed, but the building still lacks basic infrastructure to allow year-round and full utilization of the equipment in an appropriate work environment. The upgrade/betterment associated with this request includes the following:

- New radiological monitoring equipment to support glovebox activities

- Installation of a new heating, ventilating, and air conditioning (HVAC) system to support year-round operation
- Facility improvements such as repair of insulation on the building ceiling; repair of roll-up doors to prevent moisture ingress in the building; installation of new data transmission capability (phone and internet) to and within the facility; installation of a new fire alarm panel to allow additional input to the alarm system; and modification of the electrical panels to accommodate equipment additions
- The next set of proposed improvements to TESB is modification and equipment installation to support further TREAT experiment work, as described in Section 1 of Appendix D.

Risk

Existing capabilities and space are not sufficient to support the TREAT experiment assembly workload. TREAT experiments are currently assembled in a number of INL facilities including HTTL, AFF, EFF, and the TREAT reactor building. Each of these facilities support multiple missions and at times bottlenecks in experiment assembly have threatened the TREAT testing schedule. Equipment purchased for TREAT experiment support activities in the TESB cannot be fully utilized, particularly during inclement months, without building improvements that provide modern communications infrastructure and heating and cooling. With the TESB unable to meet experiment support needs, TREAT will continue to rely on an *ad hoc* collection of multi-mission facilities to prepare TREAT experiment, with a high potential to impact the TREAT testing schedule for some future priority experiment.

Estimated Cost/Status: The most recent cost estimate for TESB HVAC system installation was \$1.2M during FY-22.

4.14 MFC-798 Aurora Fuel Fabrication Facility

Description

Oklo, Inc. through a Cooperative Research and Development Agreement (CRADA), has proposed to fund conversion of MFC-798 into a Hazard Category II nuclear facility with the capabilities to fabricate fuel for their Aurora Reactor Concept. The project will entail the design of a fuel fabrication capability based on the EBR-II fuel process, procurement of gloveboxes and equipment to support fabrication, modification and upgrade of the facility, and operational readiness activities.

Benefit

Establishment of the fuel fabrication capability at MFC will enable the more efficient use of HALEU being provided to Oklo by DOE and capitalize on the fuel fabrication experience of MFC personnel. Repurposing of the facility will expand MFC fuel fabrication capabilities and capacity.

Risk

Development and production of fuel represent a critical component of the development and deployment of new advanced reactor technologies. As a fully funded private investment, Oklo is mitigating risks associated with its' first reactor deployment by establishing fuel fabrication capability for its' first core, co-located with the planned siting location of the reactor at the INL.

Estimated Cost/Status: <\$100M. CRADA has been established and conceptual design is anticipated to commence in FY-24.

4.15 MFC General Office Building III

Description

Modernizing the MFC Test Bed Campus remains a priority for INL. A third office building is needed to continue replacing aging modular office infrastructure. This ensures there are facilities available to support the anticipated growth of research and technical support staff. Adequate office space supports attracting and retaining personnel critical to support the growth of the test bed. This building is a key component of a modern nuclear energy research test bed at INL. This project is anticipated to be executed as an Institutional General Plant Project.

Benefit

Modernizing the MFC infrastructure for the future provides advantages to attracting world class talent. Many MFC personnel are still housed in aging modular offices, some without basic necessities such as plumbing. Code compliance is also at risk with this aging infrastructure. Completion of a third administrative building will greatly enhance large capacity meeting capability and provide for more professional office capacity for MFC employees, tour groups, and visiting dignitaries. This facility will support mission growth as well as replace the aging modular facilities that are approaching 40 years old.

Risk

New support infrastructure is required to replace aging and less than adequate modular structures currently exceeding capacity to house existing staff. MFC is currently over 100% capacity for office space. Many of the office buildings are decades beyond their intended design life. For example, MFC-717 was acquired in 1985, MFC-713 was acquired in 1978, and MFC-714 was acquired in 1977. There are also numerous smaller trailers such as MFC-TR-56 and MFC-TR-57, located at MFC in the mid-2000s that were originally leased and used by the Idaho Cleanup Project contractor to support operations at MFC. None of these degrading facilities were ever intended to provide long-term permanent offices for MFC personnel and do not have water or sewer.

Expected RD&D growth at MFC will further burden housing that is over capacity. There is no room for the additional personnel required to support the growing mission at MFC.

Estimated Cost/Status: \$30M. Design and construction start is targeted following completion of the West Campus Office Building.

4.16 D&D: MFC-717

Description

MFC-717 is an approximate 10,000 square foot modular office building acquired in 1992. This facility currently provides office space for MFC engineering personnel. The degraded overall condition of the 30+ yr old facility, coupled with envisioned fuel fabrication capabilities at MFC, necessitates that the facility be demolished.

Benefit

D&D of the facility will provide additional space within the MFC fence line for critical capabilities needed to sustain the NE mission.

Risk

Failure to proceed with D&D of the facility will limit areas for expanded mission activities and result in continued maintenance associated with an aged facility.

Estimated Cost/Status: TBD. Need for demolition has been identified and is being prioritized with other required investments in MFC's infrastructure.

4.17 Advanced Nuclear Fuels Fabrication Laboratory

Description

The Advanced Nuclear Fuels Fabrication Laboratory is a life cycle replacement of existing fuels research infrastructure, providing additional Hazard Category 2 space in the form of a flexible domestic facility for developing and producing multiple, new forms of HALEU fuel simultaneously on an engineering scale (hundreds of kilograms of material). It will support prototyping, demonstration, and qualification of fuel manufacturing equipment and processes at this scale, with the agility to reconfigure to accommodate improved equipment or address different process requirements. It will be capable of accommodating a variety of fuel form factors and designs and optimized for processing fuel materials with U-235 enrichments between 5% and 20%, the range of enrichments for most of the innovative fuel designs currently being investigated. The project will be executed as a line-item capital construction project.

Benefit

Establishing this fuel fabrication capability will provide DOE, and private sector with the infrastructure necessary to support development, testing, and deployment of new reactor fuels needed to demonstrate advanced reactor technologies, fuels research for existing reactor fleet and fuel development to support research and test reactors. Development and testing of these fuels will provide real data that can be used to validate models, support fuel qualification, and bring new reactor fuels to market quickly, efficiently, and cost effectively. With this capability, the U.S. will be able to deploy a diverse set of advanced reactors to meet the energy needs of the future and support the Nation's climate change goals outlined in Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*, and ensure national security through energy independence.

Facility Risk

The lack of adequate reactor fuels research capability affects NE's ability to fulfill its mission areas. INL facilities are at capacity and due for lifecycle replacement. Failure to establish fuel fabrication capability will slow the development and qualification of new fuels and advanced reactor concepts subsequently impacting NE's mission and advancement of nuclear power.

This gap also impairs the ability of U.S. developers to innovate and could force them to look to state owned enterprises in China and the Russian Federation for fuel development and demonstration needs. Consequently, this gap poses a significant national security risk affecting the US ability to maintain its leadership and undermines NE's efforts to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. Relinquishing U.S. leadership in advanced fuels research and development will limit our influence in global nuclear safety and security policies.

Estimated Cost/Status: \$150 - \$300M. CD-0 was approved 4Q FY-23. Initiation of conceptual design activities is pending appropriations.

4.18 MFC Entry Control Facility

Description

This effort will upgrade and modernize the existing MFC entry control facility (MFC-701). The existing facility is not sized or configured to support the number of individuals entering and existing MFC on a daily basis. The number of personnel at MFC has increased significantly over the past decade, corresponding to the increase in mission-enabling work conducted at MFC. Further, the existing security screening area is approximately 1/3 that of a similar sized access control facility (number of lanes) that would be seen elsewhere, decreasing the ability of security personnel to respond to prohibited or controlled items that may be discovered during ingress screening.

Additionally, the project will replace the current chain link and barbed wire front entry into MFC with modern securiscaping, eliminating the dated and imposing military look of the entrance to MFC. This will include replacement of fencing with more modern barriers seen around other secure facilities such as concrete planter barriers and more decorative style barriers such as the modern ornamental type fencing seen around the entrance to FCF. The project is planned to be executed as a direct-funded General Plant Project.

Benefit

Commercial designs to secure the MFC front entry will provide a much more modern research facility-oriented look to the test bed and still maintain critical secure access control.

Risk

Failure to modernize the MFC entry control facility could result in non-ideal response to controlled items during ingress, further congestion resulting in delayed personnel screening and entry to MFC, and safety concerns associated with personnel who must wait in adverse weather conditions prior to entry.

Estimated Cost/Status: <\$30M. Pre-conceptual development was completed in FY-23.

4.19 East Campus Utility Corridor

Description

As the MFC campus continues to mature and grow, infrastructure must also expand to support the test bed. This effort will be similar to the work done on the West Campus Utility Corridor several years ago that enabled the NW quadrant research corridor growth.

Benefit

Planned expansion of the MFC test bed in the NE and SE quadrants will require expansion of the existing utility corridor that has not been modified for decades. Electrical, firewater, and potable water, communications, and sewage utilities will need to expand to handle planned new construction including a reactor fuels research capability and east gate receiving and inspection facilities.

Risk

The current utility capabilities along the eastern borders of MFC are not adequate to support expanding needs as the MFC test bed continues to grow.

Estimated Cost/Status: Project is pre-conceptual design and costs are TBD.

4.20 MFC Stormwater Management System Modernization

Description

The current stormwater management system is largely the same system that has existed at MFC for decades. It is generally outdated and needs to be refurbished to address the growth at MFC and limit impacts to existing facilities.

Benefit

Current maintenance activities continue to address optimizing the current system, but campus growth requires a more substantial effort to support efficient campus operations.

Risk

Managing stormwater and snow run off ensures MFC campus operations remain effective and efficient. Recent intrusion of runoff into research facilities has created increased expenses and resources required to address runoff intrusion. Additional maintenance was required to address the HFEF truck lock and FMF intrusion of runoff into research facilities. The current system is not able to ensure new facilities are also protected and overall refurbishment of the stormwater management system is necessary to support effective base operations.

Estimated Cost/Status: Project is pre-conceptual and costs are TBD.

4.21 D&D: MFC-793G; 1722/MFC-TR-61; 1718

Description

D&D of facilities in the NW quadrant is envisioned to provide space within the MFC fence line for mission expansion.

Benefit

D&D of the facilities will provide additional space within the MFC fence line for critical capabilities needed to sustain the NE mission.

Risk

Failure to proceed with D&D will limit areas for expanded mission activities and result in continued maintenance associated with aged facilities.

Estimated Cost/Status: TBD. Need for demolition has been identified and is being prioritized with other required investments in MFC's infrastructure.

4.22 D&D: MFC-1727

Description

D&D of MFC-1727, a modular office facility, is envisioned to provide space within the MFC fence line for mission expansion that is co-located to MFC's other secure facilities.

Benefit

D&D will provide additional space within the MFC fence line for critical capabilities needed to sustain the NE mission.

Risk

Failure to proceed with D&D will limit areas for expanded mission activities and result in continued maintenance associated with aged facilities.

Estimated Cost/Status: TBD. Need for demolition has been identified and is being prioritized with other required investments in MFC's infrastructure.

4.23 MFC Receiving and Screening Facility

Description

The MFC warehouse (MFC-781) was built in the late 1960s to support the EBR-II mission. It is now insufficient to support the diverse needs of MFC's current and anticipated mission, programs, and facility maintenance. MFC is also lacking adequate NQA-1 controlled storage space to support the growing number of research activities requiring more stringent management and control of material associated with nuclear facilities and research. MFC-781 does not have sufficient warehousing space and functions primarily as a receiving and distribution facility. A new receiving and screening facility is being proposed that would add capacity, improve package screening, and limit the number of vehicles entering the MFC fence line. The project is anticipated to be executed as a direct-funded General Plant Project.

Benefit

This facility creates more space in and around the research corridor to support test bed growth, reduces pedestrian interaction with heavy equipment movement, and recapitalizes aging infrastructure eliminating the end-of-life maintenance issues associated with it. It will be integrated into the MFC East Gate so that deliveries do not have to enter the secure area to drop off freight. This facility will also provide limited NQA-1 secure storage. This supports the campus vision of collocating industrial functions to the northeast quadrant of MFC, separating them from the research corridor areas and freeing up campus space in the research corridor for test bed growth. This also reduces traffic within the MFC campus that will further limit truck congestion and interaction with pedestrians.

Facility Risk

Inadequate storage creates operational inefficiencies because there is no environmentally controlled storage for mission- and maintenance-critical parts, equipment, and supplies. Unnecessary double handling, additional manual material handling risk, increased material storage and labor costs, and increased damage risk occur due to the present West One warehousing arrangement for all the materials, supplies, equipment, and instruments needed to support the MFC mission. Temporary environmentally uncontrolled storage in SeaLand containers has been adopted due to inadequate storage space to support facilities' needs to stage and retain critical components, one-of-a-kind fixtures, hot cell support equipment, spare parts, and programmatic equipment for efficient retrieval. The cargo containers are located throughout MFC, creating an industrial/construction atmosphere versus a campus atmosphere. Quality storage is implemented *ad-hoc*, often resulting in less-than-optimal arrangements that increase quality risks. Items and materials are pigeon-holed throughout the facilities, resulting in multi-handling, housekeeping and safety issues, and less than optimal storage and handling of expensive, delicate, and quality-designated items. Interim radiological storage is lacking across MFC, and West One does not allow storage of contaminated or suspect contaminated items, so SeaLand containers are being used for this purpose. Waste boxes and other containers could be stored in a central location while awaiting shipment, and incoming shipments needing temporary overnight storage could be accommodated if space were available. Storage of suspect and contaminated items should be accommodated.

In many cases, roads and grounds maintenance equipment is improperly stored in the weather (trucks, plows, mowers, sprayers, sweepers, and other implements), because enclosed storage space is not available. Programs inefficiently use valuable space that could be repurposed for essential mission functions. For example, one MFC division maintains multiple storage buildings at MFC and INTEC for equipment storage. These components could be consolidated into central controlled storage for more efficient operations and free up valuable real estate. MFC fabrication shop experiences fabrication inefficiency because there is no room for bulk-source material quality-controlled storage. Semi-trucks delivering to MFC-781 perform six- and eight-point turns to access the loading dock in its current configuration. This blocks the street for lengths of time that will be untenable when the new east gate is operational.

Estimated Cost/Status: ~\$30M. Project is pre-conceptual.

4.24 MFC Secondary Personnel and Vehicle Access

Description

The north gate is currently used to support construction of SPL and serves as the secondary emergency vehicular ingress/egress point. In the past it provided interim access to MFC on an as-needed basis. This project proposes to establish the temporary capabilities of the north gate as a permanent entry/egress point with an appropriately sized security screening facility that supports personnel and vehicular access to MFC. The project is anticipated to be executed as a direct-funded General Plant Project.

Benefit

Enhancement of the NW gate will allow future ingress/egress directly into the northern research corridor. This allows quick access to SPL, IMCL, and HFEF as well as a future mock-up/engineering/testing facility. Upgrade of the capabilities (gates, screening capabilities, facility) will provide a more robust location for personnel/vehicular ingress/egress in support of the MFC mission, while ensuring that a robust entry/exist location is available for emergency services.

Risk

More direct access to a critical research hub at MFC increases overall mission efficiency providing increased footprint for and accelerating mission support. Facility ensures that emergency services (fire, security) can continue to meet facility needs.

Estimated Cost/Status: ~\$25M. Project is pre-conceptual.

4.25 TREAT Control Room Experiment Setup Laboratory

Description

This project updates or replaces the TREAT Control Room and Office Building to support the TREAT mission.

Benefit

Updating the TREAT Control Building and Office Building will enable INL to support the TREAT mission into the future. The control room sits in a modular building installed in the early 1980s and was updated during the recent TREAT restart project. The Office Building is undersized for its current and anticipated personnel usage supporting a TREAT test program, which is growing to include users and experimenters from DOE-NE, NASA, NNSA, and industry seeking a variety of test types. This deficiency will only be exacerbated by the increasing complexity of upcoming TREAT tests and increasing on-site participation by TREAT experimenters. Furthermore, the most recent addition to and upgrade of the TREAT Office Building was completed in the early 1980s, such that the building systems consist of components of different vintage, many requiring frequent maintenance or replacement.

In early FY-23, a pre-conceptual design investigated a new TREAT office, Control Room and Experiment Support Laboratory. We propose this project continue with an evaluation of different options for building and project scope and location.

Risk

If the TREAT Control Room and Office Building are not updated or replaced, the TREAT test program will be impeded by the inefficiencies of not being able to accommodate all necessary program personnel at the TREAT location. Impacts could include cessation of, or not being able to perform, certain TREAT test campaigns.

Estimated Cost/Status: The pre-conceptual design cost estimate for a new building with Office, Control Room and Experiment Support Laboratory is around \$91M. There should be opportunities to reduce that cost by revising the scope of functions to be included in the building and considering location impacts.

4.26 MFC Mock-Up and Engineering Laboratory

Description

This building will provide essential laboratory and collaboration space supporting engineering initiatives at MFC.

Benefit

Increasing use of MFC research facilities requires additional space to execute engineering efforts that support research. Dry lab and wet lab space to develop and assemble research related systems and equipment as well as plant health and other related facility systems enable research throughput and facility reliability.

Risk

More laboratory space is essential to support both research and plant health related efforts. Increased utilization of test bed capabilities requires footprint to perform engineering.

Estimated Cost/Status: This is pre-conceptual design and no estimates are available at this time.

4.27 Research Collaboration Building #2

Description

This project will provide research office, collaboration, and non-radiological laboratory space to enable research activities at MFC. Similar to the existing Research Collaboration Building, the facility will co-locate research staff, supporting increased collaboration.

Benefit

Establishment of a new research collaboration facility will enable improved collaboration among researchers, programs, and industry partners. Providing high-quality research collaboration space will improve research outcomes by improving working conditions, attracting research staff, and enabling collaboration.

Risk

Failure to provide collaboration space for MFC's growing research personnel can result in inefficiencies and hinder the ability to advance mission activities.

Estimated Cost/Status: This is pre-conceptual design and no estimates are available at this time.

4.28 Utility Upgrade – Secondary Complex Substation

Description

With continued facility growth and ever-increasing electrical demands, a secondary substation is anticipated to be required to support continuity of MFC operations and mission activities.

Benefit

The substation will provide additional electrical capacity and resiliency.

Risk

Existing power capacity at MFC may not be sufficient to maintain and sustain MFC operations.

Estimated Cost/Status: This is pre-conceptual design and no estimates are available at this time.

4.29 Versatile Test Reactor

The VTR project is a capital asset project governed by DOE O 413.3B. It received CD-1 approval in September 2020. Prior to Congressional action to not fund the VTR project in FY-22, the VTR project was in the project planning phase. The VTR's purpose is to fulfill the U.S. need for a capability to irradiate materials and fuels in the fast neutron spectrum. A sodium-cooled fast test reactor design is intended to provide a unique research capability to improve the understanding of nuclear fuels and structural materials for the development of advanced nuclear energy systems. The VTR will provide the physical means of fuel and materials testing in a user facility analogous to testing in DOE's thermal test reactors. Experimental inserts and tests loops are included in the project, but power production and thermal storage are outside of the project's scope.

The VTR Environmental Impact Statement (EIS) Record of Decision (ROD), issued on July 22, 2022, announced the decision "to construct and operate a VTR at INL, and to establish, through modification and construction, co-located facilities for post-irradiation examination of test products and for management of spent VTR driver fuel at INL. No decision has yet been made for location of VTR driver fuel manufacturing, but options evaluated were location at INL and at the Savannah River National Laboratory (SRNL).

VTR received capital funding in FY-21 and began expenditure of those funds in Summer 2021. A VTR siting investigation will include boring, trenching, and seismology measurements. Congressional funding was not provided in FY-22 – FY-24. Preliminary design, final design, and construction timelines are dependent on appropriations.

4.30 Long Term Aspirational Program Funded Facilities

Various research programs have expressed a desire to construct programmatic facilities at MFC. These facilities are aspirational in nature and may be line items within other areas of the NE budget or wholly/partially funded by industry. Examples of these facilities are listed below with no time frames or cost estimates due to the aspirational level of detail:

- The Materials Recovery and Waste Form Development Program has identified a desire to construct a hybrid ZIRCEX facility. The hybrid ZIRCEX (short for zirconium removal prior to extraction) process recovers highly enriched uranium (HEU) and downblends it to create High-Assay Low-Enriched Uranium (HALEU), defined as uranium containing between 5% and 20% U-235. This would provide HALEU feedstock to support fuel development for advanced reactor designs.
- The long-term vision for the NE test bed includes the possibility of industry partnering with DOE by co-locating facilities near the MFC campus. Examples include advanced HALEU fuel fabrication and hybrid energy facilities.
- A Nuclear Non-Proliferation and Forensics Laboratory has been discussed with homeland security personnel. This laboratory would enhance current National and Homeland Security RD&D capabilities at INL.
- A linear accelerator (LINAC) uses electricity to generate high energy beams of X-rays or electrons to support materials research and isotope production for nuclear forensics, medical, and emergency response applications. Locating a LINAC at MFC has been proposed by NHS programs. This capability could also provide critical support research of needs for the microstructural characterization of fuel.

Appendix A

Detailed Descriptions of Plant Health Activities

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1. Manipulator Refurbishment and Replacement Campaign in HFEF, FCF, and ARL

Description

This project procures a new manipulator system for replacement of the obsolete manipulators in HFEF, FCF and ARL and commences an extended manipulator replacement campaign. Replacement manipulators are not currently available and will need to be developed by the supplier. To fully test manipulator capability prior to implementation, two complete units need are being procured with additional slave arms of varying length to simulate the implementation in cell. The concept is a modular manipulator with a standard seal tube. Heavy duty master/slave and medium duty master/slave would utilize the same seal tube and allow for maximum cell configurability. Additionally, several slave arms of varying length would be balanced to a master configuration to allow in-cell configuration as needed for each workstation. This concept would minimize the total number of manipulator arms needed. Scope includes procurement of a set of manipulators for the mockup, testing and evaluation followed by optimization prior to procurement of a complete set of manipulators in each facility. The mockup manipulators will remain for use in qualification of equipment.

Benefit

This project provides replacing the aging manipulator fleet with new manipulators increasing reliability across all hot cells. This includes new models from the current provider as well as Walischmiller models. The implementation of manipulators can be scaled back based on funding but should provide one or more operating station replacements per year as funding allows.

Facility Risk

Current manipulators are obsolete. Spare parts are no longer available from vendor and increased usage is resulting in increased breakage. Many are out-of-service and cannot be repaired. Prototype manipulators are being tested with the vendor now. Delays in completing this campaign adds to the risk that cessation of mission work that could span months at critical hot cell windows if old manipulators fail and impact facility availability.

ROM Cost Estimate: \$19.7M through FY-28; Outyears TBD.

2. Hot Cell Window Replacement Campaign in HFEF, FCF, and ARL

Description

Main hot cell windows at HFEF, FCF, and ARL use mineral oil to provide clarity between windowpanes. Several windows have developed mineral oil leaks into the hot cells. HFEF window 1M is currently leaking approximately 2 gallons per month. Operators currently have to periodically clean up the oil manually. This project involves evaluating the condition of the windows and providing a means to restore the windows to their intended function. This is not considered a standard maintenance item due to the complexity of the repair and the need to breach the hot cell containment in order to implement the repair. This project will include significant interruption of facility availability. Each window replacement will require fabrication or refurbishment of a replacement A-slab (outer layer of a multi-layer hot cell window unit) with oil collection and management capability, installation of the new/refurbished A-slab, fabrication or refurbishment of replacement window tank unit extracts, and installation of the replacement/refurbished tank unit. There are multiple leaking windows at HFEF, FCF, and ARL with additional leaks materializing as the facilities age. New dry window assemblies are being considered for the ARL. Dry window assemblies do not require oil for optical coupling of the multiple panes of glass

and are comparatively maintenance free with respect to oil-filled windows, while being capable of providing superior shielding with improved light transmission in the ARL application.

Benefit

Mitigates oil leaks by establishing a leak tight A-slab and allowing for periodic draining of accumulated oil between the A and B slabs. It also corrects the source of the oil leak and establishes the original integrity of the system. Additionally, the fabrication of the replacement tank unit minimizes the downtime on the facility with the facility hot and argon filled. Dry window assemblies, if determined practical for ARL, will result in windows that are no longer susceptible to oil leaks, reduced maintenance, improved light transmission, and better shielding capability per unit of window thickness.

Facility Risk

The hot cells are aging, and additional window failures are anticipated. Failure to provide the additional window replacements may jeopardize hot cell operations due to the extensive planning and lead time associated with the evolution. A catastrophic window seal failure would cause unacceptable mission impacts on the order of months to over a year.

ROM Cost Estimate: \$12.3M through FY-28; Outyears TBD.

3. FCF Multi-Function Furnace #1

Description

The electrometallurgical treatment process used to neutralize the sodium component of irradiated EBR-II elements includes a salt distillation step as part of the process. Currently, the 25-year-old Cathode Processor (CP) is the only means of performing this salt distillation requirement from uranium dendrite or other process materials in the FCF argon cell. When maintenance needs arise, repairs to this unit must be performed remotely which results in extended treatment process downtime. This is a single point failure that limits process treatment rates. The addition a secondary distillation capability via a new high temperature vacuum atmosphere furnace in the FCF argon cell will enable salt distillation requirements to continue when maintenance occurs on the Cathode Processor and will help to alleviate the bottleneck at this process step associated with higher throughput rates. Additionally, this new furnace will be designed to support expanded missions beyond salt distillation to include cladding hull consolidation, sodium contaminant distillation, as well as uranium consolidation.

Benefit

Increase in overall treatment system reliability and process rate efficiency, while expanding capability in enhancing uranium product and process waste stream disposition

Facility Risk

The single point failure associated with the current treatment system limits the rate of treatment. Past operational conditions provided some flexibility to store dendrite on an interim basis until the Cathode Processor was available, however future operating requirements will significantly restrict this capability, resulting in shutting down the process until repairs can be made.

Workload at the CP is increasing, while equipment availability has been decreasing in the recent past due to unplanned component failure related to the age of them.

ROM Cost Estimate: \$9.9M.

4. Radioactive Liquid Waste Treatment Facility Process/Storage Tanks Replacement

Description

RLWTF has four 1,000-gallon tanks, one of four tanks has evidence of recent leaks that has not been repaired and the two other tanks have been previously patched. These tanks need to be permanently removed from service and a suitable replacement system will be installed.

Benefit

The replacement system will utilize commercial products and eliminate RLWTF process equipment O&M costs. This also reduces radiological risks.

Facility Risk

Facility risk is reduced by installing a low maintenance alternative to existing RLWTF system. Eliminate consequences of failure of this system that would entail stopping manipulator repairs in HFEF and FCF (as there would be no water reservoir for drain water from manipulator decontamination work). This would rapidly shutdown programmatic work in these hot cells.

ROM Cost Estimate: \$4.5M.

5. HFEF Small and Large Transfer Lock Doors and Drive Control System Upgrade

Description

The large and small lock drive controls are old and prone to failure. This project replaces the existing controls with new modern controls. The small transfer lock is used to transfer small materials between the main hot cell and decontamination cell. It is used to support both programmatic and in-cell maintenance. Hinges and sealing surfaces have degraded. These doors maintain argon cell containment control and limit contamination release between the two hot cells. These doors are safety significant.

Benefit

Replacement of the drive controls with modern components will increase reliability of lock door operations. Small lock door replacement will return the physical hot cell boundary to the original condition. This action minimizes the risk of future material transfer delays due to system inoperability.

Facility Risk

Failure to replace the controls would expose program work to increased schedule risk should the locks become inoperable due to control issues. Failure to perform this work increases the risks to perform material efficient material transfers to support programmatic work. The door repair is a long-lead activity with an estimate of 6-9 months to obtain, modify, and install a replacement.

ROM Cost Estimate: \$1.9M.

6. HFEF and FCF Electro-Mechanical Manipulators, Cranes, Hoists, and other In-Cell Handling Equipment Refurbishment and Replacement

Description

In-cell handling equipment in the HFEF and FCF hot cells is often single point failure threats to all or parts of hot cell operations supporting crucial research missions. These include electro-mechanical manipulators (EMM), hoists, cranes, and transfer locks. These are critical components to hot cell operations and how research material and equipment are moved around inside the hotcell. These are also how critical in-cell maintenance is performed. Most of these important systems are beyond design life and are experiencing accelerated failure rates with a direct impact on facility reliability and research equipment availability. Addressing these risks will require a multi-year campaign similar to manipulator and hot cell window replacement. Specific near-term targets are described below.

HFEF Repair Hoist Access Improvements – Observations during previous repair hoist entries, transitioning from run to failure maintenance strategy to the performance of periodic maintenance/inspections, as well the future installation of a second manipulator repair enclosure in room 318 warrant repair hoist enclosure access improvements.

HFEF Crane and EM Component Replacement – Several components for the crane and EMM's are no longer available as direct replacement. Engineering must be performed to ensure compatibility and configuration of replacement components. This includes:

- Crane Hoist Brake/Lubrication
- Crane Hoist Motor
- Crane Trolley Drive Assembly
- EM Hoist Drive Assembly
- EM Rotate Drive Assembly
- EM Carriage Drive Assembly
- EM and Crane Bridge Motor.

HFEF Repair Hoist Control System Upgrade – The repair hoist control cabinet has numerous outdated components and controls. Recent activity to restore repair hoist control have been successful in maintaining operability. Replacement of the internal of the control cabinet internals allows for maintainable system and adds monitoring capability to the system for evaluating system performance.

Crane/EM Power Feed Replacement – The power feeding the two in-cell cranes and two Ems has had issues and has been wired to spare conductors to maintain operations. Power is supplied through a wall feedthrough with in-cell wiring extending up to the wall mounted bus bars. The wall feedthrough is suspected to have had current failures but cannot be easily tested.

Replace FCF Blister Hoist and Controls – The Blister Hoist is 5-ton capacity hoist whose purpose is to remove and replace the argon cell crane trolleys and the EMM carriage-bridge drives when these devices need repair or maintenance. This hoist is within an enclosure which is a carbon steel tank connected to the top of the argon cell concrete roof. The blister-hoist enclosure is included as a safety significant Argon Cell Confinement System Passive Components. Shielding is provided by a shielding plug attached to the hoist chain so that when the chain is withdrawn, the plug nearly fills the roof through-tube. The Blister Hoist operates with no known issues but is beyond end-of-life usage, has not been inspected since the early 90s, and repair components will be difficult if not impossible to locate for procurement. The equipment is original to the facility.

Replace FCF Air Cell Exit Cell Crane and Controls – The exit cell houses a 5-ton crane whose purpose is to remove and replace the air cell crane trolleys and the EMM carriage-bridge drives when these devices need repair or maintenance. The exit cell crane is located over a hatch in the air cell that has sliding doors to allow items to be hoisted or lowered between the air cell and the exit cell. A door between the exit cell and the cart area was sealed shut for security purposes as part of the HRA restoration work. The Exit Cell Crane operates with a potential future problem with bus bar insulation and is beyond end-of-life usage and repair components will be difficult if not impossible to locate for procurement. The equipment is original to the facility. Replacing the Exit Cell Crane will include modifying the door between the existing cell and old Decontamination Spray Chamber (DSC) roof to allow access for inspection.

Benefit

The general benefit of executing in-cell handling equipment refurbishments and replacements is increasing research capability availability. Since these systems are critical to cell operations, all aspects of operations, maintenance, and execution of various research missions depend on them.

Refurbishing and replacing HFEF and FCF in-cell handling equipment link directly to facility reliability and research capability availability. Any movement of materials or equipment into, out of, or within the hotcells rely on these critically important tools. Recent down time associated with the FCF transport lock and HFEF repair hoist failures significantly impacted research capability availability for extended periods of time. This adversely impacted progress on important research program milestones, HALEU production, and regulatory support of the Idaho Settlement Agreement. Certain failures of handling equipment also reduce availability of functioning equipment to protect remaining capabilities and limited availability of research capabilities within the hot cells. For example, the HFEF repair hoist failure eliminated the ability to reduce manipulator repairs which impacted progress on research.

Facility Risk

Failure to refurbish or replace these systems would result in loss of overhandling capabilities in the facilities and significant or complete stop of any work.

ROM Cost Estimate: 18.6M.

7. Replace FCF SERA/DSC Crane and Control Equipment

Description

The Suited Entry Repair Area (SERA) allows maintenance of large equipment items that require hands-on servicing. It has a 5-ton-capacity overhead bridge crane which connects with the crane bridge above the DSC; the crane hoist trolley can carry a load from one bridge to the other, between the SERA and the DSC. The SERA Crane is essential to move EMMs, Cranes, Process Equipment, Waste, and Manipulators to and from the repair enclosure which is critical to maintaining capability of performing EBR-II Fuel Processing and HALEU Production program mission commitments.

The SERA has experienced control system failures at an increase frequency and problems with crane bridge latching at the interface of the SERA and DSC.

Replacing the SERA/DSC Crane will include Bridge Latch Limit Redesign & Rebuild, developing a replacement plan for Crane and controls, initiate advanced procurement, and execute replacement of the Exit Cell Crane.

Benefit

Reliable capacity to perform Material/Equipment transfers and needed maintenance on Argon and Air Cell Manipulators, EMMs and Cranes to ensure availability for project/program missions.

Facility Risk

Without additional funds mission commitments are at-risk of completing on time as we have committed.

The SERA/DSC Crane is evaluated as a single point failure piece of equipment. Its failure would significantly and adversely impact EBRII Fuel Processing and HALEU Production program commitments.

ROM Cost Estimate: \$12M (IRA).

8. New SCRAPE Cathode Module for FCF Electrorefiner

Description

The electrorefiners in FCF are used to separate the EBR-II used fuel and irradiated blanket materials into individual components as part of the treatment process to neutralize the sodium used in constructing the elements. As part of the process, the separated uranium is recovered on a cathode mandrel and removed from the vessel for potential re-use in other nuclear fuel cycle applications, including high assay low enriched uranium for proposed fast spectrum research reactors. Removal of the cathode with accumulated uranium dendrite is time consuming and occurs 4 to 6 times (on average) during a treatment batch. Implementation of the scraped cathode concept is intended to reduce the frequency of cathode withdrawal via accumulation of uranium dendrite in a co-located product collector and use of an integrated compaction plate to increase the amount of uranium dendrite removed from the electrorefiner each time the cathode is withdrawn.

Benefit

Increase in overall treatment system reliability and process rate efficiency.

Facility Risk

The task of removing the electrode assembly and connected cathode mandrel from the ER is one of the more time-consuming aspects of the treatment process. The frequency of handling electrode assemblies to remove the cathode is manipulator intensive and disruptive to processes occurring in the adjoining workstations, thus concepts that could lead to a reduction in the frequency with which this operation is conducted could yield significant overall efficiencies to the treatment process.

ROM Cost Estimate: \$2.7M.

9. Replace FCF Facility Control System

Description

The facility and process monitoring and control systems in the Fuel Conditioning Facility (FCF) were designed, constructed, and installed by in-house MFC engineers and technicians. The backbone of these systems consists of three integrated component types. These components are:

1. Programmable Logic Controllers (PLC)
2. Small Logic Controllers (SLC)
3. Operator Control Stations (OCS)

These components were last replaced in the 1990s and are past obsolescence. The old components operate under the Windows XP platform that is no longer supported or maintained by Microsoft. The individual PLCs and SLCs within the systems use modules that are no longer available from the vendor. The vendor is requiring replacement of these older system components with new, up-to-date hardware in order to

provide vendor support. Migrating to new hardware involves porting the existing PLC/SLC application software to a modern, vendor supported, operating system. The OCS human machine interface (HMI) was developed using the FIX32 (Supervisory Control and Data Acquisition software system) will not run on platforms running Microsoft Windows' versions newer than XP. Fortunately, the Fix32 HMI software can be converted to a new version, iFIX, that will operate under current Windows operating system platforms (and should be supported for many years to come). All the components within a system must be upgraded simultaneously to maintain proper system functionality.

As the older components continue to fail in service, the FCF has experienced unscheduled system outages that have delayed facility operations while repairs are made. Replacement of these system components, under crisis management methods, has not proven timely or cost effective. This project will replace the obsolete components, repair or replace the networking backbone of the systems, update all components to run on supported Microsoft Windows operating systems, and do so in a series of scheduled facility outages that will be coordinated with other facility operations and schedules. In this way, high facility reliability and availability can be sustained.

Benefit

1. Increased facility availability and reliability
2. Network security of systems is reestablished
3. New hardware will be supported
4. Commercial spare parts readily available

Facility Risk

The FCF monitoring and control systems have reached end-of-life. The systems in question provide critical data and control functionality to/from various processes and systems throughout the facility. Equipment failure has had a detrimental impact on FCF's daily operations and overall mission. The impairment caused by the failure of this equipment has resulted in facility outages that have prevented facility activities from being performed (such as EBR-II fuel processing). This equipment must be upgraded in order for FCF to operate through its anticipated life.

ROM Cost Estimate: \$4.4M (IRA beginning in FY-23).

10. ARL Lab Space Renovations

Description

The ARL provides high-quality processing, analysis and characterization of radiological materials. The ARL laboratory rooms house sample preparation and examination equipment and analysis instrumentation. The majority of the lab rooms are located in the B-wing and Sodium wing of the ARL. The B-Wing and Sodium Wing were put into service in 1957 and 1969, respectively, with little to no updating since being put into service. Damaged asbestos based floor tiles and work surfaces are present in many of the lab rooms. Windows are single-paned with aluminum framing, providing marginal insulation value. Additionally, modern instrumentation detection limits are so low that background radiation levels within some of the rooms interfere with new instrument capabilities. Therefore, laboratory rooms need to be decontaminated and new sample preparation fume hoods and work surfaces need to be installed.

Benefit

A clean and modern work environment with more efficient equipment and use of lab space will optimize the performance of personnel in their workspaces. Updated work areas and equipment will reduce the amount of maintenance required.

Facility Risk

The conditions can be less than ideal for operating equipment. The inefficient layout of workspaces present challenges for personnel when preparing samples for analysis. Personnel output is reduced both in volume and quality when working environments are not satisfactory. Background levels are interfering with the lower detection limits required by programmatic work and capabilities of current instrumentation being installed in the ARL.

ROM Cost Estimate: \$10.0M (1.5 - \$2.0M/lab room).

11. HFEF Argon Regeneration Valve Replacement

Description

The regeneration system in HFEF provides heated dry air and argon for regenerating the purification system dryers. The regeneration valves are old and need replacement. The summary of work for this project is the procurement and replacement of the HFEF argon cell regeneration valves. This includes design of components to ensure proper interface of the new valves with existing piping.

Benefit

Replacement of the regeneration valves will increase the reliability of the regeneration system.

Facility Risk

The risk to the facility if the regeneration valves are not replaced is the increased chance of the regeneration system failure which in turn would impact the facility capabilities to support programmatic work.

ROM Cost Estimate: \$2.5M.

12. HFEF MetBox Refurbishment – Purification System Replacement

Description

The met cell is a small, shielded, inert gas-filled hot cell (located in Room 123). The cell houses a Leitz Model MM-5RT gas-sealed metallograph, a LECO AMH55 Micro-Hardness Tester used for microhardness testing, and a Leica DMi8 Advanced Microscope used for microscopic examination of prepared samples. The cell maintains the inert atmosphere required for loading and examining samples and shields personnel from radiation from the samples. The atmosphere control system maintains an inert gas atmosphere (< ppm O₂ and H₂O) in the loading cell. It is maintained at negative pressure with respect to Room 123, and is regulated by its own controls located on the north wall of Room 123. The met-cell atmosphere is automatically controlled by the feed and bleed, analytical instrumentation, cell-exhaust, purification, and nitrogen/Argon systems.

Benefit

Restoration of full capabilities optimized RD&D support efficiency and reduces rework on samples.

Facility Risk

The only atmospheric control that is currently functional is pressure and thus there is no information for the purity of the atmosphere in the Met Box. Not controlling the atmosphere allows oxygen and moisture into the atmosphere which causes oxidation of the Met mounts and degradation of susceptible system components.

ROM Cost Estimate: \$1M.

13. FCF In-Cell Lighting Feedthroughs

Description

FCF In-cell lighting in a highly degraded condition. After determining the failure locations of many of the lighting circuits we have determined that they cannot be repaired remotely in the argon cell. As a manned entry for repair is also not possible our most logical alternative is to utilize other conductors to provide power to the in-cell lighting. Currently there are spare feedthroughs currently installed, available and capable of supplying the necessary power for in-cell lighting. Original ballasts and light fixtures will be reused. Ballasts were replaced in the last decade and these are still serviceable items. Some lighting fixtures will need to be replaced on as-needed basis.

Benefit

In-cell lighting directly impacts the ability to perform work in the argon cell. Many times, supplemental lighting in the form of handheld spotlights are being used to augment the low light conditions in the argon cell. The use of the handheld spotlights increases the quantity of personnel required to perform work at the cell windows as 1 person is often shining the light while the other operator(s) perform the task in cell. The increased lighting will reduce the risk of mistakes performed during in-cell operations that are caused by inadequate lighting.

Facility Risk

Reduced lighting in the argon cell will increase the risks associated with in-cell operations. Incorrect identification of containers, unintentional striking of other items with remote overhead handling equipment, increased time for all in-cell tasks will be negatively impacted with low light conditions. Efficient critical mission work in the argon cell will continue to be impacted or will not be able to be completed.

ROM Cost Estimate: \$1.3M.

14. I&C Obsolescence: EDACS Installation/Upgrade

Description

The TREAT Experiment Data Acquisition and Control System (EDACS) is a non-safety system used to monitor and record signals from an experiment and to control experimental systems, such as heaters or pumps. The primary interface is the EDACS console in the TREAT Control Room, although the system allows control and monitoring from inside the Reactor Building. The current EDACS was assembled and installed during TREAT restart and provides the minimal functionality needed for tests and experiments to date. However, an expanded capability will be necessary for more complex TREAT experiment systems and vehicles, such as for the Hydrogen Test Loop and the Sodium Test Loop. The EDACS Installation/Upgrade project will update hardware and software to provide an expanded and more-robust control capability and an increased number of data signal channels for monitoring and recording.

Benefit

The EDACS Installation/Upgrade project will provide the expanded capability necessary to operate more complex TREAT experiment systems.

Facility Risk

Completion of this project will ensure that TREAT has the capability needed to accommodate increasingly complex and evolving needs of experimenters and users, reducing risk of not being able to adequately control testing conditions or of missing data due to an inadequate signal processing capacity. The upgrade to separate controllers similar to those used in other TREAT systems will enhance EDACS maintainability by TREAT personnel.

ROM Cost Estimate: \$310K.

15. Fire Barrier Refurbishment for MFC Nuclear and Radiological Facilities

Description

Fire barriers within MFC facilities serve two functions: 1) protect life; and 2) protect property, including research equipment and experiments. There is no documentation that alterations that have occurred to the fire barriers over time are compliant with NFPA 221. The work scope involves penetrations and seals in fire rated walls that need to be repaired or replaced. The scope also includes door repairs, wall joint repairs, and window & door replacements.

Benefit

Inspections of the barriers have identified gaps that would affect the barriers' performance in a fire. As a result, it is uncertain that adequate protection would be provided to property, personnel, and equipment if a fire were to occur in one of these MFC facilities.

Facility Risk

The barriers will continue to be potentially non-compliant with NFPA requirements and weaknesses in the fire protection system will continue to pose a potential threat to MFC property and personnel.

ROM Cost Estimate: \$1.5M.

16. Refurbish HFEF Precision Gamma Scanner

Description

The precision gamma scanner's (PGS) gamma detector has surpassed its expected useful life by 3 years and is showing signs of failure. The system is using ~4x the coolant it once did, indicating that it is no longer running optimally. The PGS gripper has experienced significant down time in recent months. Further equipment failure is likely, which would shut down production for weeks or months to procure replacement parts. These delays could affect program milestones. The control components within the PGS electrical cabinet are old, and drop-in replacements are not commercially available.

Benefit

The PGS is considered a "portal" instrument supporting almost every nuclear fuel research effort. This is considered a base R&D capability and refurbishment is essential for mission execution.

Facility Risk

Loss of this capability would stop the post-irradiation workflow not only in HFEF, but in all other MFC facilities as the gamma scanning is a critical technique used for all the programmatic work.

ROM Cost Estimate: \$3M.

17. Replace MFC Fire Protection and Potable Water System

Description

Approximately 1.2 miles of underground piping and two deep well pumps that were installed as part of the original EBR-II infrastructure in the 1960s. This piping is cast iron and has surpassed service life. Recent piping failures (4) in the past 15 months that have cost over \$2.5 million to replace.

Benefit

Replacing the pumps and associated piping will eliminate piping failures associated with system components that are beyond design life. This will ensure that water for fire protection, research needs, and employee occupancy are provided as required to support the MFC mission.

ROM Cost Estimate: \$15M (IRA).

18. Replace MFC Industrial Wastewater System

Description

Current system was installed in the 1970s with approximately 1,500 ft of asbestos cement underground piping and about the same linear footage of open ditches.

Benefit

Enables protection of personnel who could be exposed to system components and the Snake River Plain aquifer.

ROM Cost Estimate: \$10M (IRA).

19. ARL Emergency Shower/Eyewash Compliance Updates

Description

The emergency eye wash and showers in the ARL are currently compliant only because they were installed so long ago. They do not meet current ANSI standards, which says they must provide 20 gpm at 30 psi for 15 minutes between the temperatures of 60 and 90 degrees.

Providing for tepid water by installing an electric water heater/storage tank to provide hot water, to be mixed with cold water, to provide 80°F (median required water temperature) is required. Assuming cold water is 50°F, and 140°F hot water storage temperature, 100 gallons of hot water would be required to mix with cold water to provide 300 gallons at 80°F. A mixing valve will be needed, and they require annual maintenance and testing. A return line and circulating pump should also be installed from the storage tank to each lab (parallel to existing supply piping) to ensure the tepid water supply is nearly instantaneous in the event a shower is activated.

Benefit

Installation of a new system to provide warm water to the shower and eye washes throughout the facility meets ANSI standards. Additionally, it also provides comfort to individuals in dire circumstances to be able to rinse for the recommended time and prevent further harm. Currently, with the temperatures where they are, if something were to happen, individuals could not stay under the shower for enough time to fully mitigate the hazard of the chemicals.

Facility Risk

The Analytical Research Laboratory currently is operating at risk due to the shower and eye wash. The safety of the technicians in the lab is compromised. It would be hard for anyone to stand under a 65 degree shower for 15 minutes to rinse during an abnormal event when there is already chaos.

ROM Cost Estimate: \$750K.

20. Roof Repairs for Nuclear/Radiological Facilities

Description

This covers maintenance activities associated with repairs and/or replacements of sections of roofs that cover the nuclear research facilities.

Benefit

Steady funding for ongoing maintenance activities on nuclear research facility roofs ensures that facilities remain available to support research missions and that the vital research capabilities are protected from damage. An ongoing roof maintenance campaign of targeted replacements of sections of these aging roofs ensures that research operations are not disrupted.

Facility Risk

Roof leaks in nuclear facilities put facility and research equipment at risk from infiltration of water. It can disrupt operations and poses a risk of damage to facilities, systems, and research equipment.

ROM Cost Estimate: \$20M (IRA).

21. ARL Ultra Pure Water Stations

Description

Ultra-pure water stations deliver on-demand water that has been purified and de-ionized to a conventional standard and that ensures native elemental species in supplied water do not interfere with the quantification of elemental and isotopic analytes in solutions under investigation. To maximize the efficiency of laboratory operations and take full advantage of the ultra-pure water characteristics, these water stations should be installed wherever sample preparation occurs in the laboratory, typically those rooms with benchtop areas and fume hoods for preparative work.

Benefit

The majority of the ARL's elemental and isotopic analyses require the use of ultra-pure water in all steps of the sample and standards preparation processes to prevent the introduction of contamination that will alter the results of the analyses. The sensitivities of the mass spectrometers, for example, are so high that low concentrations of samples are used to achieve increasingly lower detection limits of analytes. Native elements present in the water used to prepare the dilution acids could skew measurement or result in false-positive detection. Ultra-pure water is therefore necessary to ensure accuracy in challenging measurements.

Because sample preparation, including dilutions, takes place in each benchtop laboratory space in the ARL, it is necessary to have local ultra-pure water stations in each of the pertinent rooms. The need to access ultra-pure water rapidly arises with sensitive analytes and acids. In addition, the need to reduce the handling of the water by, for instance, transporting it from one room to another, is critical because increased handling results in greater probabilities of introducing contaminants. Ultra-pure water stations at each benchtop increases the ARL's sample throughput and improves quality control and assurance.

Facility Risk

The absence of ultra-pure water stations at each benchtop (or one per laboratory room) limits the accuracy and precision of the ARL's results and jeopardizes the ARL's ability to meet ultra-low detection limits in its characterization of low levels of impurities in experimental fresh fuels. It also reduces the precision in the characterization of used fuels during post-irradiation characterization. Both of these functions are critical mission areas for the ARL.

ROM Cost Estimate: \$300K.

22. TREAT He-3 Injection System Final Design and Hardware Procurement

Description

The Helium-3 Enhanced Negative Reactivity Insertion (HENRI) is a gas injection system designed to inject He-3, a neutron poison, into the TREAT core to terminate a transient pulse more quickly than the TREAT Transient Rod Drives can be inserted, for the purpose of achieving a narrower pulse width. Narrow transient pulses are of interest to sponsors of LWR testing, to be more consistent with conditions expected in postulated LWR reactivity insertion accidents (RIAs), and to Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL). RIAs are a class of events to be addressed in regulatory approval of new LWR fuel designs, and testing under representative conditions (i.e., time-dependent deposited energy and time-dependent heat removal) is important to ensure that phenomena of interest are adequately represented. Pulses that are too wide would present a non-conservative assessment of relevant phenomena, while too-narrow pulses would unnecessarily exacerbate phenomena and possibly lead to overly conservative interpretation of results.

Benefit

Completion and installation of HENRI will place TREAT as the only operating transient test facility in the world capable of providing representative LWR RIA test environments. Results from such tests will be important to regulatory approval of new fuel designs, particularly approval to operate reactors in manner that takes advantage of new fuel characteristics. These results would be one piece of the case that allows new fuel designs, such as Accident Tolerant Fuels (ATFs), to be utilized in a manner to reduce LWR fuel cycle cost. In addition, better providing test conditions of interest to LLNL and LANL will open possibility for increased TREAT utilization for NNSA programs, increasing the diversity of TREAT program sponsors and stakeholders.

Facility Risk

If TREAT is not equipped with He-3 capability, then TREAT RIA tests will be less effective for addressing regulator questions about new LWR fuel designs, possibly leading to greater conservatism or fuel cycle penalty imposed on reloads with new fuel designs. Such regulatory could impede introduction of new fuel designs into LWRs. TREAT testing would also be less attractive to LLNL and LANL experimenters, limiting TREAT utilization by those sponsors.

ROM Cost Estimate: \$3.2M.

23. TREAT Reactor Building Exterior Stair Upgrade

Description

The ladders previously used to access the levels of the TREAT Reactor Building roof from outside do not meet current requirements for safe climbing. Because of this, most high work outside the TREAT building must be supported by a tall lift borrowed from elsewhere at INL. This is inefficient and complicates any emergent work with schedule uncertainty. New stair assemblies have been procured for installation to the outside of the Reactor Building but must now be installed.

Benefit

With the new ladders in place, TREAT maintenance personnel and sub-contractors will have more-convenient access to the levels of the TREAT Reactor Building roof, once again providing better schedule control.

Facility Risk

Without installing the new stairs, TREAT personnel will continue to borrow a tall personnel lift for work on the TREAT Reactor Building's exterior high spaces.

ROM Cost Estimate: \$326K.

24. TREAT Zone 9 Platform Addition

Description

Installation of the TREAT Microreactor Experiment Cell (T-REXC) into and near the North High-Bay Equipment Pit in the TREAT Reactor Building, and the subsequent installation of the MARVEL reactor into T-REXC will occupy a significant portion of the operating floor in the North High Bay. That location is where TREAT experiments are prepared for insertion into the reactor. Because the upcoming Pele project will tie up a large portion of the South High Bay, that area is not available to compensate. To recover operating floor space, a low mezzanine or platform will be built over the top of the Zone 9 storage area. The materials and equipment stored in Zone 9 are seldom accessed, so the additional time needed to access the storage positions through the platform will have minimal or no impact on expected TREAT operations.

Benefit

Installation and use of the platform will give TREAT Operations additional floor space to compensate for the loss of floor space due to accommodating reactor projects in the TREAT Reactor Building.

Facility Risk

Without the platform, TREAT Operations will be constrained in how they can prepare TREAT transient experiments, with a likely impact on experiment turnaround time and test schedule.

ROM Cost Estimate: \$656K.

25. NRAD Fuel Procurement

Description

NRAD reactor in the 64-element configuration has \$0.82 of excess reactivity at full power. The banked critical rod heights at full power are at 85% of core height. \$0.54 is required to reach equilibrium xenon conditions, leaving \$0.28 of available reactivity for experiments and associated in-core hardware before the experiment irradiation schedule becomes restricted due to xenon preclusion. Several proposed irradiation fixtures (e.g., NRAD pneumatic transfer system [NPTS] and large drywell heater) have reactivity penalties estimated to be $\geq \$0.50$ depending on core position. Several programs have expressed interest in performing work that would require a higher neutron flux than that produced from the 250 kW power output of NRAD, which would necessitate an uprate of 500 kW – 1 MW. Additional fuel will be required for these experiments and/or any power uprate. Regardless of the future vision of NRAD, NRAD will need additional fuel to compensate for burnup.

Planned fabrication schedule, with transfer of HALEU feedstock from Y-12 to TRIGA International in France being initiated in FY-24:

Element Types	FY2025	FY2026	FY2027	FY2028	FY2029
Cat. No. 419 – Standard Fuel Element (SFE) 30 wt% - Stainless Steel, Conversion	10	10	6	8	8
Cat. No. 519 – Instrumented Fuel Element (IFE) 30 wt% - Stainless Steel, Conversion	0	0	2	1	1

Benefit

Makeup fuel will extend the life of the reactor. Experiment enabling fuel quantities will allow NRAD to reconfigure the core to compensate for larger negative reactivity experiments, tailor the core flux in the vicinity of an experiment, and maintain the flux profile to protect the fuel. Increased neutron flux availability will expand the spectrum of experiments NRAD is capable of conducting.

Facility Risk

TRIGA Fuel International fabricates TRIGA fuel on a campaign basis. If NRAD misses the next fabrication campaign then NRAD will shut down permanently before the following campaign which could be 25 years or longer away, or never.

If a commitment is not made to purchase makeup fuel, then soon NRAD will reach a point that excess reactivity available will not allow extended reactor runs due to xenon preclusion to support projects such as TRISO, aU furnace LDRD and molten salt LDRD, or perform large negative reactivity irradiation experiments.

If experiment enabling fuel is not purchased, then NRAD will not be capable of configuring the core to compensate for high negative reactivity experiments, limiting the reactor value as a multifunction research platform.

ROM Cost Estimate: \$7M.

26. HFEF Fire Suppression: NRAD East Radiography Station (ERS) & Preparedness

Description

The current suppression system in the basement East Radiography room uses Halon as the suppressing agent. This substance is considered hazardous to the environment and is no longer manufactured, making supply limited. The current system has been impaired and finding repair parts has been difficult. Replacing this system with an inerting system will prove to meet the needs and reliability required.

Additionally, administrative documents will be reviewed for effectiveness and ability in activating suppression and extinguishing activities in the Decon Cell and the Hot Repair Area.

Benefit

Installing an automatic fire suppression system in the East Radiography room would provide reliable fire suppression to allow NRAD research activities to continue.

Reviewing documentation will assist in identifying issues or inability to properly respond to a fire in areas where traditional suppression is not found. Reducing human error will allow the facility to operate with increased confidence by knowing what risks are present and at what magnitude they exist.

Facility Risk

Existing fire suppression is not adequate for NRAD. If adequate fire suppression is not available, these mission activities will not be able to continue.

Allowing procedures to go unchecked introduces unknown risk. In the event of an emergency, human error will play a big role in the outcome of that emergency.

ROM Cost Estimate: \$1.0M.

27. Increase FMF HVAC Capacity to Support Facility Heat Load

Description

MFC-704 Fuel Manufacturing Facility (FMF) is provided with two 12 1/2 ton outdoor condensers that provide refrigerant to an evaporator coil located in an air handler unit (AHU) that serves FMF. This AHU provides cooling for the entire facility. The south workroom located in FMF has two supply air ducts from the AHU used to condition this space. The sensible cooling capacity provided to the south workroom from the AHU is approximately 15,500 BTU/h.

Current plans for the addition of gloveboxes and additional processing equipment in the south workroom will add a total heat load capacity of approximately 100,000 BTU/h (29.3 kW). An additional cooling system will need to be provided to the south workroom to support the facility cooling needs. A variable refrigerant flow (VRF) system with four indoor wall mounts would address the expected heat load and provide the ability for future expansion.

Benefit

The installation of a variable refrigerant flow (VRF) system with four indoor wall mounts would address the expected heat load and the system would also provide the ability for future expansion. This will position the facility to support currently planned and future programmatic work.

Facility Risk

Failure to address the need for additional cooling capacity will limit the ability to add new equipment to the facility.

ROM Cost Estimate: \$1.5M.

28. Expand Waste Drum Storage Capacity at FMF

Description

Historically, the FMF facility has needed 10 drum locations within the north and south workrooms to support its ongoing mission in the Transuranic Breakout Glovebox (TBG) and SNM glovebox. This demand will remain, and future project operations will require additional storage locations in FMF for waste drum and equipment storage. The addition of the new gloveboxes in the South Workroom will further reduce the available storage areas. The pit (9' x 11' x 3' deep) in the northeast corner of the FMF North Workroom has been identified as an underutilized space, and a platform will be constructed to bring the working surface up to the same grade as the surrounding floor in the FMF work room.

Benefit

This alternative will allow for storage of (24) 55-gallon, 7A drums on the new platform surface.

Facility Risk

There are limited locations for waste drum and equipment storage in FMF. Failure to create additional storage locations could impact the success of future projects.

ROM Cost Estimate: \$600K.

29. MFC-722 Roof Replacement

Description

The TREAT Guard Post (MFC-722) is a small building used to control access in the fence around the TREAT Reactor Building. The roof has leaked repeatedly in recent years, and the past year's rain and snow leaking into the building damaged internal structures. This project will repair the current roof to once again be watertight.

Benefit

Replacing the roof on the current building will delay the more-expensive project to replace the building with a new access control building.

Facility Risk

Not repairing the roof will most certainly allow water ingress again during Spring of 2024, prompting repairs to internal structures and to remove internal moisture.

ROM Cost Estimate: \$0.2M.

30. Big BUSTER Facility Support Equipment Modifications

Description

The transition from BUSTER to Big BUSTER as primary containment for experiment campaigns requires new designs for 12” and 24” storage hole adapters and pedestals. 12-in. single storage hole adapters and pedestals were designed and fabricated in early FY-24. Five 24-in. storage hole adapters are needed to support storage for current and upcoming experiment campaigns. Due to size, the 24-in. storage hole adapters will be fabricated by an off-site subcontractor.

Benefit

Provision of the 24” storage adaptors is necessary to accommodate planned TREAT experiments using the Big BUSTER container without complication of storage logistics and excessive inter-facility transfers.

Facility Risk

Without this additional storage re-configuration, the TREAT facility will struggle to support the planned transient testing schedule with associated experiment assembly and Post Irradiation Examination (PIE) facility transfers.

ROM Cost Estimate: \$0.3M.

31. Install FCF Drum Filling Station

Description

With decontamination and demolition of the large-scale radioactive liquid waste process/storage capability at MFC-798 and planned repurposing of the facility to support fuel fabrication capabilities, a permanent drum filling station at FCF is required to support continued FCF operations. This project will establish a drum filling station that supports shipment of liquid waste generated at FCF off-site for treatment and disposal. The interim drum filling capability established at MFC-798 will be removed and isolated.

Benefit

The drum filling station will enable FCF to directly fill waste drums for off-site shipment for treatment and disposal, supporting continuity of operations at FCF.

Facility Risk

Without a drum filling capability, process liquids resulting from FCF operations would not have a pathway for disposal, hampering operations and slowing programmatic work at the facility.

ROM Cost Estimate: \$1.5M.

32. IMCL Ventilation Modification

Description

IMCL ventilation system is credited in SAR-418 as Defense In Depth (DID) to control/mitigate radioactive airborne release. Negative differential pressure in the IMCL Laboratory relative to atmosphere, is controlled via 6 Variable Air Valves (VAVs) located on the supply duct work of the laboratory. The actuation response time on these VAVs is approximately 90 seconds from full open to full close. This is an inappropriate response time to control differential pressure and should be closer to 5 seconds. Software controls have been put in place to limit the VAVs to 50% open due to the slow

response time of the actuator. This mitigation reduces airflow into the laboratory which reduces facility air exchange below ASHRAE recommendations (CO 2023-1926), HVAC's ability to cool the laboratory and results in regular freeze up of IMCL's air conditioning system. Replacement of the VAVs or potentially just the controllers to a system with a better response time would allow the HVAC/ventilation system to perform to its designed capabilities.

Supply and exhaust ventilation ducting is located only on the ceiling of the IMCL laboratory. This results in poor air exchange at the instrument/glove box worker level. Lowering the exhaust ducting near the floor of IMCL laboratory would promote better air exchange and provide better worker protection during off-normal events by removing contaminated air from the breathing zone of the employee.

Benefit

Modification to the VAVs will allow the IMCL DID ventilation system to operate at its design parameters, provide better control of differential pressure in the laboratory and associated Class A gloveboxes, and eliminate freeze-up conditions on the air conditioning portion of the ventilation system. This will improve the ventilation systems ability to maintain a consistent temperature in the laboratory which will improve scientific instrument performance. Lowering ventilation exhaust to the floor of IMCL laboratory will improve air exchange in the building and provide contamination control mitigation during a potential off normal event.

Facility Risk

Continued poor performance of IMCL ventilation system causes unplanned facility unavailability during warm summer months, supply fan trips/shutdown due to loss of differential pressure control in the laboratory, poor air exchange effects environmental controls and poor mitigation for a potential contamination event.

ROM Cost Estimate: \$500K.

33. HFEF Cell Chiller Replacement

Description

The HFEF cell chillers were replaced around 2010. Since then, the chillers, while functional, have never performed as desired. The HFEF cell chillers continue to experience repeated failures due to a hybrid controller system, excessive start/stop sequences, and unbalanced run times. The hybrid control system does not allow start/stop sequences and unbalanced run times to be remedied. The current cell chillers do not have the correct duty cycle and are not the correct type of unit to maintain the required atmosphere inside the HFEF hot cell. Multiple repairs and partial replacements have been conducted since the units were installed, but the underlying problem remains, requiring increased cell chiller maintenance due to failures. Over the last several years nearly every mechanical component has failed and has been replaced without effectively solving the problem. This project will replace the current HFEF cell chillers with process type chiller that is designed for extended operating cycles.

This project will be a 2-year effort with 1 year of design, including issue of procurement, and 1 year for implementation and close-out.

Benefit

The benefit to the facility is increased chiller reliability resulting in reduced maintenance costs (now roughly cumulated to ~200K), less schedule delays to accommodate the repairs as well as less potential for cell down time and impact to programmatic work.

Facility Risk

If the replacements are not procured and installed and the main cell chillers fail, there will be a complete stop work of all the activities in the main cell, including containment box, metbox, and purification system. The main cell would be in a feed and bleed style for pressure (would fluctuate between -1" and 4" of H₂O) and be unable to control the moisture and oxygen content of the cell. If not corrected in a timely manner will lead to experiments becoming degraded and potentially completely damaged beyond recovery.

ROM Cost Estimate: \$2.0M.

34. IMCL Laboratory House Chiller System

Description

Heat loads in the laboratory have continued to increase due to additional new equipment. In particular the number of air-cooled chillers, computers, research instruments and other sources of heat. The existing HVAC unit for cooling the laboratory can no longer keep up with the heat loads. There are now fourteen (14) air cooled chillers that expel heat into the laboratory that have been added to cool scientific instruments: these include the SEM, TEM, EPMA, FIB, PPMS, TPC Instruments, G4-FIB, Atom Probe LEAP, SEM-6500, PXRD, etc. Additional equipment heat sources also include vacuum pumps and lighting.

Benefit

An upgraded chiller system can support increased research throughput and enhances facility reliability.

Risk

Research is halted and impacts scheduled commitments and milestones. Temperatures during the summer months are when laboratory temperatures are highest. Temperatures can reach into the 80+ degree F ranges, and the result is that scientific equipment is either shut down, or in some cases overheat, and can result in costly repairs and down time.

ROM Cost Estimate: \$1.5M

35. HFEF Building Lab Exhaust Fan Replacement

Description

The HFEF Building Lab Exhaust system moves approximately 35,000 CFM through HFEF. This system works in tandem with the supply systems to regulate climate pressure in the building. The building lab exhaust maintains the differential pressure for the building and ensures that potential contamination does not spread throughout the building. The system also provides exhaust for the various labs and hoods in HFEF. The building lab exhaust flows through the HFEF stack and is constantly monitored in compliance with the HFEF air permit.

Benefit

The fans and dampers will be replaced. After 40 years of continuous operations the foils of the fan have mostly eroded; this, along with the failed damper, is causing a reduction in air flow. The vibration isolation system has also degraded over the years and often transmits a noticeable vibration through the building. The new blowers should correct the deficiencies noted. The new blowers will be capable of being operated with a variable frequency drive (VFD), allowing the differential pressure system to be upgraded at some future time.

Facility Risk

The flow through this system has degraded over the year and is lower than what the original documentation indicates. The dampers have been adjusted multiple times to balance flow and restore building flows. There is also a significant variation in the flow rate between the two fans, damper adjustments have no effect on this either. This is most likely a failed inlet damper internal to the ducting. Vibrations in the building reduce research quality from the optical microscopes and are restricting HFEF's ability to complete programmatic work. When any part of the system fails, HFEF enters "low flow mode" due to flows below the calibrated range of the stack monitoring system. While in "low flow mode" numerous in-cell research operations are prohibited including fission gas puncture and collection (GASR) and furnaces operations (affecting JFCS and HALEU).

ROM Cost Estimate: \$2M.

36. MFC Glovebox Oxygen Monitors

Description

The Servomex MonoExact DF310E (formerly Delta-F 310E) oxygen analyzers are installed on gloveboxes in FMF, ZPPR, IMCL, ARL and EFF. The original Delta-F 310E oxygen analyzers have been discontinued and the company, Servomex, has purchased the rights to the Delta-F product lines and replaced it with the Servomex MonoExact DF310E. Getting a replacement analyzer (Servomex MonoExact) or parts has become increasingly difficult, and the lead time is 12+ weeks. Currently, there is one Delta-F analyzer available at the warehouse and it was purchased for the AFCI glovebox in FMF. The AFCI glovebox oxygen analyzers are Safety Significant SSC's per SAR-404. There are two Servomex MonoExact analyzers currently in testing with I&C but they have erratic performance and one is no longer functioning and awaiting parts/repair from Servomex.

The Ntron Senz-Tx oxygen analyzer is currently being evaluated as a potential replacement for the Servomex MonoExact analyzers at MFC. Pending a successful evaluation, the MonoExact analyzers will be replaced with the Ntron analyzer at the critical facilities (FMF & IMCL). This will require glovebox, piping, and software modifications to implement into existing gloveboxes. A commercial grade dedication of the Ntron's will also be required for use in the AFCI glovebox (in FMF).

Benefit

The bench-top testing at MFC have shown the Ntron Senz-Tx analyzers have quick response times, short stabilization times, high accuracy, low variations to pressure and flow fluctuations and no failures (with a statistically small sample of eight units). The Ntron's also have a lower cost (\$2,000 per sensor, \$6,000 per sensor/analyzer combination) and lower lead times (approx. 8-week lead time). They also are available in two mounting configurations (flow-through and KF-40). The KF-40 option allows the analyzer to be installed directly into the glovebox atmosphere, eliminating the need for a sample loop to draw glovebox atmosphere through the analyzer.

Facility Risk

A Servomex MonoExact analyzer may fail on an existing glovebox while the evaluation and design work for incorporating the Ntron's is being implemented. The evaluation may reveal that the Ntron's do not meet MFC's design specifications which would re-start the selection process for a new analyzer. INL also does not have experience with the long-term reliability of the Ntron analyzer.

ROM Cost Estimate: \$900K.

37. Replace AFCI Glovebox Purification Units

Description

The purification units for both the VAC and Wilkins gloveboxes in the AFCI enclosure in FMF are obsolete and are reaching the end of their serviceable life. This project would replace the two purification units with modern units.

Benefit

Replacing the glovebox purification units with modern, vendor supported, units will increase the reliability and serviceability, which will improve the ability of the AFCI gloveboxes to support programmatic work.

Facility Risk

The purification units for both the VAC and Wilkins gloveboxes in the AFCI enclosure in FMF are obsolete. Vendor support and parts availability are limited, and the current units are reaching the end of their serviceable life. Programmatic work would be impacted if the purification units required repair and parts/support were not readily available.

ROM Cost Estimate: \$1.5M.

38. Establish IMCL Backup Power Connection

Description

IMCL added a standby diesel generator and UPS system around 2017. Due to funding constraints, the standby generator was not connected to HVAC or other facility support equipment. Currently, power sensitive scientific equipment is connected to standby diesel generator and UPS to mitigate scientific instrument damage during loss of normal power. IMCL ventilation systems are not connected to the standby generator/UPS and, as such, the IMCL laboratory is evacuated during a loss of normal power.

Benefit

Connecting HVAC and facility support equipment to the standby diesel generator and UPS system will keep the facility operational and help maintain confinement on multiple class A gloveboxes.

Facility Risk

Loss of confinement of class A gloveboxes during normal power loss could contaminate the laboratory and associated instrumentation which results in a loss of mission work and added complexity in operating and maintaining instruments.

Normal power loss and subsequent evacuation causes significant delays with regaining access to the facility. As ventilation is lost to confinements, detailed radiological surveys are required prior to allowing re-entry into the laboratory space without respiratory protection.

ROM Cost Estimate: \$500K.

39. Replace FCF Decon Spray Chamber Chiller Unit

Description

The DSC system is used to decontaminate manipulators, EMM's, and various materials/equipment used in the FCF hot cells. Decontamination is needed to mitigate the high dose rates. The chiller unit that reduces fogging of the shield window at the DSC Control station has been failing and parts are not readily available due to the age of the equipment. Without the DSC Chiller fully functional productive decontamination spray activities cannot be performed. Need to replace Current Chiller System with a

Benefit

Reliable capacity to perform the facility decontamination of manipulators, waste, or other process equipment. This avoids downtime in the facility as the materials/equipment requiring decontamination cannot be performed until the chiller unit is repaired and the subsequent potential for missed mission commitments and milestones.

Facility Risk

Without additional funds mission commitments are at-risk of completing on time. Currently, the interim actions have been to replace components (fuses, capacitors, etc.) on the compressors as needed. However, due to the age of the equipment, some parts are not easily replaced and finding equivalent parts is time consuming.

ROM Cost Estimate: \$2M.

40. TREAT Scoping Assessment for I&C Obsolescence

Description

TREAT has a large number of custom electronics chassis performing various functions central to reactor plant operations; however, custom electronics may no longer be necessary due to advancements in technology and lower costs of off-the-shelf equipment. The biggest challenge with replacing many of these auxiliary electronics chassis is their relatively high density afforded by their custom design as compared to modern, commercial-off-the-shelf replacements. The recommended sustainment strategy is to contract a scoping assessment, which would include identifying of high to low-risk failure I&C components and developing a plan to mitigate down time. This plan would guide the staged acquisition of replacement spares or upgrades to modern electronics.

Benefit

The scoping assessment will provide a strategic TREAT I&C updating plan with clarity of risk and its mitigation, reducing the size of the pool of spare parts. The resulting updated I&C systems are expected to improve equipment reliability and reduce downtime needed for corrective maintenance.

Facility Risk

As with other TREAT custom electronics, this hardware was designed and manufactured during the 1980s, and TREAT has a limited and finite set of spare components to support repairs on these systems. TREAT cannot execute reactor transients if these systems are unavailable.

ROM Cost Estimate: \$0.2M.

41. I&C Obsolescence: TREAT Reactor-to-Control Room Cable Replacement: Engineering

Description

The cables between the TREAT Reactor Building and the TREAT Control Room include a combination of original and updated copper wire, and some fiber optic cables installed during TREAT restart. The cables are buried in an earthen mound that runs the distance between the two buildings. Although the cables have been reliable all this time and still provide good results when tested for continuity, their emplacement and age represent a vulnerability to TREAT operation. In addition, signals received in the TREAT control room often include noise that might be reduced with a new cable. This project will identify and recommend the scope of cable replacement project that would provide a modern cable race between buildings and provide flexibility to connect control cables to a new control room that might be provided at a later date with a new TREAT Control Room and Office Building.

Benefit

A modern cable race between buildings would better protect control cables than the current configuration, possibly reduce signal noise, and accommodate future control room replacement.

Facility Risk

If this initial engineering project is not completed, then a cable replacement project will not be planned or initiated, leaving the current vulnerability in place.

ROM Cost Estimate: \$550K.

42. TREAT Radiography System Modifications

Description

The new Large Experiment Capability (LEXC) experiment vehicles (Big-BUSTER) are significantly larger in size than the standard experiment vehicles (BUSTER) currently in use. Neutron radiography has been requested for several upcoming experiments using this new vehicle. The radiography facility in its current configuration can only accept vehicles up to 8 inches wide and cannot image the larger vehicle due to the increased size (9 ½ inch diameter).

Benefit

The Radiography System Modifications will increase the size capacity of specimens that can fit into the TREAT beam line, accommodating the Big-Buster vehicle. The image size will be increased from 4 ½” wide to approximately 5 ½” wide providing a larger imaging field necessary for the sodium loop experiments planned for FY26. The existing capabilities will be retained, but with greater options and flexibility for neutron radiography.

Facility Risk

The Big BUSTER vehicle is too large to fit into either beam line at HFEF without substantial modifications at HFEF. SO, without this modest modification at TREAT, neutron radiography of experiments in the Big-BUSTER vehicle will not be possible at INL, greatly limiting the information obtained from each TREAT test. to accommodate.

ROM Cost Estimate: \$200K.

43. TREAT Reactor Building, RM 108 AC Units Replacement Engineering Design

Description

The AC Units in Room 108 of the TREAT Reactor Facility provide cooling for the I&C Cabinets via ducting beneath the false floor. Due to limited available space for personnel, Room 108 has been used for office and desk space for operations personnel since TREAT Restart. This has adversely affected equipment cooling, resulting in I&C equipment performance issues. The current AC units are aged and in need of replacement.

Benefit

With the recent development of Transient Reactor Experiment Cell (T-REXC) as a microreactor testbed, additional cooling may be required to support upcoming microreactor projects, in addition to the need to replace aging equipment.

Facility Risk

Not replacing the AC Units could continue to degrade I&C equipment performance and reliability, requiring additional procurement of replacement parts, and possibly even jeopardize equipment cooling needed for future microreactor projects.

ROM Cost Estimate: \$200K.

44. TREAT 15-Ton Crane Remote Control System Replacement

Description

The 15-ton crane in the TREAT Reactor Building serves the North High Bay to the reactor top and is the primary means for moving TREAT fuel and for inserting and removing experiment vehicles from the TREAT core. The crane is mostly original from 1959 and requires considerable maintenance every year. The Remote Control System has shown signs of degradation, and a new remote control system is needed until the entire crane can be replaced. This replacement will improve crane reliability while the procurement specifications for a new crane is being developed.

Benefit

A crane remote control system replacement will improve crane reliability by reducing failures of new components and would reduce maintenance durations with modern parts available on the market.

Facility Risk

Continuing with the existing crane leaves the TREAT reactor vulnerable to a crane failure with an uncertain repair time.

ROM Cost Estimate: \$300K.

45. MFC-720 East Gate Replacement

Description

As TREAT mission continues to grow, infrastructure must also expand to support TREAT mission. The current condition of the gate is outdated and difficult to open. This replacement will allow capability to open automatically for emergency entrance purposes.

Benefit

Replacement and enhancements will allow ingress/egress from the East gate for equipment and experiment access and transfers. This will also assist in emergency responses and mitigate personal injury during manual operations of the gate.

Facility Risk

More direct access to the TREAT reactor facility and increases overall mission support. Reduces the liability from an emergency response.

ROM Cost Estimate: \$0.3M.

46. MFC-720 & MFC-722 HVAC Upgrades

Description

The Replace AC HVAC at TREAT 720 and 722 project will include: 1) Removal and replacement of the 5-ton air handler on the roof of MFC-720. Modifications to the equipment stand, duct work and roof penetration. Also, reclamation of refrigerant; 2) Removal of the 2-ton air handler on roof of MFC-722. Also, reclamation of refrigerant, removal of conduits, and blocking air passages with rigid insulation and replace the roof. Installation of a mini split air conditioning system; 3) Removal and replacement of the 7.5 ton self-contained unit that supplies the Hodoscope room of MFC-720. Modifications to the equipment stand and duct work. Also, reclamation of refrigerant.

Benefit

The current units are old and obsolete and will increase reliability. MFC 722 unit will reduce hazards of elevated work.

Facility Risk

Provides reliable heating and cooling to occupied spaces.

ROM Cost Estimate: \$350K.

47. Replace TREAT Loop Handling Cask Winch System

Description

The TREAT Loop Handling Cask is used to transfer test loops containing previously irradiated fuel from a shipping cask, such as the HFEF-15 cask that will be used to move loaded loops from HFEF to the TREAT Reactor building, to the test location in the TREAT reactor core. The winch located on the cask is used to pull to raise and lower the loop into or out of the Loop Handling Cask. A new winch system is needed because spare parts are no longer available for the current winch, original in 1982. The project was initiated in FY-23, and only a small workscope remains to be completed in FY-24.

Benefit

The replacement system will improve Loop Handling Cask reliability and will also have a higher load capacity, which is believed necessary for supporting upcoming projects using the BIG-Buster containment.

Facility Risk

Facility risk (schedule interruption due to winch failure) will be reduced because the new winch will be less prone to wear-induced failure and will be more readily maintained with spare parts available through suppliers.

ROM Cost Estimate: \$100K.

48. I&C Obsolescence: TREAT Reactor Trip Logic and Actuator Interface Replacements

Description

In addition to nuclear instruments, TREAT's Reactor Trip System (RTS) has separate electronics chassis that interface to other reactor plant systems and provide the actual 'trip logic' to shut down the reactor. As with other custom electronic systems at TREAT, these systems were designed and constructed in the 1980s. TREAT's RTS is currently designed as a 1-out-of-N system, where any input signal will initiate a reactor trip, with no protection against spurious inputs nor any ability to bypass faulty signals. The recommended sustainment strategy is to pursue either a redesign and modernization of TREAT's existing electronics by acquiring new-build chassis with interchangeable drop-in replacement circuit boards, or to replace the Trip Logic and Interface components with a commercial-off-the-shelf replacement system.

Benefit

New, replacement electronics would mitigate system obsolescence and age-related degradation issues. The use of a commercial-off-the-shelf replacement system might significantly improve long-term sustainability by minimizing the need for future custom design work. The optional addition of combinatorial logic capabilities would improve TREAT's overall transient reliability by preventing a spurious, non-safety-related input signal from improperly terminating high-value transients, potentially resulting in the loss of irreplaceable specimens for no programmatic gain.

Facility Risk

TREAT has a limited number of spare electronic components on-hand to support board-level repair of the existing Reactor Trip System Trip Logic and Interface hardware. These components are often as old as the original chassis and circuit boards, are no longer in production, and age-related degradation is eventually expected to dominate known failure modes. Further, because TREAT has no spare chassis or circuit boards, every repair adds wear-and-tear to the existing equipment, further accelerating hardware degradation. TREAT cannot conduct reactor operations if this system is unavailable.

ROM Cost Estimate: \$7.2M.

49. I&C Obsolescence: TREAT Critical Spares for ARC, DIS, and RTS

Description

The Dedicated Information System (DIS), the Reactor Trip System (RTS) and the new Automatic Reactor Control System (ARCS) are all necessary for TREAT operation in support of its testing mission. However, there are very few spare parts maintained in controlled inventory, making TREAT operation vulnerable to schedule impact from breakdown of one of those systems. This project will identify, procure, and place into controlled inventory the critical spare parts for each system.

Benefit

An inventory of these critical spare parts will ensure that any component failure can be quickly addressed, and the affected system returned to service as soon as possible.

Facility Risk

An unexpected component or system failure could jeopardize the operation of a system key to completing scheduled TREAT experiment.

Cost Estimate: \$420K.

50. I&C Obsolescence: Dedicated Microprocessor Tester (DMT) Development & Installation

Description

Prior to reactor operation, changes to TREAT reactor trip point settings and other functionality require microprocessor testing to ensure set points were entered correctly and trip systems operate as intended. A new Dedicated Microprocessor Tester (DMT) is proposed to replace outdated computer systems and software, similar to the recent Automatic Reactor Control System (ARCS) replacement (but with less scope for a simpler system).

Benefit

The new DMT will provide hardware and software that is more efficiently maintained and updated. The new DMT is also expected to reduce the turnaround time needed to complete the microprocessor tests.

Facility Risk

As with any outdated computer and software, the current DMT presents a vulnerability and risk for schedule impact, should the system fail and require hardware maintenance with parts that are difficult to find or software revision using computer languages unfamiliar to today's personnel.

ROM Cost Estimate: \$150K.

51. Compressed Air Supply Systems for Research Facilities

Description

The MFC Compressed Air System was designed to supply HFEF, FCF, and ARL with compressed air for process, instrument, and breathing-air purposes. Currently, two large air compressors (with dedicated air dryers) located in the MFC-768 power plant run continuously with standby air compressors at FCF and HFEF to augment the system upon low pressure. The smaller standby air compressors are not large enough to provide adequate volume for full operation if more than one of the large compressors in MFC-768 is out of service. The air compressors in MFC-768 are frequently out of service due to breakdown creating costly and timely repairs that have adversely effected HFEF and FCF mission planning. Currently, only FCF and HFEF utilize breathing air. None of the current compressors are breathing air rated, breathing air is qualified by dryer/filter systems and local quality monitoring. Local breathing air systems at FCF and HFEF that can also provide process and instrument air needs would provide a more cost-effective supply of breathing air than a site wide system that is only periodically used for breathing air. Newly designed systems that provide for individual facility needs with the ability to be manually cross connected should be engineered. Individual air compressor systems would be provided at MFC-768, FCF, HFEF and ARL.

The MFC protected area Instrument Air (IA) System is used by multiple facilities including EML, FMF, SSPSF, and ZPPR. Reliability of the IA system has been decreasing over the past 8 years indicating multiple IA components are approaching end-of-life. System outages are reoccurring, maintenance costs are increasing, and facility availability is decreasing; all resulting in negative trend impacts to multiple existing programmatic milestones. Instrument air supports various systems and equipment important to security and to defense-in-depth safety features.

Benefit

Having a facility-specific, decentralized compressed-air system will allow nuclear and non-nuclear facilities to have reliable compressed air that is adequate for their own individual load. Additionally, individual facilities will not be affected by preventative maintenance and outages being completed on other facilities. This will allow for more nuclear facilities to have more uninterrupted work towards mission critical deliverables.

Facility Risk

The current compressed air system at MFC is unreliable and outdated. Without an updated compressed-air system, we continue to risk untimely outages at FCF and HFEF and not being able to stay ahead of compressed air needs to support MFC facility expansion.

During periods where instrument air is unreliable, the PIDAS facilities will experience increased cost due to: Increased maintenance costs (\$900/week for compressor rental); Increased security costs (\$1500/day for extra guards); Decreased facility availability; New mission support with increased IA demands is not sustainable with the current available system capacity; Running to failure increases system recovery costs.

ROM Cost Estimate: \$10-12M.

52. HFEF Hot Cell HEPA Replacement

Description

The HEPA filters in the HFEF hot cells (argon and decontamination) have not been replaced since the facility started operations in 1975. This project will design, fabricate, and test the tooling and equipment necessary to replace the in-cell HEPA filters. In addition, this project will replace the HEPA filters. This project will take 3-4 years (1 year of design, 1 year of fabrication and testing, and 2 years of implementation) to complete. The filters for the HFEF main cell are located under the false floor where programmatic work is performed; in addition to temporarily relocating program work, a significant amount of waste in the cells will need to be removed in order to access the filter housings.

Benefit

The benefit to the facility is that replacement of the filters will reduce the risk of filter failure due to seals or a media breach and subsequent contamination of the fixed (non-replaceable) secondary filters and associated ducting.

Facility Risk

If the filters are not replaced, the facility risk continues to increase with the potential for filter failure (seal or media) and subsequent contamination of the fixed secondary filters and associated ducting in turn causing difficulty in future filter change operations. The importance of changing these filters will continue to increase as the age of the filters increases and as the mission in HFEF continues to evolve to include more fuel furnaces.

ROM Cost Estimate: \$5M.

53. New Instrument Room and Mezzanine in IMCL

Description

Construction of a quiet, climate-controlled room to optimize the performance of high-resolution instruments. The roof of the room would also be used as a mezzanine for storage of IMCL instrument accessories.

Benefit

IMCL currently houses only one climate controlled, quiet room for the operation of high-resolution instruments. Construction of an additional instrument room would allow the installation of new instruments in an environment that optimizes characterization results. High-resolution characterization allows understanding of radiation damage on the same spatial frame at which it occurs, contributing to better understanding and validation of simulations.

Facility Risk

There is a large demand for the high-resolution microstructural and characterization in IMCL by internal and external users. Operation of instruments with degraded performance provides less-than-adequate data and result in INL's leadership position as a nuclear science user facility.

ROM Cost Estimate: \$2M.

54. Replace FCF McQuay Air Conditioner

Description

The McQuay air-conditioning unit located on the north side of FCF supplies cool air to the first floor and SERA of FCF. It works intermittently due to the age of the unit and when the weather gets hot outside the unit cannot keep up with demand. The first-floor high bay and argon cell operating corridor temperatures can reach 85-90 degrees on hot days making working conditions in these areas unbearable. The McQuay unit is the only air conditioning unit that provides cool air to the first floor of FCF. Currently the McQuay HVAC is performing at reduced capacity. Portable A/C units and a large swamp cooler have been brought in to provide cooler air, however the temperatures in the high bay, hot cell operating corridors, and Suited-Entry Repair Area (SERA) are unacceptably high requiring more frequent breaks and heat stress controls.

Benefit

Habitable work conditions are essential to productive and safe operations activities in support of project/program missions.

Facility Risk

Consequences of Failure to Mitigate Problem include the first-floor area becomes unbearably hot requiring more frequent breaks and the SERA of FCF has temperatures that invoke heat stress controls that severely limit our ability to perform productive work in support of multiple project/program missions.

ROM Cost Estimate: \$2.0M.

55. Provide Additional Storage Areas for FMF and ZPPR

Description

Upcoming facility modifications in FMF and ZPPR will greatly reduce each facility's storage space. The installation of the FCG and FMG gloveboxes and an additional planned glovebox/hood will occupy areas in FMF that are currently used for Quality storage, precious metal storage, and equipment storage. The LOTUS facility modification in 776 will require the conversion of the ZPPR control room which currently houses storage cabinets for ZPPR container and equipment storage. Available areas for storage are already limited in FMF and ZPPR, and the additional loss of storage areas will greatly impact operational efficiency. The selected alternative is to convert one of the two restrooms in the FMF support wing into a storage area. The other restroom will become a gender-neutral restroom for the facility.

Benefit

Converting one of the FMF restrooms into a storage area will address some of the reduced available facility storage areas. Having the storage area located inside the FMF support wing, within the Protected Area, will allow for easy, quick access to the storage area for FMF and ZPPR Operations.

Facility Risk

Failure to provide storage areas that are immediately adjacent to MFC-704 and MFC-775 will impact operational efficiency.

ROM Cost Estimate: \$1.5M.

56. FCF High Bay Crane Refurbishment/Upgrade

Description

Due to the vintage of the crane, some systems should be considered for modernization to minimize down time due to the failure of obsolete systems – when/if they occur. There are systems that would require upgrading if any modernizations were to be performed to bring the crane up to current standards. This includes the open span conductors; wooden bridge bumpers and trolley stops.

The objective is to replace components consistent with the components recently supplied on the upgrade/modernization of the 40 Ton MFC-785 Building Crane.

Benefit

Reliable capacity to perform needed Material Handling of shipping casks, waste boxes, and other materials required to ensure availability for project/program missions.

Facility Risk

The High Bay Crane is evaluated as a single point failure piece of equipment. Its failure would significantly and adversely impact EBRII Fuel Processing and HALEU Production program commitments.

ROM Cost Estimate: \$5M.

57. Hoar Frost Buildup on IMCL HVAC Intake Filters

Description

During winter months the air intake filters on the HVAC air supply system builds up excessive hoar frost. The current design of the installed radiant heaters do not adequately remove the frost build up, which restricts air flow into the IMCL laboratory. The restricted air flow results in increased room temperatures in the laboratory which increase to a point where research equipment is impacted, or potentially damaged, and research equipment must be shut down.

Benefit

Enhancing HVAC operations reduces maintenance associated with cleaning the intake. It also increases facility reliability.

Risk

Frost buildup can impact operation of the IMCL HVAC Laboratory research equipment is shut down or fails to operate.

ROM Cost Estimate: \$350K.

58. RCL Backup Power

Description

Currently RCL does not have back up power. RCL has a single exhaust fan. When power is lost unexpectedly the facility is immediately evacuated due to potential radiological release from fume hoods. When this occurs, all work is stopped and placed in safe configuration.

Facility Risk

An emergency power system would be able to provide power in a situation like this and would prevent potential radiological release. RCL has an electric duct preheater that is the primary heat source for air coming from the outside of the facility. In the event of loss of power, the facility would have no heat available.

Benefit

Backup power in the Radiochemistry Laboratory would provide redundancy for the exhaust system, which in turn would allow greater flexibility and reduce risk in the event of a power failure. In addition to the reduction in risk from an exposure standpoint, there is also the benefit of better control of the heat, preventing unnecessary impact to liquid samples.

ROM Cost Estimate: \$1.75M.

59. HFEF Decontamination Spray System

Description

Adding a CO₂ spray system to the HFEF decontamination spray chamber will improve decontamination of hot cell equipment, particularly manipulators, and reduce dose to workers during repair. This project will install a CO₂ spray system into the existing HFEF decontamination spray chamber and associated containers for storing dry ice pellets.

Benefit

Adding a CO₂ spray system to the HFEF decontamination spray chamber will improve decontamination of hot cell equipment, particularly manipulators, and reduce dose to workers during repair. The water wash system will still be required, but less water will be used for decontamination efforts, reducing the overall radioactive liquid waste generated in HFEF. Additionally, the CO₂ dry spray can be used to reduce contamination on equipment that is sensitive to water and cannot currently be washed prior to repair. This improves the remote life of equipment by allowing for repair of more equipment once it can be appropriately decontaminated.

Facility Risk

If the new spray system is not installed in HFEF, dose to workers performing hands-on decontamination and dose to workers repairing contaminated equipment will be higher than necessary.

ROM Cost Estimate: \$1.2M.

60. TREAT BAR HVAC Duct Remediation & Repair

Description

A ventilation duct that served the Basement Auxiliary Room (BAR) in the TREAT Reactor Building is not functional after corroding over the years and collapsing. Although a recent installation of air conditioning units into the BAR and Subpile Room maintain Summer and Winter temperatures to the necessary range, the BAR gets little exchange of air with the rest of the Reactor Building. Although the project cost estimate is roughly \$300K, in FY-24 TREAT personnel are attempting a less-expensive solution, which could address this issue.

Benefit

Completing this duct remediation and repair will restore intended air circulation to the BAR.

Facility Risk

Although this repair could be delayed another 2 or 3 years, after being delayed already several years, not completing the repair soon leaves additional time for air in the BAR and Subpile room to continue stagnating, with possible implications on component lifetime.

ROM Cost Estimate: \$300K.

61. TREAT 15-Ton Crane Replacement

Description

The 15-ton crane in the TREAT Reactor Building serves the North High Bay to the reactor top and is the primary means for moving TREAT fuel and for inserting and removing experiment vehicles from the TREAT core. The crane is mostly original from 1959 and requires considerable maintenance every year. Some components have proven to be unreliable. To address this vulnerability for failure with the associated mission schedule impact, replacing the crane with a modern unit is proposed.

Benefit

A modern crane replacement would improve crane reliability from fewer failures of new components and would reduce maintenance durations by allowing service with modern parts available on the market.

Facility Risk

Continuing with the existing crane, which is certainly possible, leaves the TREAT reactor vulnerable to a crane failure with an uncertain repair time.

ROM Cost Estimate: \$2M.

62. TREAT Replacement Inert Gas Valves and Regulators

Description

TREAT experiments often require flowing gas, such as argon, nitrogen, or helium. These are supplied by a bank of gas cylinders located inside the reactor building. The supply system is due for replacing the valves and cylinders, to ensure the right amounts of the right gases get to the gas control panel at the reactor.

Benefit

The experiment quality will be supported by continued reliability of the gas supply system.

Facility Risk

If the gas system is not maintained preventively, then a worst-case scenario of an expensive TREAT test (for example, one using an irreplaceable test fuel previously irradiated in EBR-II or FFTF).

ROM Cost Estimate: \$150K.

63. TREAT Security Building (MFC-722) Replacement

Description

The TREAT Security Building (or Guard Post, MFC-722) has degraded from water leakage and vermin infestation. The Security Building has been important not only as the access control point into the TREAT Reactor Building and surrounding grounds, but also where pre-visit briefs are held. The near-term need to replace the roof is addressed in another project proposed for FY-24, but the long-term solution is to replace, or substantially refurbish, the building. At minimum the replacement should replace functionality of the existing building, but additional functions might be considered. The effort would begin with engineering tasks to properly scope the task and prepare a cost estimate suitable for planning.

Benefit

Action to replace or refurbish the access building into TREAT will reverse the degradation of the current building and provide an access control location that forms the right impression on visitors.

Facility Risk

Worst case risk is that the building continues to degrade and no longer provides the proper access control function. More likely, the risk is continued funding spent to plug leaks, remove vermin, and repair walls and flooring.

ROM Cost Estimate: \$2.5M.

64. Install Facility-Specific Plant Cooling Water Systems

Description

The MFC plant cooling water system is a chemically-treated closed-loop cooling-water system that supplies cooling to vital loads in buildings MFC-768 (Power Plant), -765 (Fuel Conditioning Facility - FCF) and -787 (Fuels and Applied Science Building - FASB).

The system includes a cooling tower at the power plant and a piping network and pumps within the power plant that travels to FCF and FASB above ground and then returns to 768 via underground piping. The system cools various loads; HVAC equipment, air compressors, process equipment, with the most vital load being the FCF argon chillers which serve as the heat sink for the FCF hot cell.

This system is comprised of mostly original piping of which approximately 500 linear ft is buried 1960-era cast iron on the return side. The piping within FCF has had numerous sediment issues and leaks, and the line has had multiple underground failures (3) in the past 4 years. The system is largely oversized as system loads have been systematically taken out of service since EBR-II was deactivated.

The proposed system modification would be to separate FCF and FASB loads from the main system through the design and installation of self-contained facility specific cooling systems. These new systems would be properly sized for current loads and provided for expansion as needed. The original system would be re-routed and appropriately downsized to provide cooling to power plant (768) loads only. Due to the latest piping failure, cooling is being supplied to FCF via a cross connect with the potable water system and just being dumped to industrial drains until repairs can be made.

Benefit

New dedicated systems for FCF and FASB would likely be above ground in controlled environments eliminating the potential for underground piping failures that are difficult to locate and then require a significant project to repair/replace the failed components.

Facility Risk

Given the condition of underground return piping, if replacement is not completed negative mission impacts from failed piping will increase in frequency and the associated cost of repairs will be absorbed accordingly. It is not improbable that a break in a bad location could force an extended FCF shutdown due to effects on the hot-cell heat sink.

ROM Cost Estimate: \$10M.

65. HFEF Intrafacility Pneumatic Sample Transfer Systems Overhaul

Description

The HFEF pneumatic transfer systems (PTS) are at their end-of-life, have components that are antiquated, and are exhibiting more frequent failures. Specifically, there are two systems of focus, (1) the highly-used interfacility PTS, which moves valuable research samples between HFEF and the ARL via FCF, and (2) the 6D PTS, which moves various items between the Decon Cell at window 6D and the glovebox in room 130. Crucial components for these systems are no longer available; therefore, redesign and system upgrades are needed to ensure these systems are available for use. There are very limited spare parts for these systems with some components having no replacements or replacement parts. The interbuilding PTS, a single-point failure, is crucial to getting research samples to the Analytical Research Laboratory and has some components that are difficult to access. System upgrades to include redesign and fabrication of crucial components is imperative to support research operations at HFEF.

Benefit

Greatly increase reliability, better efficiency of system operations, and reduced downtime in both frequency and duration with corresponding confidence for movement of valuable research samples. Upgrades will reduce the risk of mission impacts. Crucial components include:

- Updated motorized ball valve assemblies
- New solenoid operated valves
- Updated vacuum pumps
- Updated instrumentation (pressure switches, indicators)
- Replacement of piping runs as required.

Facility Risk

The interbuilding system from HFEF to FCF is highly used to move valuable research samples between HFEF and FCF and the ARL and is a single-point failure for this capability. The loss of use of this system greatly inhibits the capability to make sample transfers to the Analytical Research Laboratory. Some components are not repairable, can be long lead acquisitions from suppliers, and require a redesign process as well as fabrication prior to installation. This combination of processes could result in significant and extended downtimes leaving the systems out of service for several months, thus stranding valuable research samples; creating unsustainable delays to a vast majority, if not all, of the projects executed in HFEF; and jeopardizes various programmatic work and mission milestones. Without system overhaul, failures are expected to increase, resulting in loss of mission research.

ROM Cost Estimate: \$3.1M.

66. Interfacility Pneumatic Shuttle Transfer System Refurbishment

Description

The interfacility pneumatic shuttle transfer system, also known as the rabbit system, has been in existence for decades. This system is key to moving hot samples between HFEF, FCF, and the Analytical Research Laboratory. Samples are prepared in HFEF and moved to FCF and ARL for further analysis. This is a key transport capability between HFEF and ARL. This system has not been evaluated in depth for decades and this is a single point failure for transport of hot samples.

Benefit

Evaluating and refurbishing this single point failure radiological sample transport system will ensure operational readiness is not impacted by a system key nuclear research facilities rely on.

Facility Risk

The rabbit system is a single point failure risk. Sample transfer activities between HFEF and ARL will be significantly impacted if this capability is not available.

ROM Cost Estimate: \$10M.

67. Analytical Research Laboratory Process Management System Upgrade

Description

Updating the lab management system to support the ARL sample management processes.

Benefit

This update will provide state of the art updates for all the analytical instrumentation in the laboratory, tie-in measurement activities, and provide desktop access to individual analysts.

Facility Risk

The current version does not operate as effectively as needed to optimize laboratory operations.

ROM Cost Estimate: \$1M.

68. FCF Hot Repair Area Reactivation

Description and Benefit

The FCF Hot Repair Area (HRA) was abandoned in the late 1990s due to seismic and radiological confinement concerns. As the workload for FCF increases, the facility requires more maintenance for remote manipulators and cranes (that have component wear and part failure). Further, to fully utilize the hot cell space, it would be advantageous to be able to remove some components from the hotcell for interim storage and future reuse. The existing maintenance space for repair of in-cell equipment is quite limited in FCF and has become a facility schedule bottleneck. Further, a site utilization study conducted over 10 years ago did not foresee the resurgence of nuclear research for FCF (or other nuclear facilities at INL), and the Contaminated Equipment Storage Building was declared surplus and was subsequently reclaimed for other R&D purposes. No space currently exists at MFC for storage of contaminated equipment outside the hot cells.

A recent evaluation of the HRA, conducted to determine if that space could be reactivated, identified engineering and seismic analyses deficiencies that would prevent the immediate reuse of that space. The space is located over top of the FCF air and argon hot cells. It is proposed that an engineering evaluation be conducted to close out those seismic and engineering deficiencies and propose a restructuring of the HRA in a manner that will space to be reused. The proposed missions for the space would be: 1) in-cell equipment repair, 2) storage of transient in-cell equipment, and 3) insertion/removal of equipment into the hot cells. The evaluation must also consider modern radiological and nuclear safety requirements,

Facility Risk

Challenge to repurposing of the Fuel Condition Facility (FCF) areas in support of NRIC and other RD&D missions.

ROM Cost Estimate: \$7.0M.

69. I&C Obsolescence: TREAT Nuclear Instrument Spares and Replacement Chassis

Description

TREAT has 18 different “Nuclear Instrument” channels that support its Reactor Trip System, Dedicated Information System, and Automatic Reactor Control System. All current nuclear instruments were designed and constructed in the 1980s. Because TREAT has unique reactor performance characteristics (high-amplitude, short-duration pulses) and its nuclear instruments are highly integrated with TREAT’s supporting systems, commercial-off-the-shelf replacements are not possible. The recommended sustainment strategy is to design and procure drop-in replacements for the current circuit boards and chassis using modern technology.

Benefit

A full set of drop-in replacement circuit boards and chassis for TREAT’s existing nuclear instruments would allow for faster troubleshooting and repair of instrument faults, and having refreshed circuit board and chassis design documentation would simplify future re-design efforts as technology evolves. It is anticipated that TREAT will eventually develop multiple hardware generations of functionally interchangeable circuit boards that can be used within existing electronics chassis designs, allowing for eventual optimization of long-term sustainment costs.

Facility Risk

TREAT has a limited number of spare electronic components on-hand to support board-level repair of existing nuclear instruments. These components are often as old as the original chassis and circuit boards, are no longer in production, and age-related degradation is eventually expected to dominate known failure modes. Further, because TREAT has no spare chassis or circuit boards, every repair adds wear-and-tear to the existing equipment, further accelerating hardware degradation. TREAT cannot conduct most reactor operations if any nuclear instrument is unavailable. While TREAT engineering has made significant efforts to identify and purchase spare components, there are certainly components that TREAT does not have on hand.

ROM Cost Estimate: \$3.2M.

70. I&C Obsolescence: TREAT Automatic Reactor Control System Master Clock Spare or Replacement

Description

The TREAT Automatic Reactor Control System (ARCS) Master Clock is required for the operation, as it acts as a physically independent hardware watchdog for the other ARCS nodes. It provides assurance that each node is continuously executing the loaded prescription during a transient, coordinating a reactor trip in the event that any of the nodes experiences certain software or hardware faults.

Benefit

A full set of new design, drop-in replacement circuit boards and chassis for the ARCS Master Clock would allow for faster troubleshooting and repair of problems with the ARCS Master Clock.

Facility Risk

As with other TREAT custom electronics, this component was designed and manufactured during the 1980's, and TREAT has a limited and finite set of spare components to support repairs on this system. TREAT cannot execute reactor transients if this system is unavailable.

ROM Cost Estimate: \$700K.

71. I&C Obsolescence: TREAT Auxiliary Electronics Spares and Replacements

Description

TREAT has a large number of custom electronics chassis performing various functions central to reactor plant operations, but for which custom electronics may no longer be required due to advancements in technology and lower costs of off-the-shelf equipment. The biggest challenge with replacing many of these auxiliary electronics chassis is their relatively high density afforded by their custom design when compared with modern, commercial-off-the-shelf replacements. The recommended sustainment strategy is to pursue replacing multiple custom chassis at a time in order to reduce footprint growth and take advantage of the consolidation options available with modern electronics.

Benefit

Replacing these obsolete electronics with modern systems will allow for faster and more efficient maintenance, reduce the utilization of a finite pool of spare parts, and could allow for improved reactor plant capabilities when compared with the current systems.

Facility Risk

As with other TREAT custom electronics, this hardware was designed and manufactured during the 1980s, and TREAT has a limited and finite set of spare components to support repairs on these systems. TREAT cannot execute reactor transients if these systems are unavailable.

ROM Cost Estimate: \$2.4M.

72. NRS Elevator and Cask Interface Upgrade

Description

This project will modify the cask handling station over the North Radiography Station (NRS) elevator to accommodate additional casks, and design/build a new payload auxiliary hoist to facilitate lowering experiments onto the NRS elevator.

Benefit

A new design will allow a larger variety of casks to be used in the NRS along with specimens of varying diameter and lengths.

Facility Risk

Only the HFEF-14 and HFEF-5 loading casks, with their top and bottom features, fit on the current cask handling station. The station interfaces with the elevator in the NRS, located directly under the cask handling station in the NRS high bay. TREAT is planning on using other casks for shipment of TREAT loops (e.g., 15-cask) that will require modification to the station. In addition, the old hoist mechanism which hung from the NRS crane hook, is no longer functional and is missing parts that are obsolete. The

ability to perform radiography of TREAT loops at NRAD in about 3-4 years will be jeopardized if this capability is not restored.

ROM Cost Estimate: \$4.1M.

73. ARL Acid Scrubber Replacement

Description

The Analytical Research Laboratory has had an acid scrubber connected to the wet prep glovebox for over 10 years. We have now added a radiochemistry glovebox into the same system. The acid scrubber has been operationally down several times this year. The effect has ranged from solids within the scrubber and needing to clean it out to acid on the walls of the glovebox, causing degradation to the glovebox. While there has been no change in methods used in the gloveboxes, we have continued to have issues. The ARL would like to purchase and install a new system.

Benefit

Collecting the alkaline components to balance pH inside of the glovebox will significantly extend the life of the glovebox. The reason for the installation of the radiochemistry glovebox is due to the degradation of the old glovebox from acids.

The maintenance issues associated with the current system will not go away and will continue to affect the ability to perform programmatic work within the wet-prep glovebox, which is the glovebox used for dissolutions.

ROM Cost Estimate: \$3M.

74. TREAT Reactor Building Radio Signal Booster

Description

The radios used by the TREAT Building Emergency Director and the MFC Emergency Response Organization do not reliably receive signal when inside the TREAT Reactor Building. This project will place a signal booster in or near the TREAT Reactor Building to improve reception.

Benefit

Procurement and installation of the signal booster will allow emergency personnel inside the TREAT Reactor Building to reliably communicate over the INL emergency response radio frequencies.

Facility Risk

Facility risk (inadequate communication during emergency response) will be reduced by ensuring the TREAT Building Emergency Director and other MFC Emergency Response Organization personnel can reliably communicate with the MFC Emergency Control Center when in the building.

ROM Cost Estimate: \$100K.

75. Replace FCF Argon Cell North and South Recirculation Blower and Install Purification Instrument

Description

The argon cell recirculation and cooling system assists in the control of pressure or temperature within the argon cell by recirculating and cooling argon gas to remove heat generated by in-cell lighting, process equipment, and decay of irradiated reactor fuels and related materials.

The purification Analytical Instruments draw from the south loop recirculation and cooling system downstream of the recirculation blower and returns the flow to the recirculation loop upstream of the cooling box. The Purification Analytical Instrument provides continuous monitoring of the argon cell for oxygen, nitrogen, water vapor, and hydrogen. Failure of the South Recirc Blower would cause the Purification Analytical Instrument to be unable to accurately measure Argon Cell atmosphere. The North Recirc Blower operates with bearing temperatures abnormally high at 81 degrees Celsius and is at EOL. The blower is in a contaminated enclosure with limited space and will involve significant planning for radiological control while facilitating material handling.

Risk

Failure of the South Recirc Blower would cause the Purification Analytical Instrument to be unable to accurately measure Argon Cell atmosphere. The South Loop Recirculation Blower and Purification Analytical Instrument are evaluated as a single point failure piece of equipment. Failure would significantly and adversely impact EBRII Fuel Processing and HALEU Production program commitments.

Benefit

Reliable capacity to reliably perform Argon Cell cooling for pressure & temperature control and Argon Cell atmosphere monitoring to ensure Argon Cell availability for program mission.

ROM Cost Estimate: \$2.5M.

76. HFEF In-Cell Compressed Argon Manifold Supply and Associated Controls

Description

Each window has a compressed argon manifold located in cell for using argon to run instrumentation, tooling, and general use. The solenoids that supply argon are in control boxes under each window in the basement. Portable control stations are located on the main floor and can be moved to selected locations for controlling solenoid operation for each manifold.

Benefit

The operability of the compressed argon manifolds, solenoids, and controls for each window needs to be restored to a functioning capacity, standardized, and maintained to support programmatic work.

Facility Risk

Over time, the solenoid boxes have been modified to support programmatic work. Documentation of these mods is lacking; the boxes no longer function the same as originally designed. Several solenoids do not work, the boxes are not finger safe electrically, and at any given station manifold operability is limited. Several hoses are laid across the cell floor to supply compressed argon from a location where it is available to a location where it is needed. This is inefficient, time consuming, and costly.

ROM Cost Estimate: \$750K.

77. Replace HFEF Freight Elevator

Description

The HFEF freight elevator is suffering from age related failures and needs to be updated. Parts are no longer manufactured, greatly increasing downtime. Failures in the mechanical, electrical and control system are occurring more frequently. In 2020 the elevator was out of service for more of the year than it was in service.

The proposed solution is to replace the elevator with a modern elevator of similar capacity. The reason for this is that the brakes for the elevator are no longer available, the motor is no longer manufactured nor are most of the components in the control system. While many of these items can be replaced with an alternate replacement item, this takes considerable resources and time while only fixing that problem. This approach does not improve the long-term reliability of a 50 plus year old machine.

Benefit

The elevator is used to move materials throughout HFEF from items from hand carry sized things up to a 4 ton pay load. When the elevator is not available the movement of materials becomes an engineering task to develop lift plans to safely rig the item. This can significantly delay work; a functioning elevator allows crafts and operators to easily move materials as needed.

Facility Risk

When the elevator is out of service different methods of material movement must be utilized. This can be as simple as carrying an item up or down a flight of stairs. This increases the risk of a slip or trip while carrying the items as many times the use of both hands is required to safely carry the item. For items that are bigger than hand carry the overhead crane must be utilized. Most items are not designed to be rigged to a crane, increasing the chance for a load drop.

ROM Cost Estimate: \$2M.

78. Upgrade FASB Ventilation System

Description

Currently FASB ventilation system is working however, it is limping along. We have outdated pneumatic controls that are no longer made (1975). We have been running on 1 fan due to this issue for 5-6 years. The air handler is on a variable speed drive however the exhaust fans are not, this causes the air handler to ramp up more than needed when any of the larger north side doors are opened. We also need an expanded exhaust system to hook up additional equipment. Currently none of the characterization equipment is plumbed to suspect exhaust due to the limited capabilities i.e., flow.

Benefit

An upgraded HVAC system increases capacity for future fuel fabrication work. This also decreases the risk of facility down time due to minor and major repair. This reduces the risk of contamination of suspect exhaust system, facility, and workers.

Facility Risk

This aging system requires increased maintenance costs to address risk of failure. Increased maintenance results in an increase in the frequency of short duration facility down time during failures. There is also a facility reliability risk associated with major facility downtime in the case of major component failure (EF-1, EF-2). Reduced performance of the existing system decreases capacity for existing equipment and new processes.

ROM Cost Estimate: 2.0M.

79. ARL Hot Cell 5 and 6 Reconfiguration

Description

The Analytical Research Laboratory at the Materials and Fuels Complex has six interconnected hot cells for processing of high dose radiological samples. Each hot cell has a different purpose, ranging from sample receipt, gamma counting, waste processing, etc. Over the years, very few modifications and updates have been made to the ARL hot cells. As a result, the equipment and instrumentation contained within each hot cell has degraded and become obsolete. It is necessary to upgrade and refurbish equipment and instrumentation to prevent delays in sample results and improvements to the processes.

Benefit

The reconfiguration and refurbishments to equipment and instrumentation in the hot cells will allow for efficiency gains and reduced sample processing delays and rework. The updates will support multiple programs simultaneously, increase throughput, and reduce maintenance efforts. Improvements will also provide greater ergonomic benefits and reduce the strain on the manipulators.

Risk

Aging equipment results in additional costs, whether through maintenance efforts or inefficiencies of processes. There is also a risk of events with wear and tear on equipment, resulting in potential spills and loss of samples.

ROM Cost Estimate: \$6.5M.

80. ARL Waste Volume Reduction Capability (A28)

Description

The Analytical Research Laboratory processes waste in cell 2. Cell 2 is also where sample preparation is performed. Only one of those activities can be performed at a time. The only way to keep up is to perform waste processing on overtime.

We have an empty room with a pneumatic transfer line from the hot cells that was used for ALP7 cask loading in the past. The ARL would like to repurpose that room for waste processing to allow for increased efficiencies and throughput. It would require some kind of containment walls or mobile hot cell for the dose, a 2-way blower, as the current blower is only one-directional, and a sample evaporator instrument. The challenge is getting the equipment into the basement due to the size and weight.

Benefit

Repurposing this room allows for efficiencies in the process to allow waste and sample preparation to be performed at the same time. This would allow waste to be charged closer to when the sample analysis were complete, thereby helping with the issue of programs closing numbers and having to find funding for the waste. It would also allow us to utilize space that currently sits empty in a building where realty is hard to come by.

Facility Risk

The ARL currently must shut down one operation, clean up, and set up the new process each time they need to switch processes. The result is a lot of wasted time and effort. Being required to complete waste processes on overtime raises the cost of an already expensive part of the process. We would be able to significantly reduce the backlog of waste waiting to be dispositioned.

ROM Cost Estimate: \$5M.

81. Replace TREAT Control Rod Segments

Description

A recent discovery of an unusual-looking end-plug welds in two segments of TREAT reactor Control/Shutdown rods (1 instance in each of two rods) prompted an investigation into the condition. The end result of the evaluation was the determination that the control rod segments (and any others that might unknowingly be in the same condition) are Operable but Degraded. The determination was made primarily as a conservative action for a condition that may have been adequate and possibly even accepted as-is with justification during early TREAT operation in 1960; however, unless or until additional information from 1958 can be found or the weld condition can be better characterized, it is prudent to move toward replacing any affected control rod segments with new parts. The engineering evaluation demonstrated that the affected rods are not likely to fail, based on their nearly 40-year operational history to date, so replacement can be pursued in parallel with TREAT operation. This project will procure and install new control rod segments wherever needed, removing any question about component reliability.

Benefit

Ensuring that this safety-related component meets today's manufacturing and inspection criteria will establish confidence in TREAT component quality.

Facility Risk

An unexpected component or failure of a control rod might arguably be sufficiently severe to prevent control rod insertion, which, though anticipated in the TREAT SAR, would have a negative impact on the TREAT operations schedule.

ROM Cost Estimate: \$1.25M.

82. FCF Material Tracking System and Support Infrastructure Replacement

Description

The FCF material tracking system is aged and portions of the system do not lend themselves to the NQA-1 software quality rules where testing is concerned. FCF process operators experience errors because the user interface does not clearly display process flow of the system which changed over the last 10 years and software modification of the HTML process screens is necessary. Original development team with Argonne was 15 developers. In the last 10 years this has been reduced to 2 part-time developers who have other responsibilities to the Pyro Processing project. A team of software engineers is needed to not only maintain the system, but to help update the code to meet the NQA-1 standards for regression testing and quality. The scope of this effort will be to replace the current process flow screens with new updated process flow screens to meet the current mission.

Benefit

The scope of this effort will replace the outdated process flow screens with new updated process flow screens and update the code to meet the NQA-1 standards for regression testing and quality and significantly improve process flow software changes to the system to make the facility process simpler and easier to follow with minimum delays to meet the current mission.

Facility Risk

Without this revision and update EBR-II Fuel Processing and HALEU Production activities relying on MTG will be challenged to demonstrate compliance with NQA-1 standards and effective and efficient process activities.

ROM Cost Estimate: \$5.5M.

83. Replace ARL Backup Diesel Generator

Description

The current 250KW diesel generator provides adequate power to support primary safety systems in the event of a loss of power based upon current demand. However, with the forthcoming upgraded exhaust fans for the Sodium and NDA wing of the ARL, conversion from steam to electric heat and numerous new research capabilities and support systems within the ARL, the current 250KW generator would not support in the event of a loss of power. Additionally, the current diesel generator, while providing an essential level of backup power for safety related systems, does not provide power to help ensure that vital research systems are not damaged in the event of a loss of power.

This capital asset project replaces the ARL's existing 250KW backup diesel generator with an upgraded 350KW diesel generator. The scope includes connecting all the ARL's primary safety systems and vital research systems to the backup power source. It provides a pre-engineered electrical building outside of ARL on a co-located concrete pad and a 350KW backup diesel powered generator.

Benefit

The upgraded backup power capability would provide adequate power to support the ARL's primary safety systems and allow for safe and timely shutdown of sensitive research capabilities if it is necessary to do so. This minimizes damage to the ARL research infrastructure housed inside this vital nuclear research facility.

ROM Cost Estimate: \$3.0M.

84. ARL Instrument UPS Installation

Description

When power goes out in the Analytical Research Laboratory, whether planned or unplanned, there is a risk to the instrumentation. With planned shutdowns, the instruments can be shut down in a controlled manner, but there is still risk to the instrument. When the outage is unplanned, the risk is increased. In previous power bumps, we have damaged instruments. The instrumentation in the lab is very sensitive and does not take much to skew results of samples.

Addition of uninterrupted power supplies to the instrument significantly reduces the risk of damaging the equipment. The downtime on these pieces of equipment has a substantial effect on programmatic work. It is desired to add UPS's to at least 7 instruments that are both high dollar and increased risk of damage affected programmatic work. These power supplies would allow the instrument to switch to backup power during an outage. It would allow time to perform a controlled shutdown, which lowers the risk.

Benefit

The installation of UPS's provides protection for multi-million-dollar instrumentation from damage and ultimately replacement. Reduced downtime because of damaged instruments from power bumps and shutdowns whether planned or unplanned increases the amount of programmatic work completed.

Facility Risk

The effects of shutting down sensitive instrumentation is very volatile. There is a high probability of damage to the equipment, creating down time and possibly necessary replacement of the instrument.

ROM Cost Estimate: \$1.25M.

85. ARL Multi-Zone System Overhaul

Description

The Analytical Research Laboratory (ARL) multi-zone system serves the lab/office space on the south side of the B-wing hallway (rooms B-102, B-116, B-120, and B-134). This area of the building was originally designed for lower hazard activities or general office space, but due to space limitations, has been converted to low hazard lab space and is separate from the main ARL contaminated exhaust system. More laboratory space is needed as the ARL's capabilities are expanded and as sample throughput demand increases. This system upgrade would likely include replacement of the supply air handling unit (AHU) in the basement including DX-Cooling system (evaporator in AHU and condenser on roof) and a larger electric heater (in AHU), D&D of existing AHU and HEPAs as well as some ductwork, significant structural modifications (to safety significant SSC) to allow new exhaust ductwork to be routed into each room, new supply ductwork, an upgraded control system including new ventilation control instrumentation such as flow control valves, sensors, duct heaters, sealing the labs for pressure control, etc. The existing exhaust systems that serve other portions of the ARL (fans, HEPA banks, and ductwork) would need to be evaluated to determine if they could support exhaust demand for this additional area and exhaust stacks would require evaluation to determine if they are adequately sized for the additional air flow. If exhaust fans, HEPA banks, exhaust stacks, etc. are not sized to handle this additional load, then a complete new exhaust system would potentially be required for this upgrade.

Benefit to ARL/MFC

- Better utilization of existing building footprint/floor space to accomplish the mission of the ARL.
- Improved area/space to use instruments that require connection to suspect exhaust, which is the vast majority of equipment used and needed at the ARL.
- Better temperature and pressure control in the affected area will provide an environment where optimal sample results can be obtained from analytical research equipment, which require an environment having steady and specific temperatures.
- Better contamination control in this section of the building, which allows the same types of activities that are performed in the other areas of the ARL to be performed in this area.

Facility Risk

Utilization of this area to accommodate additional R&D capabilities is not possible without these modification.

ROM Cost Estimate: \$5M.

86. Decontamination and Demolition of Abandoned Lines and Equipment

Description

Over the years, modifications in the Analytical Research Laboratory have left equipment abandoned in place. Though the current processes involve removing the abandoned equipment as we go, a campaign is needed to completely remove existing equipment. The campaign would involve removing lines and equipment that continue to take up space for current and future projects. These lines and equipment are located throughout the facility and will involve extensive work up front to identify all the lines that need to be removed.

The casting lab glovebox in B147 is an inert-atmosphere glovebox that is approximately 250 ft³. The inventory in the glovebox represents a large portion of the material inventory for the lab. Additionally, it is one of the highest risks to the Analytical Research Laboratory (ARL) due to material processing, operational challenges and continual issues. The box is in B147 of the ARL but operated by the fuel fabrication division. The fuel fabrication division has plans to add the capability to complete the work in their facility with hazard category 2 limits of materials, which is not able to be performed in the ARL. Once the capability is installed in FMF, there will be no need for the glovebox in the ARL.

Facility Risk

The glovebox will continue to be an operational risk due to outdated equipment and obsolete parts that impact the availability of the glovebox and increase the cost to maintain. Additionally, the amount of legacy contamination within this glovebox impacts expansion of capabilities. The material limits in the facility impacts the ability to complete other programmatic work.

Risk

Old systems and equipment crowd lab operations and impact operational efficiency. It also limits useable footprint for additional mission support.

The glovebox will continue to be an operational risk due to outdated equipment and obsolete parts that impact the availability of the glovebox and increase the cost to maintain. Additionally, the amount of legacy contamination within this glovebox impacts expansion of capabilities. The material limits in the facility impacts the ability to complete other programmatic work.

This includes abandoned systems within ARL Room B-35.

Benefit

The removal of the legacy equipment and abandoned piping will allow for future growth under the existing footprint of the Analytical Research Laboratory to meet the INL's mission. It eliminates the need to route piping around the legacy piping. The removal of the legacy piping would allow direct runs on current and future projects, ultimately reducing the costs of future installs.

Removal of the CLGB from the ARL would significantly reduce the material. The greatest risk to the facility would be removed, allowing for increased operation and research capabilities and efficiencies.

ROM Cost Estimate: \$10M.

87. FMF HVAC/Suspect Exhaust System

Description

FMF HVAC/Suspect exhaust system upgrade.

Benefit

The upgrades will allow fuel fabrication activities to expand throughput. This type of expansion will be needed to meet the requirements to fabricate VTR fuel.

Facility Risk

Increased Pu processing in FMF will require upgrades to the facility ventilation to meet Pu processing facility standards.

ROM Cost Estimate: \$2.5M.

88. Implement Uniform SNM Containers and Design Verification

Description

There are multiple designs/types of Special Nuclear Materials (SNM) containers used at MFC. Many of these are based upon old designs and have been in use for many years.

Benefit

Transitioning to a uniform design for SNM containers will increase operational efficiency and reduce the risk of human error. Multiple container types require slight variations in operations to address unique aspects of each container. A single type of SNM container used across all SNM operations reduces the variation during specific material evolutions.

Facility Risk

This issue increases the risk of human performance errors.

ROM Cost Estimate: \$3.5M.

89. FCF In-cell Periscope and Camera System Replacement

Description

There are three FCF periscopes used for in-cell viewing of small items or small print on in-cell pieces of equipment. These are early 1960s vintage. These periscopes are mechanically operated, and the operating gears are very worn and replacement parts are no longer available. The high power/low power switches no longer operate reliably. The rubber eye pieces have deteriorated away. These represent single point failure potential. Failure would require ceasing all reprocessing operations.

Benefit

Improved system reliability and availability. Supports achievement of research mission.

Facility Risk

Current hardware is no longer vendor supported. Current operations are dependent upon these scopes to improve efficiency. Loss of periscopes and cameras would shut down processing operations for up to 12 months as upgrade components are procured and installed.

ROM Cost Estimate: 2.5M.

90. Addition of Pneumatic Transfer Line from ARL Hot Cells

Description

Installation of a pneumatic line from the hot cell to the B-wing, most likely the radiochemistry glovebox in B137. Installation of this transfer system would reduce the dose to the workers. To remove a sample from the hot cells currently, we have to dilute the sample far enough down to make sure the dose meets the requirements for ALARA. The pneumatic line would make it so we could send higher dose samples to the B-wing, thereby reducing the efforts and dose.

Benefit

A pneumatic line to a glovebox in the b-wing would allow us to transfer higher dose samples for processing in the glovebox. The only options currently are to dilute the sample enough to back out and hand carry or process the sample in the high contamination area with manipulators. Cost saving from reduction in time spent and moving samples to a less contaminated environment improves the results analyses.

Facility Risk

Processing samples within the hot cells increases the risk of contaminating the sample due to the environment, as well as operational risk from handling the sample remotely with manipulators. The time and effort are also increased for processing this way.

ROM Cost Estimate: Outyears \$3.5M.

91. IMCL Contamination Control Updates

Description

Recent contaminations in IMCL with the Shielded Sample Preparation Area (SSPA), Plasma-Focused Ion Beam (P-FIB) Microscope and the Electron Probe Micro-Analyzer (EPMA) exposed greater potential for local contamination events to have a greater facility impact and a potential for prolonged facility outages. Installing downdraft capability at rapid transfer ports on confinements (6 locations), provide connection from the sample chamber housing of microscope to suspect exhaust or HEPA filtered air mover and install a semi-permanent enclosure over the EPMA that facilitates maintenance on the instrument in the long term will significantly reduce risk.

Benefit

Implementing engineered solutions to these issues will reduce the risks to personnel and instrument availability to support research missions. These would provide an engineered, defense in depth, control to minimize effects of local contamination issues. The ability to keep contamination issues localized would keep other facility instruments at full Utilization. The cost to implement controls would pay for itself vs. loss of access to 14 (soon to be 16) instruments for programs.

Facility Risk

Recent events have resulted in significant loss of availability for some of the IMCL research capabilities. Corrective actions are necessary to support instrument availability and reduce cost of operations.

ROM Cost Estimate: \$1.5M.

92. MFC Private Facility Control Network (PFCN) Critical Infrastructure, Industrial Controls Servers, and Data Repository Storage Facility

Description

MFC's PFCN is experiencing dramatic server, switching, data storage, and cyber-security equipment growth due to the onboarding of new research facilities, projects, and operation activities being developed at MFC. MFC's nuclear unclassified control information systems and industrial control systems (ICS) production devices have been the focus for historical retention, analytical applications, and material tracking for many years. As the requirements to support the research initiatives and mission at MFC increase, new systems for high-definition scanning and high-resolution imaging for material analysis has put tremendous pressure on the PFCN's current server, switching, and data storage systems. Such high-resolution images result in many large files requiring high-capacity storage. Recently, PFCN computer engineering, at the request of research projects, ordered a large-scale data storage platform to handle the anticipated retention requirements. This installation completes the capacity of current facility space. With new facilities being built, maturing research project needs, cyber-security requirements, and operational needs, the requirement for a new or expanded facility is warranted.

MFC PFCN shares space with information management, life-safety, and security in the INL/MFC Communications Facility building MFC-1728. There are many demands for the limited rack space currently in MFC-1728 and it is currently at capacity with no room for growth. As built, MFC-1728 is a data communications central facility and was not designed to meet the cooling requirements of a data center. With the increase of server, switch and storage systems, heat loads have become a problem and require constant monitoring. The need for a new location for the PFCN operation of a proper data storage environment is self-evident. Our proposed action is to revisit the existing plans of MFC-1728 and add a new datacenter room which would satisfy the growth requirement.

Benefit

Expansion of the current MFC-1728 communications facility with the addition of a data center room will help us meet the demands of physical growth allowing for additional communications equipment, environmental controls, and cooling. This physical space will provide a climate-controlled environment for server, switching, and data storage equipment to meet the demands of the MFC mission.

Facility Risk

If we do not act, the MFC mission risks the possibility of hardware failure due to increased cooling requirements and the inability to provide support for new hardware expansion, project opportunities, cyber-security equipment space, and data storage within the controlled environment of MFC.

ROM Cost Estimate: \$10M.

93. Install FASB Vacuum System

Description

There are currently multiple individual vacuum pumps throughout the facility supporting various equipment. There are a variety of different makes and models. The proposed solution is to install a centralized facility vacuum system with distribution lines throughout the facility.

Benefit

A consolidated facility vacuum system would reduce the amount of maintenance and spare parts required compared to the current vacuum systems. The vacuum system could also provide redundant vacuum pumps to increase the reliability of the system. The facility vacuum would reduce the footprint taken by the individual vacuum pumps. Providing a facility vacuum system would reduce the cost of future equipment installations.

Facility Risk

There is no redundancy for lab equipment with the equipment specific vacuum pump approach.

ROM Cost Estimate: \$1.0M.

94. Install Uranium Process & Synthesis Glovebox in ZPPR Workroom

Description

The existing capability in FMF will likely need to be removed in the future to make room for large quantity transuranic processing gloveboxes that currently can only be supported in FMF. Enduring glovebox capability to process legacy and newly generated enriched uranium scrap and repackage for stable storage and likely shipment to offsite processing facility for recovery/reuse. This capability can also be used for uranium R&D and fuel fabrication support, especially if larger quantities of existing HEU need to be down-blended to High Assay LEU to support efforts outside of the secure facilities fenced area.

Benefit

This project would provide additional Uranium processing and synthesis and rather than install the new glove box in FMF where future transuranic capability will be housed. This glovebox would be in ZPPR. This location would also put it closer to the HEU and reduce transport issues.

Facility Risk

If the existing capability in FMF is removed to make room for large quantity transuranic processing gloveboxes that currently can only be supported in FMF then current capability to disposition this type of material will no longer be available.

ROM Cost Estimate: \$5.0M.

95. Refurbish ZPPR/AFF Concrete Floors

Description

Portions of the floor in AFF are bare concrete. The ZPPR Vault, Work Room, Equipment Room, and Corridor are coated, but the coating is failing due to wear and age. The proposed solution is to prepare the existing floors and applying new epoxy floor coatings.

Benefit

New floor coatings would address minor surface damage and reduce the potential for future damage and wear. The new coatings would also seal the concrete from water, chemicals, and contaminants.

Facility Risk

The areas of exposed concrete are more susceptible to damage from water, chemicals, and use. These areas are inside of RBA boundaries, and having exposed cracks, and bare concrete, makes the area more vulnerable in the event of any potential spills or contamination. The appearance of the floors in these areas do not reflect the professional standards of nuclear and radiological facilities. Areas could be more difficult to maintain as part of RBA boundary. Uncoated concrete could spall or degrade over time.

ROM Cost Estimate: \$1.5M.

96. HFEF Building Chiller and Cooling Tower Upgrade

Description

The current building cooling water chillers and cooling tower are dated to the original installation of HFEF dating back to 1970. (The DOE Financial Management Handbook CH10 rates useful service life of chillers at 20-25 years.) Recently there have been instances of component failures where replacement parts are difficult, if not impossible, to locate and procure. As this equipment gets older procurement of spares will be increasingly difficult eventually rendering the equipment unusable. Both chillers and the cooling tower are currently functioning, however, the chillers are specifically showing signs of compromised reliability with equipment component failures. Cooling water pumps are also leaking and should be repaired. In addition, the cooling water chemistry treatment is antiquated and is in need of upgrades to industry standard water treatment chemicals and user interface. The equipment is currently functioning at a minimum level of performance and reliability is questionable. Failure of the chillers or water tower will render HFEF without building cooling capability.

Benefit

Refurbishing the equipment will result in the building to regain compliance and ensure HFEF remains operational.

Facility Risk

The equipment is currently functioning at a minimum level of performance and reliability is questionable. Failure of the chillers or water tower will render HFEF without building cooling capability.

ROM Cost Estimate: \$3.0M.

97. HFEF Main Cell Exhaust Replacement

Description

CES-EF-4A, CES-EF-4B, and CES-EF-4C work in parallel to provide the cell exhaust for HFEF. Two of the three fans operate at once to provide the required airflow with one fan serving as backup.

All fans are over 40 years old and are at the end of their life expectancy and could fail. Since the system is old, replacement parts might be difficult to procure. It is proposed to replace all fans with new similar sized fans. Each fan will be provided with updated controls and a VFD to modulate the fans. Related interlocks and controls to the fan system will be updated as necessary to provide proper operation and control of the cell exhaust system. If these exhaust fans are not replaced, one or more fans could fail without warning and leave the Decon Cell and HRA without the required exhaust.

Benefit

The main cell exhaust reliability would be greatly improved, ensuring proper working conditions for the system.

Facility Risk

If these exhaust fans are not replaced, one or more fans could fail without warning and leave the Decon Cell and HRA without the required exhaust.

ROM Cost Estimate: \$3.0M.

98. HFEF Cask Cart Control System Refurbishment

Description

Recently the control system for the HFEF Cask Cart and Floor Plates has shown signs of instability and has components (PLC) that are aged and difficult to procure (components are obsolete). Programming anomalies have caused minor delays to high visibility operations and have been labor intensive to repair. The system is circa 1998-1999 and is somewhat antiquated (i.e. at risk for failure) for controls systems. Failure of this system will render the facility unable to receive fuel shipments via cask until the cask cart is repaired. Recent hardware and software anomalies rendered the system inoperable for a week with high visibility commercial fuel held hostage until software issues were identified and restored to operation. This caused delays and unnecessary incurred cost for the program, jeopardizing mission outcomes. One used replacement component was located at MFC but alternative acquisitions would be procured via auction web sites.

Benefit

Refurbishments would restore reliability of such mission critical piece of equipment.

Facility Risk

If the reliability of the control system is not improved, unexpected failures during operations could result in significant delays in mission execution or in an unrecoverable situation. The facility would not be able to move casks in and out, stopping mission delivery.

ROM Cost Estimate: \$750K.

99. HFEF Facility Electrical Distribution System

Description

Motor Control Centers (MCCs) supply and distribute electricity to HFEF. HFEF MCCs are original equipment from 1975. These MCCs are no longer supported by the vendor and replacement parts are difficult to obtain. Standards have changed since 1975, current MCC footprints are larger than existing equipment, and current codes require changes in placement. This project will design, procure, and install modern MCCs. If MCCs are not updated to modern components, maintenance will become increasingly difficult. When spare parts are no longer available, repair will not be possible and HFEF will be at risk of not being able to supply power to facility systems.

Benefit

Upgrades will eliminate current increasing costs for corrective maintenance.

Facility Risk

When spare parts are no longer available, repair will not be possible and HFEF will be at risk of not being able to supply power to facility systems.

ROM Cost Estimate: \$3.0M.

100. HFEF Containment Box Temperature Control refurbishment

Description

The containment box (conbox) is the most used window in HFEF where all the samples are prepared for destructive examinations that are subsequently executed in HFEF, ARL, IMCL and EML. Programs supported by the capabilities here installed include, but are not limited to, ARDPs, ATF, AFC, USHPRR, Naval Reactor, NSUF, AGR. Microreactor fuel sample preparation will also be performed in the conbox, leveraging years of experience in sample preparation from the AGR program.

The atmosphere and temperature control capabilities have been lost from the containment box. The temperature readings are as high as 100F and there is no active atmosphere monitoring other than the main cell one. This project will address the design, procurement and installation of a new atmosphere and temperature control system. Without appropriate temperature and atmosphere control we proceed at risk and could incur the possibility of damaging the experiment or to obtain less-than-acceptable quality in the samples prepared.

Benefit

More reliable temperature and atmosphere monitoring and control will be restored. The quality of the sample preparation will be improved, as well as the turnover.

Facility Risk

Without appropriate temperature and atmosphere control we proceed at risk and could incur the possibility of damaging the experiment or to obtain less-than-acceptable quality in the samples prepared.

ROM Cost Estimate: \$2.0M.

101. Seal Pot #2 Relief Valve Replacement

Description

The Hot Fuels Examination Facility (HFEF) utilizes a seal pot system as over and under pressure protection for the argon cell. The seal pot portion of the system, SP-2, has a large diameter over/under pressure relief valve, PSV-1, installed internally to ensure air does not enter the cell as a back up to the oil reservoir within the seal pot and to vent cell pressure should it become excessive. The seal pot is filled with oil to a specific height that provides a seal keeping outside air from contaminating the cell atmosphere with oxygen. Concern exists that PSV-1 will not operate at its setpoints due to lack of maintenance. SP-2 was installed in the early 1970's with PSV-1 already inside the vessel. Once SP-2 was installed in the basement of HFEF, there was no practical means of accessing the valve to perform the maintenance, which brings into question whether or not it would operate as designed. Without being able to test the valve, it must be assumed that at this point it will not operate at the design set points. This design needs to be upgraded to eliminate the existence of the PSV. Ultimately, the most serious concern is that the valve is failed closed and will not open to relieve an over or under pressure condition if needed (If the valve is failed open, then SP-2 operates as a traditional seal pot and the relief values are controlled by the oil level). It is poor engineering practice to leave a pressure relief device in an unknown operational state. If the valve is closed and will not operate as designed, it could potentially lead to an over or under pressure event in the cell. This course of action runs contrary to the accepted practice of testing or replacing pressure relief valves on a regular basis.

Benefit

The current state of the PSV is unknown and cannot be verified to meet design functions. Redesign/removal of the PSV will result in a system with known configuration and being maintainable for future operations. More importantly, the re-designed system would be reliable to perform the intended design function to protect the HFEF Main Cell from over or under pressure conditions.

Facility Risk

If the valve is closed and will not operate as designed, it could potentially lead to an over or under pressure event in the cell. This course of action runs contrary to the accepted practice of testing or replacing pressure relief valves on a regular basis.

ROM Cost Estimate: \$1.5M.

102. Renovate and Expand HFEF Women's Restroom

Description

HFEF was constructed with a single (one-stall) women's restroom located on the facility operating floor (main floor). As workforce demographics have shifted the number of female employees has grown to exceed the functional use for a single stall restroom. This has created congestion in the restroom at peak use times and also allows for limited use for the restroom accommodating large tour groups. It should be noted that there is an additional single stall restroom and shower on the 3rd floor restricted access area.

The consequences of failure to mitigate the problem may include violation of OSHA 1910. Failure to mitigate is also a significant inconvenience to the female workforce located within the facility.

Benefit

Addressing this issue will make HFEF a truly inclusive facility up to modern standards.

Facility Risk

The consequences of failure to mitigate the problem may include violation of OSHA 1910. Failure to mitigate is also a significant inconvenience to the female workforce located within the facility.

ROM Cost Estimate: \$750K.

103. ARL Air Conditioning Unit Condenser Replacement

Description

Major components of LBAS-ACCU-4 and LBAS-ACCU-5 air conditioning condenser units have failed. During the summer months optimal temperatures in the labs that these units support (South side of B-wing Corridor and NDA Wing) are not able to be maintained as needed to support mission work. Temperature must be maintained within a specific band (68°F +/- 3.6°F) and must not change significantly over time during sample analyses using specific instruments. Pressure control of Labs must be maintained as well for contamination control within the building. When AC units are out of service, maintaining the required temperature conditions throughout the course of the day is difficult and impossible on other days depending on outdoor temperatures. Maintaining pressure control while trying to maintain temperature control is also exceedingly difficult. These units have had repeated problems for years.

Benefit

The facility will be capable of maintaining the individual laboratory spaces at a room temperature of 68°F +/- 3.6°F. This temperature range allows for optimal performance of the current instrumentation in the facility.

Facility Risk

Sample analysis results are impaired when laboratory temperatures vary. As laboratory temperatures increase, analytical chemistry instrumentation reliability decreases.

ROM Cost Estimate: \$500K.

104. Permanent Cover Over ARL Sodium Wing Stairwell

Description

The Analytical Research Laboratory (ARL) has purchased and installed temporary stairwell covers for years to prevent snow and ice buildup in the exterior stairwell that enters the basement at the sodium wing. These temporary covers are easily damaged by wind, snow, and ice. This prevents the cover from performing its primary function of keeping snow and ice out of the stairwell preventing slips, trips, and falls. In the winter of 2022/2023, part of the cover buckled under snow and ice loads and damaged a pressurized gas line. Adding a fixed stairwell cover will improve safety and be a permanent fix to a chronic problem. The stairs and retaining wall leading to the basement entry are degrading and need repaired as part of the project to affix the permanent cover to and reduce a tripping hazard.

Benefit

The permanent stairwell cover will prevent ice and snow from building up on the stairs. This reduces the potential for slips, trips, and falls while using the stairs. The permanent cover will prevent future degradation of the stairs and interior retaining wall leading to the basement by protecting it from the elements.

Facility Risk

Snow and ice collect in stairwell creating unavoidable hazards. Stairs become unsafe to use by operations and construction contractors. There is a risk of water ingress into the building's radiologically controlled areas due to melting snow and ice.

ROM Cost Estimate: \$500K.

105. ARL Hot Cells 1, 2, and 3 Reconfiguration

Description

The Analytical Laboratory at the Materials and Fuels Complex has six interconnected hot cells for processing of high dose radiological samples. Each hot cell has a different purpose, ranging from sample receipt, gamma counting, waste processing, etc. Over the years, very few modifications and updates have been made to the AL hot cells. As a result, the equipment and instrumentation in each hot cell has degraded and become obsolete. It is necessary to upgrade and refurbish equipment and instrumentation to prevent delays in sample preparation and improve material handling capabilities.

Benefit

The upgrades and refurbishments to equipment and instrumentation in the hot cells will allow for efficiency gains and reduced sample processing delays and rework. The updates will simultaneously increase throughput and reduce maintenance efforts. Improvements will also provide ergonomic benefits and reduce the strain on manipulators.

Facility Risk

Aging equipment results in additional costs, whether through maintenance efforts or inefficiencies of processes. There is also a risk of events with wear and tear on equipment, resulting in potential spills and loss of samples.

ROM Cost Estimate: \$2.0M.

106. IMCL EPMA Instrument Enclosure within the EPMA SAS

Description

The EPMA instrument at IMCL requires routine maintenance and repairs. This servicing requires access to instrument internals that are alpha contaminated. This work significantly impacts the laboratory as it is posted as an Airborne Radioactivity Area, PAPR required for entry, which restricts access to all other instruments. Instrument repairs often last multiple days. Installation of a semi-permanent enclosure would provide an engineered control to minimize contamination risk to other instruments and the laboratory. This would also allow for continue facility occupancy during EPMA maintenance activities.

Benefit

The incorporation of an enclosure (Perma-Con) around the EPMA would also allow access to the laboratory for research instrument utilization during EPMA maintenance. This would reduce overall cost that results from shutting down the facility to support EPMA servicing. A semi-permanent enclosure would also be equipped with fire protection equipment and elevate long term fire impairments that occur during tent installations.

Facility Risk

Restricting laboratory availability incurs risk to the ability of IMCL to meet its mission goals and milestones. Performing routine maintenance on the EPMA and accessing highly contaminated internals increases risk to loss of contamination control and potentially contaminating the laboratory and surrounding instruments.

ROM Cost Estimate: \$500K.

107. Convert FCF Steam Heat to Electric

Description

Conversion from steam heating within FCF to electric heating would provide a more reliable means to heat the facility. The current steam heating systems has numerous issues such as leaking valve stems, plugged steam traps, leaking heat exchangers, faulty control valves and heaters that don't work. Annually, new steam system issues arise due to the poor system layup at the end of the season. Corrosion is rampant in the steam piping and it's only a matter of time before there will be serious issues with the steam piping and components. A conversion to electric heating would increase reliability and decrease maintenance time and costs on the system. The conversion to electric heating would likely require an upgrade to the current substation that brings power into the facility.

Benefit

A conversion to electric heating would increase reliability and decrease maintenance time and costs on the system.

Facility Risk

Annually, new steam system issues arise due to the poor system layup at the end of the season. Corrosion is rampant in the steam piping and it's only a matter of time before there will be serious issues with the steam piping and components.

ROM Cost Estimate: \$5.0M.

108. Refurbish/Replace Vilter Freon Compressors

Description

Refurbishment or replacement of the Vilter Freon Compressors in FCF would position the facility for the near future with regards to argon cell cooling. The current compressor units (qty 2) were installed in 2001 and have ~100,000 run hours on each compressor. This system uses R-22 refrigerant which is no longer manufactured and the price of R-22 is high and the availability is scarce. Replacement or refurbishment of the compressors may also require a replacement of control panels and, depending on selected replacement refrigerant characteristics, the sub-cell cooling boxes may require replacement to accommodate a needed increase in system pressure. The Vilter Freon compressors are an integral part of the argon cell pressure and temperature control system (PTCS). In the temperature control mode, the PTCS maintains argon cell temperature at an acceptable level by sensing argon gas temperature at the inlet of each recirculation loop. Using sensed pressure or temperature, the PTCS manipulates the refrigeration system by controlling Freon flow to the recirculation system cooling boxes to vary the argon cell pressure or temperature, respectively. Cell pressure and temperature are critical to maintaining an acceptable cell environment for programmatic work. It is anticipated that as the compressors continue to run and the runtime hours increase that internal parts will begin to fail. Although parts are still available from Vilter, refurbishment or replacement of the compressors is warranted to decrease maintenance downtime. In addition, changing to an alternate refrigerant would resolve the issue related to use of R22 refrigerant that is no longer produced. Failure to address this issue could result in unacceptable delays in programmatic work.

Benefit

Decreased risks to argon cell cooling. Cost Savings due to the scarcity and availability of R-22 refrigerant. Decrease in delays of programmatic work if a failure were to occur.

Facility Risk

Although the compressors are presently operating under a rigorous maintenance program and parts are still available from Vilter, a refurbishment or replacement of the compressors is warranted to decrease maintenance downtime. In addition, changing to an alternate refrigerant would resolve the issue related to use of R22 refrigerant that is no longer produced. Failure to address this issue could result in unacceptable delays in programmatic work.

ROM Cost Estimate: \$6.0M.

109. Additional FCF Argon Supply Tank

Description

Installation of a new 3,000 gallon liquid argon tank next to the current 1,500 gallon tank on the east side of the facility. Presently, the facility refills the current tank on a weekly basis. The installation of a new tank would provide more storage to the facility and prevent potential disruptions with operations due to lack of argon. When argon is not available, the operations in the cell are stopped until the cell atmosphere can be put back to normal levels. In the event that the argon tank is not filled on schedule, FCF has the ability to cross connect with HFEF to use argon from that facilities argon tank.

Benefit

The installation of a new tank would provide more storage to the facility and prevent potential disruptions with operations due to lack of argon.

Facility Risk

When argon is not available, the operations in the cell are stopped until the cell atmosphere can be put back to normal levels. Stoppage of work inside the argon cell affects programmatic work and milestones.

ROM Cost Estimate: \$2.5M.

110. Backup Electrical Supply for RSWF

Description

The increasing workload at RSWF in support of EBR-II transfers in accordance with the Idaho Settlement Agreement and legacy LLW and MLLW transfers to RHLLW Disposal Facility and INTEC facilities in support of the INL Site Treatment Plan can be and have been impacted by loss of electricity in recent years. A backup generator would provide additional certainty that work can continue and milestones are met. Establishing backup electrical supply for RSWF will include a new diesel generator and likely upgrades to the current infrastructure for RSWF to bring it up to code. These code deficiencies were discovered when the north gate security gate was installed and the issue corrected for the portion from the gate house back to the source but are assumed to also be necessary for the remainder of the leg from the gate house to RSWF.

Benefit

Increased reliability in power at RSWF to support mission needs and security requirements for the facility.

Facility Risk

Recurring power outages could continue to impede programmatic work and related milestones at RSWF with negative impacts to the budget and schedule due to increased Security personnel resources needed, inability to access the facility, etc.

ROM Cost Estimate: \$3.0M.

111. HFEF Main Cell Gas Chromatograph

Description

Currently there is no capability to delineate gasses being generated within cell from processes and examinations. Recently the purification beds have been replaced in what seems to be a premature periodicity. It is suspected that there may be potentially harmful gasses being passed to the argon purification systems. With the potential for new processes and equipment being installed in cell - the only indication (aside from preliminary analysis) of harmful substances would be damage to the purification system. Installation of a gas chromatograph would allow engineering to analyze the atmosphere prior to passing through the purification system. Consequences of failure include purchasing and replacing catalyst beds more often than necessary.

Benefit

This would help eliminate unnecessary maintenance, however, it would also improve the capability and understanding of the cell atmosphere.

Facility Risk

The consequences of failure include purchasing and replacing catalyst beds more often than necessary, incurring unnecessary costs for replacements. Unplanned repairs would also have consequences for timely mission delivery as the main cell work will need to be stopped.

ROM Cost Estimate: \$1.0M.

112. Modernization of MFC Data Archival Software System

Description

The Materials and Fuels Complex (MFC) houses many instruments, sensors and tools that generate a continuous stream of raw data and measurements. By capturing this raw time-series data and archiving it in a searchable, discoverable way, researchers will have access to data, maintenance personnel will have access to sensor readings for performing diagnostics, auditors will have access to data that will allow them to determine compliance levels, and operations personnel will be able to analyze efficiency and productive use of resources.

The current method of capturing and presenting data to stakeholders relies on a custom Data Acquisition Support System (DASS), which has become obsolete and incompatible with modern architecture and operating systems. As a result, maintaining user access traceability and system upkeep has become increasingly challenging. To address these issues, the outdated DASS will be phased out in favor of a commercial, off-the-shelf (COTS) solution known as AVEVA PI Solution. This transition will involve developing and managing robust connectors to ensure seamless data ingestion from the various instruments and sensors at MFC. Access to the new system will be facilitated through a secure custom web interface, designed to offer all necessary analytical tools for effective research and monitoring purposes.

Benefit

The migration to AVEVA PI Solution, coupled with a custom web interface, yields several benefits. Firstly, it ensures compatibility with modern hardware and software, enhancing system performance and longevity. Secondly, it incorporates advanced algorithms and analytics for efficient data gathering and processing. Thirdly, robust authentication and authorization mechanisms bolster data security across all access points. Additionally, the migration leads to reduced licensing costs, optimizing expenditure. Furthermore, users can easily compile and disseminate data visualizations and reports, fostering informed

decision-making. Lastly, the integration offers seamless API connections for streamlined data ingestion into other systems, enhancing interoperability and workflow efficiency.

Facility Risk

Time-based data analytics from programmable logic controllers, sensors, and other low-level devices are integral to the effective operation and maintenance of MFC facilities and laboratories. Inaccessibility to this information could result in overlooking critical time-sensitive decisions. The existing DASS system is approaching the end of its operational lifespan and lacks scalability to accommodate the evolving needs of MFC. Moreover, it poses vulnerability to unauthorized access, highlighting the pressing need for enhanced data security measures. Safeguarding such operational output has become increasingly paramount.

ROM Cost Estimate: \$500K.

113. Industrial Control System Engineering Cyber Requirements Implementation

Description

This project would implement cyber security requirements for MFC's industrial control systems.

Benefit

Provide robust cyber security controls for MFC's systems.

Facility Risk

Cyber security threats are increasing across all industries and represents a risk to MFC's industrial control systems.

ROM Cost Estimate: \$5.0M.

114. IMCL Intrafacility Pneumatic Transfer Capability

Description

Currently transfers inside IMCL take place using the ISC cask and cart. These components have proven less reliable than originally anticipated. The ISC cask/cart has had several outages due to equipment malfunctions and reoccurring issues. The process to transfer the ISC cask inside IMCL is prone to operator injury. The cask/cart combination weighs just under 3000lbs and requires maneuvering into very tight spaces.

Benefit

More reliable transfer system leads to:

- Increased facility availability for material transfers
- Reduced burden on IFM dollars as a result of a more efficient transfer method and reduction in creation of radiological waste
- Reduction in risk to personnel injury by reducing ergonomic and industrial hazards.

Facility Risk

It is anticipated that continued delays and outages caused by ISC equipment issues will continue. Both ISC's and cask cart have had multiple failures causing significant delays to material transfers and risking IMCL's mission goals.

Continue to deal with radiological risk. Each transfer between confinements breaches our Class A glove boxes (nonessential personnel and tours are restricted in IMCL based on this risk or transfers are delayed).

Continue to deal with ergonomic and industrial hazard risk by manually moving the ISC cask.

ROM Cost Estimate: \$4.5M.

115. FCF Satellite Analytical Capabilities

Description

The installation of an inductively coupled plasma mass spectrometer (ICP-MS) and an ICP optical emissions spectrometer (ICP-OES) within the radiological buffer area at FCF would allow for rapid analytical capability to support in-process verification of uranium composition and rapid evaluation of certain waste streams from these processes. The analytical support room should also contain a containment system (hood, glovebox, etc.) that would be utilized for the dissolution and sample preparation for these sample types. This satellite laboratory will support rapid analyses of current and future programs, including EBR-II, Beartooth, MSTEC, and HALEU Polishing.

Benefit

Installation of a satellite analytical capability at FCF would provide rapid turnaround analyses for several current projects as well as new test bed capabilities currently being developed for installation in the FCF MBA.

Facility Risk

Uranium composition samples and certain waste samples will need to be packaged and transported to the Analytical Research Laboratory for verification. This will severely impact throughput and cause delays to operations. Maintaining continuity of operations is critical to EBR-II program work and meeting elevated targets for HALEU polishing.

ROM Cost Estimate: \$4.0M.

Appendix B

General Infrastructure Descriptions

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1. Replace MFC-773 Substation

Description

The existing 773 substation is a 13.8kV to 480V 2MVA substation that supplies power to multiple indirect IP facilities in the northeast area of MFC. The main transformer for this substation TF-022 is showing signs of failure. Recent preventative maintenance has shown degraded test results and other abnormalities within the substation which point to shortened life expectancy.

This substation supplies power to 13 facilities: MFC-703, MFC-753, MFC- 772, MFC-773, MFC-778, MFC-781, MFC-783, MFC-789, MFC-706, MFC-790, MFC-1750, MFC-794, and MFC-782 and 796 which are part of the Advanced Manufacturing Facilities.

EWR has been submitted, walked down, engineering estimate received awaiting award.

Benefit

Re-designing the MFC-773 substation to remove the existing 2MVA transformer and attached switch gear and installing multiple smaller transformers and sectionalizing switches provides a more reliable utility distribution system.

Replacement of the substation will ensure commercial power failure at Advanced Manufacturing Facilities, FMF, ZPPR, and 13 additional support facilities is less likely. This re-design will reduce Arc-Flash Hazard as well. Additionally, the existing medium voltage option being employed at MFC is to use sectionalizing switches and facility-level transformers. This would reduce the number of facility outages necessary to perform periodic maintenance on a substation feeding multiple buildings/facilities.

Facility Risk

Providing clean reliable energy to MFC facilities is a fundamental principle in ensuring important milestones can be met. Unreliable energy sources can cause increased facility down time as well as potential safety concerns due to extensive maintenance requirements (exposure to higher flash hazards). The current distribution system is becoming more unreliable and will eventually fail.

ROM Cost Estimate: \$1.5M.

2. HFEF Non-Nuke/Rad Building HVAC Maintenance

Description

This request is to cover work scope to be completed this FY to replace aging and obsolete (in some cases 50+ years) Heating Ventilation and Cooling (HVAC) units at various MFC locations. All units listed in this INDIRECT IPL are obsolete and near complete failure. Repairs to these units have been frequent resulting in downtime during the peak summer months. Spare parts are becoming nearly impossible to obtain resulting in longer out of service delays. All units utilize R22 refrigerant which is no longer produced as of 2020. This work is above and beyond normal corrective maintenance. Specific locations and details are listed in the table and scope descriptions below.

Benefit (ROM Estimates)

Priority	Project	Amount	Status	Notes
1	MFC-774 Replace AHU-1	\$1,000,000	Design nearly complete. Indirect IPL is for execution.	50+ year old unit that is obsolete and frequently out of service including 2021. Parts to repair are difficult to obtain.
2	MFC-710 Replace CU 1 & 2	\$615,000	Design nearly complete. Indirect IPL is for execution.	30+ year old unit. Frequent failures over the past two years.
3	MFC-753 AC-3	\$390,000	Design nearly complete. Indirect IPL is for execution.	40+ year old unit mounted to the exterior side of the building.
4	MFC-721 HVAC Replacement	\$270,000	Design nearly complete. Indirect IPL is for execution.	40+ year old units that are obsolete and close to failure.
5	MFC-752 Replace Water Cooled AHUs	\$460,000	Design nearly complete. Indirect IPL is for execution.	Units are water cooled. One serves the dial room and the others serve office space in the basement. The MFC plant cooling loop is no longer available to support these units. Currently they are temporary supplied by a potable water cross connections that provides once through water for cooling.
6	MFC-752 HVAC Replace E&D Wings	\$250,000	Indirect IPL is for design phase.	AHU-16 serving E-wing is an obsolete 50+ year old unit that was out of service for much of the 2021 summer. D wing is served by 30+ year old fan coil units that require constant maintenance to remain functional.
7	MFC-774 Replace AHU-2	\$200,000	Indirect T IPL is for design phase.	50+ year old unit that is obsolete. Parts to repair are difficult to obtain.
7	MFC-752 Replace Water Cooled AHUs	\$460,000	Design nearly complete. Indirect IPL is for execution.	Units are water cooled. One serves the dial room and the others serve office space in the basement. The MFC plant cooling loop is no longer available to support these units. Currently they are temporary supplied by a potable water cross connections that provides once through water for cooling.

Risk

If these projects are not completed, the current units will fail unexpectedly resulting in months of downtime due to planning requirements and the long lead times for equipment. Supply chain issues caused by the global pandemic have prolonged already long lead times to 16+ weeks. While the equipment is out of service, temporary units must be mobilized, or occupants must endure lower than ideal temperatures or be sent home due to unsafe working conditions. Meanwhile, buildings risk freezing utilities and stress on other HVAC systems within the building that attempt to compensate for the loss of service.

ROM Cost Estimate: \$6.5M.

3. MFC Asphalt Replacement and Roadway Maintenance

Description

MFC interior asphalt is significantly degraded to the point that many areas require complete replacement and in other large area require significant repair.

MFC asphalt needs include multiple miles of existing roadway, vehicle and equipment parking areas, pedestrian walking surfaces, and new pavement of miles of existing gravel roadways. Additionally, drainage and water flow are adversely affected in some of these areas and aesthetics are negatively impacted by the visual condition of much of our flat asphalt and gravel surfaces.

The MFC U&IS department has an interior asphalt replacement strategy document that details the condition, estimates replacement or repair costs, and breaks the areas into prioritized repair/replacement zones. The approach taken to date is to repair or replace areas in a piecemeal fashion based on annual funding allocation, however a comprehensive replacement execution strategy is preferred and should be considered when holistic revitalization made to our major support infrastructure systems (fire main, potable water, electrical distribution, sewer, etc.).

Benefit

Well-maintained roads are required for proper drainage control, safe pedestrian travel, efficient and effective fire and security emergency response, transport of materials and supplies including casks and other mission critical functions. Additionally, there are aesthetic impacts associated with well-maintained roadways and vehicle parking/staging areas that reflect the values of the organization.

Facility Risk

Most of the interior asphalt is beyond minor repairs and requires full repair or replacement. This degradation potentially increases in slips-trips-and falls, affects efficient snow removal without increasing pavement damage, is aesthetically unappealing, and will continue to degrade annually.

ROM Cost Estimate: \$15M.

4. MFC Parking Lot Maintenance

Description

MFC parking lot asphalt was replaced in FY-22. However, the project value engineered out the chipseal and repainting of the parking lot. In FY-23 the parking lot was crack sealed but still has not been chip sealed and repainted.

MFC parking lot asphalt needs include periodic maintenance to provide adequate life and protect the INL investment in the MFC parking lot. The maintenance needs include a every three-to-five-year process to crack-seal, chip, and repaint the MFC parking lot.

Benefit

Well-maintained parking lots are required for proper drainage control, safe pedestrian travel, efficient and effective fire and security emergency response, transport of materials and supplies including casks and other mission critical functions. Additionally, there are aesthetic impacts associated with well-maintained vehicle parking/staging areas that reflect the values of the organization.

Facility Risk

The INL invested significant amounts of indirect discretionary monies into the MFC parking lot. Lack of maintenance will result in premature failure of this investment and degradation will increase slips-trips-and falls, affects efficient snow removal without increasing pavement damage, is aesthetically unappealing.

ROM Cost Estimate: \$6M.

5. MFC Communications Network Infrastructure Maintenance

Description

MFC Network Infrastructure includes:

- Fiber-optic cabling, copper-wire cabling, network hardware (patch panels, servers, switches and associated communications rooms) for data computation, system monitoring and control, and alarm reporting
- Voice over internet phone (VOIP) and analog phone lines and hardware
- Fire alarm communication equipment
- WiFi internet equipment
- Cellular phone service equipment.

Much of the common infrastructure (mainlines) have been updated to provide high speed/volume capability. What remains is the update of the network infrastructure internal to the buildings/facilities themselves. For example: the majority of facility/building internal network cabling is Cat 3 which is not capable of adequate communication over the cloud of existing base computer programs, much less higher functioning programs that perform computation or have advanced graphic requirements. If the internal network cabling within the facilities/buildings were replaced with Cat 6a (current recommendation), it would provide decades of acceptable performance (ten times the speed and capacity of current data flow). Modernizing the network infrastructure becomes more urgent as technology advances, reliance on cloud based capability increase, and communication, cyber security, and data management demands accelerate.

Benefit

By performing the above improvements, sustainability of current infrastructure needs will be met, and it will facilitate expansion of the MFC network to accommodate future growth of projects and facilities. Replacing equipment and infrastructure will improve the performance (speed and capacity), reliability, and serviceability of the network.

Facility Risk

In some buildings, if updates are not made to the current components, maintenance will become increasingly difficult. When replacement parts are no longer available, restoring network service quickly will become difficult. Finally, if network revitalization is not implemented:

- Network performance will stagnate
- Innovation will be stifled
- End user expectations will not be met.

Cost Estimate: \$1M annually with outyears being \$20M.

6. MFC-781 Warehouse – Loading Dock Reorientation

Description

MFC warehouse loading and unloading truck traffic impacts emergency, security, and general traffic flow. The MFC East Gate was completed in 2021 and is now fully utilized as the primary entry/exit location for maintenance equipment, delivery trucks, construction vehicles and equipment, emergency response ambulance and firetrucks, and security vehicles. Typical delivery vehicles are full-size tractor/trailer (semi-trucks) that back into the loading dock to off-load their fare. Currently, we average 120 ingress/egress events through the East Gate daily. The number of events is likely to increase with expected construction at MFC going forward.

When offloading to the MFC warehouse delivery trucks execute a three point turn to back into the loading dock. When unloading these trucks are pointed north/south which is perpendicular to the ingress/egress road. While maneuvering into position these large trucks effectively block the ingress/egress road for general traffic and force security and emergency response vehicles to execute coordinated drive-arounds to respond to emergent situations. Additionally, there are two additional problems that need correction associated with the warehouse loading dock. Water has been accumulating in front of the dock for years. In the winter, this water freezes making truck offloading and pedestrian travel more hazardous. The original loading dock has spalled and cracked in many locations and has antiquated hydraulic lift mechanisms that require significant maintenance to maintain them functional.

Benefit

A redesigned loading dock would eliminate the need for trucks to maneuver and park perpendicular to the road, correct the water pooling situation, and would modernize the material handling hydraulic system. Overall, this effort will greatly increase the efficiency and safety of emergency and security response and daily ingress/egress of commercial traffic through the East Gate.

Facility Risk

Emergency and security response timeliness may be affected if trucks are in the process of maneuvering for offloading. The volume of traffic flow through the gate has exponentially increased the probability of general traffic being adversely impacted by delivery truck maneuvering. Age, degradation, and pooling water continue to adversely affect the functionality of the current loading dock.

Estimated Cost: \$2.5M (class 5 estimate has been performed).

7. MFC Office/Space Maintenance

Description

New support infrastructure and revitalization of existing office space is required to replace aging and less than adequate modular structures exceeding capacity to house existing staff and projected growth of onsite researchers and support staff. The new administration building, planned west campus office building and future proposed consolidated mock-up, engineering, and testing facility provide, or will provide needed expansion of onsite offices and labs needed to support the research mission. Planned revitalization of the current office and administration space is critical to maintain the research campus in a modern and efficient capacity. This area will provide annual targeted revitalization of existing space and limited expansion in areas where there is an inadequate footprint such as the need for additional TREAT office space to support mission growth.

Benefit

Revitalization of existing office space reduces the need for construction of new space by providing more modern offices and amenities, increasing satisfaction of staff housed in aging facilities and contributes to operational efficiency.

Risk

Many of the office buildings are decades beyond their intended design life. For example, MFC-717 (currently at 107% capacity) was acquired in 1985, MFC-713 (98% capacity) was acquired in 1978. There are also numerous unplumbed smaller trailers such as MFC-TR-56 (98% capacity) and MFC-TR-57 (81% capacity), located at MFC in the mid-2000s that were originally leased and used by the Idaho Cleanup Project contractor to support operations at MFC. None of these facilities was ever intended to provide long term permanent offices for MFC personnel and do not have internal bathroom spaces. This requires the provision of additional temporary bathroom trailers (comfort stations) for tenant use. Most of the large modular offices are in a degraded condition.

ROM Cost Estimate: This is proposed as annual incremental investments between \$1.0M and \$2.0M annually.

8. MFC-767 EBR-II Cathodic Protection Restoration

Description

A new impressed current cathodic protection system for MFC is needed to limit potential external corrosion to direct-buried metal structures and piping at MFC. Through decontamination and demolition (D&D) efforts conducted over the past two decades associated with shutdown of the Experimental Breeder Reactor (EBR)-II reactor and associated support systems, the originally installed MFC cathodic protection system has been rendered inoperable. The cathodic protection system is needed to accommodate all buried metallic materials at MFC with the exception of the steel liners at RSWF (Radioactive Scrap and Waste Facility), which are provided with their own cathodic protection system.

An impressed current cathodic protection system was installed around the perimeter of the EBR-II in 1969 with supplemental anodes installed in 1980 – 1981. Each of the installations included a dedicated transformer rectifier. Test stations and stationary zinc reference electrodes were positioned around the outer circumference of the unit and used for monitoring electrical potentials to verify the adequacy of protective current output. This system provided cathodic protection to all buried MFC metal structures and piping. The two rectifiers specific to EBR-II are no longer on site and it does not appear that any form of impressed current cathodic protection is being afforded to MFC either at this time or in the recent past. There has been significant construction work at MFC, and it is reasonable to assume that any buried conductors (i.e., positive and negative header cables as well as anode lead wires) have been impacted by excavation and are no longer intact.

With the exception of RSWF, MFC does not have a current functioning cathodic protection system for buried piping or other metallic structures in contact with the soil. The previously installed impressed current cathodic protection systems are no longer operating, and all equipment associated with the past cathodic protection system is no longer effective.

The soils at the north and northwest of EBR-II are classified as slightly to moderately corrosive to carbon steel residing between grade and 15-ft below grade. If conditions such as stray current or galvanic (dissimilar metal) corrosion exist, increased corrosion rates would be expected.

Benefit

A new cathodic protection system would provide corrosion protection to current underground utilities, increasing the life of the systems and reducing costs for piping replacement. Additionally, cathodic protection is critical for ensuring the longevity and integrity of direct-buried metal structures such as EBR-II.

Facility Risk

Without the installation of a new cathodic protection system the increased corrosion rates would cause the underground metallic structure of EBR-II as well as underground metallic piping to corrode to the point of needing replaced which would be very extensive, costly and would adversely impact MFC missions. Additionally with plans of installing the new NRIC DOME reactor project in EBR-II it is crucial to maintain the structural integrity of the structure.

ROM Cost Estimate: \$4.5M.

9. MFC Fire Protection and Potable Water System Piping Replacement

Description

The MFC Fire Protection and Potable Water System has approximately 1.2 miles of underground piping and two deep well pumps that were installed as part of the original EBR-II infrastructure in the 1960s. This piping is cast iron and is approaching the end of its service life as demonstrated by recent piping failures (4) in the past 15 months that have cost over \$2.5 million to replace.

Forensic inspection is warranted to identify a preferred path consisting of select maintenance of certain sections or components or complete replacement of all 1960s era main lines (approximately 6000 ft.), 2 deep well pumps, 50 system valves, approximately 15 hydrants and building service lines. This action is proposed to alleviate the realized risk of service water delivery upsets for infrastructure and nuclear facility potable water, building HVAC systems, industrial and research process water, purified water supply, and fire protection.

Benefit

Replacement of the end-of-life piping will provide many facilities with an improved reliability for the potable, industrial and firewater systems. Many facilities utilize potable water for processes and building cooling that is essential to keep the facilities operational. Replacement of valves will allow reliable outages for future connections and maintenance activities as well.

Facility Risk

If we do not act, we will continue to see facility and mission impacts through piping failures. These unpredictable failures lead to long outages, substantial flooding, and very high repair costs.

ROM Cost Estimate: \$1.0M to \$2.0M annually with an outyear \$16 million (based on the 2021 cost of approximately \$1.2 million for 500 ft of piping for 713 water main project, recent hydrant, and PIV replacement, and \$1 million for the replacement of each deep well pump).

10. MFC-786 Substation Maintenance

Description

The MFC-786 substation was constructed in 1971 and has seen little revitalization other than required maintenance since original installation. This substation provides the main feeds for HFEF, FCF, and FASB. For several years, the substation breakers have not been supported, replacement breakers are unavailable, and spare parts are difficult to procure. Rotating breakers during preventive maintenance allows for reduced outage time during maintenance but also introduces challenges in configuration management. A significant risk exists in the event a component within the breaker fails while in use or in testing while a replacement part is unavailable. Additionally, the south transformer has developed a significant oil leak. The original transformer manufacturer no longer supports this equipment and spare parts are unavailable. Quarterly oil sample testing results have come back with high levels of flammable gases which indicates possible internal arcing. This arcing reduces the life expectancy of the transformer and increases potential reliability issues through internal faults.

These aging components are causing significant maintenance issues and require increased costs in personnel time, maintenance testing, and replacement parts.

Benefit

Replacing the substation with loop fed sectionalizing switches and dedicated transformers would provide for a much more robust and reliable utility distribution system. Supplying the dedicated transformers with these 480V double ended feeds would provide system redundancy and alleviate the need to take down facilities during maintenance, which would in turn reduce facility down time during planned maintenance and unplanned faults.

Sectionalizing switches require less maintenance as recommended by the manufacturer compared to circuit breaker operated switch gear. This would reduce the cost by reducing the amount of personnel time required to maintain the equipment. Sectionalizer switches also greatly reduce arc flash hazards.

Facility Risk

Providing clean reliable energy to nuclear testing facilities is fundamental in ensuring important milestones can be met. Unreliable energy sources can cause increased facility down time as well as potential safety concerns due to extensive maintenance requirements. The current distribution system is becoming more unreliable and will eventually fail. This revitalization would provide a more reliable and robust system which could be depended upon for future expansion capability.

ROM Cost Estimate: \$25M.

11. MFC-752 Substation Repair/Replacement

Description

The MFC-752 substation consists of two 1500kVA transformers and dual bus switchgear with normal and alternate feeds. This substation was installed in 1979 and is rapidly approaching the end of life. The original manufacturer no longer supports this equipment and spare parts are hard to find. This substation provides power for multiple facilities including: MFC-701, MFC-717, MFC-737, MFC-752, MFC-791, Radio Chemistry Laboratory (RCL) MFC-1702, and the Analytical Laboratory MFC-752AL.

A significant issue with replacing the MFC-752 substation is the down time and the extensive coordination required for the changeover. The substation is in the basement of MFC-752 and there is insufficient space to install a redundant substation, perform testing, and then changeover to the new substation. Therefore, an extended outage may be required.

Additionally, MFC-752 has water intrusion issues. The conduits that enter the substation from the south wall of the building are not sealed properly and need repair. This may require excavation on the outside of the building.

Benefit

Replacement of the substation will ensure commercial power does not fail at RCL, Analytical Lab, and eight additional nuclear and support facilities. This will also ensure National Electrical Code compliance. Repairing the conduits will ensure that water is prevented from entering the facility and damaging electrical equipment in the basement of MFC-752.

Facility Risk

Providing clean reliable energy to nuclear testing facilities is a fundamental principle in ensuring important milestones can be met. Unreliable energy sources can cause increased facility down time as well as potential safety concerns due to extensive maintenance requirements. The current distribution system is becoming more unreliable and will eventually fail.

ROM Cost Estimate: \$15M.

12. Re-Establish Western Loop of Main Road Inside MFC

Description

The southern loop of the western-most north/south roadway was eliminated when multiple trailers and associated temporary electrical distribution equipment were set in place to facilitate the installation of temporary office modular trailers. This loop is still required for normal maintenance, construction, and emergency/security response. A self-guided work-around path has been established up and over the abandoned-in-place basement foundation of the legacy MFC-766, Sodium Boiler Building (SBB). It requires turning driving over permitted ditch culverts not designed for this traffic. Much of the area above the legacy SBB is likely to be utilized for micro-reactor support buildings and construction laydown.

This loop road is also imperative to access the water fill station for emergency response, construction, and maintenance water trucks. Currently, water trucks inside of MFC are being filled from fire hydrants that causes significant water-hammer shock to the fire protection water system when the fire-pumps automatically start on low pressure. Access to a fill station that fills from a large tank will remove that repeated water hammer of the fire main piping.

Benefit

Re-establishing an engineered south-west loop will allow safe and redundant traffic paths for normal, maintenance, construction, and emergency/security response vehicles. It will also allow easy access to the water fill station eliminating un-necessary shock to the service water system and free up access to support buildings associated with micro-reactor projects in MFC-767, EBR-II Dome.

Facility Risk

The MFC service water system has ruptured 4 times in the last 3 years causing considerable damage to SSCs and significant cost of repair to the system itself and related structures and components. The likelihood of continued failure remains high if there is no access to a system that fills from a reservoir. Access to the area above the SBB will continue to be encroached upon by traffic over a non-designed roadway.

ROM Cost Estimated: 4M.

13. MFC Storm Drain System Maintenance

Description

The MFC storm drain system needs to be modified to properly operate. As MFC has grown with new structures, proper storm drain elevations were not required and the system is in a state that does not effectively clear storm water and snow melt out of MFC.

The proposed modification would provide for grading improvements to direct run off to appropriately designated collection areas that would include engineered catch basins and covered culverts instead of the current open ditches. MFC storm drain system currently consists of approximately 2000 ft of large open ditches. When replaced with culverts this will allow increased use of the limited space at MFC.

Benefit

This maintenance will protect nuclear, radiological and infrastructure facilities by properly routing water away from buildings and off site. Site aesthetics will be greatly improved by this effort.

Facility Risk

The main risk is continued and worsening water intrusion to nuclear, industrial, and administrative structures and flooding during heavy rain events and spring snow/ice melt off.

ROM Cost Estimate: \$20 million execution would include \$1.5M average annual incremental funding.

14. MFC Sanitary Sewer System

Description

The MFC Sanitary Sewer System is comprised of 2500 ft of clay and cast-iron building drain lines, lift stations, and sewer piping mainlines that combine to exit the site and flow into the evaporative lagoon system. All buildings except TR-65 and SPL are part of the MFC sewer system that is at least 50 years old. All recent remodels of structures that contain bathroom facilities that have disturbed the sewer systems have required replacement of the piping (badly eroded yielding years of sewer leaking to ground under the buildings and out to the main lines).

Benefit

Replacement of failed system components will allow the system to operate as designed and not dump waste directly to ground. It will also eliminate untimely piping failures that are difficult to repair (particularly in the winter).

Facility Risk

If we fail to act, piping will continue to fail requiring unplanned repairs that are costly, untimely, and unfriendly to the immediate work environment.

ROM Cost Estimate: \$10M.

15. MFC Industrial Waste System

Description

The industrial wastewater system was first installed in the 1970s and includes ~1500 ft of asbestos cement underground piping, and about the same linear footage of open ditches. 300 linear feet of asbestos cement piping were recently uncovered during construction and the entire length of the underground piping has failed (cracked and caved in) and is being replaced. Any remaining underground piping has likely failed and will need to be replaced as well. The lift stations are antiquated and frequently requiring repair and should be replaced. The industrial wastewater system combines with the stormwater drain system and exits MFC on its way to the Industrial Waste Pond. Industrial waste permitted ditches are monitored for flowrate and constituent concentrations. The flume and sample testing system are being updated under its own project. The industrial waste pond receives storm water in addition to industrial wastewater and is functioning properly.

Benefit

New lift stations and piping systems will improve flowrates and increase the accuracy of monitoring and reporting. Effluent will not be escaping underground to locations that are not monitored.

Facility Risk

If the system is not brought up to date and include replacement of existing failed piping/lift stations, unregulated exposure to the ground could cause non-compliance with our permits and lead to DEQ fines.

ROM Cost Estimate: \$10M.

16. MFC Roofing Replacement

Description

MFC and INTEC facilities include more than 534K square feet of roofing consisting of 232 independent roof sections. Many of these critical roofs leak which introduces mission and personnel safety risks.

Through the DOE Department of Technical Assurance Roof Asset Management Program (RAMP) the FY-20 replacement value of the 232 roof sections was estimated to be over \$34 million dollars before being normalized to INL and current supply chain costs.

Currently, the RAMP database categorizes approximately 68% of the roof sections at MFC and our INTEC facilities to be in failed or poor condition. Most of the roof sections in these categories are on our mission facilities.

Roof maintenance should be prioritized across all MFC managed buildings and funding allocated to systematically repair or replace the roof sections.

Benefit

Well-maintained roofs are required for safe and efficient operation and to enable MFC critical mission objectives. Clean and dry facilities are also critical for the safety of staff, equipment, materials, and research activities including properly packaged nuclear and radiological materials and waste. Additionally, an aesthetic impact is realized when facilities do not leak water, contributing to our ability to attract top research candidates to our Lab and MFC.

Facility Risk

Data shows that 68% of roof sections inside MFC need immediate repair or replacement. Most of the sections in the “failed” to “poor” categories are on mission driven facilities or critical infrastructure facilities. Unaddressed roof degradation affects day-to-day operations, degrades underlying building structure, and could affect mission critical instruments and ultimately mission accomplishment.

ROM Cost Estimate: \$20M.

17. MFC Security Entrance Gates

Description

MFC North and East entrance gates were added in FY-22. However, the projects have proven to be unreliable and have impacted mission and Emergency response on numerous occasions. In FY-23 there were numerous repair efforts, but it has become evident the significant repair or replacement are required to ensure the reliability of the entrances to MFC.

Benefit

Well-designed and maintained entrance gates are required to provide secure, safe, and effective vehicle ingress and egress into MFC. Additionally, there are real emergency impacts associated with well-designed and maintained entrance gates that impact the general public and reflect the values of the organization.

Facility Risk

The INL invested significant amounts of indirect discretionary monies into the MFC entrance gates. They have proven to be unreliable and maintenance heavy systems. Lack of proper installation and maintenance will result in premature failure of this investment and degradation will impact Security, and Emergency operations at MFC.

ROM Cost Estimate: \$2M.

18. MFC Electrical Distribution System

Description

Currently the MFC Electrical distribution system is not installed in a loop system. The scope of this project would be to replace and reroute aged wiring that is beyond its design life. Additionally, some transformers would be replaced with sectionalizer switches.

Benefit

Well-designed and maintained electrical distribution system are required to provide secure, safe, and effective power to all MFC facilities. Additionally, there are mission impacts every time required maintenance is performed on the distribution system which would be mitigated with the upgraded distribution system.

Facility Risk

The MFC electrical distribution system has numerous parts that are beyond designed life. Additionally, failure to invest in a system upgrade will continue to impact MFC missions every time required maintenance is performed. Proposed new projects will increase the loads on the antiquated system which increases the risk of failures to occur.

ROM Cost Estimate: \$6M.

19. Treat Modular and Utilities

Description

New mission demands of TREAT and the reactor projects require more office space and utilities for the additional staff that have been hired. The scope includes a modular office building, new septic system, and water, power and fiber utilities.

Benefit

Well-designed and maintained facilities are required to provide secure, safe, and effective space for TREAT staff. Proposed new projects will increase the positive impacts on the TREAT staff and the TREAT mission.

Facility Risk

The new research projects at TREAT would be negatively impacted without new office space for staff. Additionally, failure to invest in a facilities upgrade will continue to impact MFC and TREAT missions and staff and could potentially delay missions.

ROM Cost Estimate: \$2.2M.

20. MFC 752 Life Extension and HVAC Replacement

Description

MFC U&IS Facilities are aged and much of the heating ventilating air conditioning (HVAC) equipment is antiquated and significantly degraded to the point that repair is extremely cost prohibitive. MFC U&IS has prioritized six (6) HVAC Systems in two highly populated and one continually manned facility: MFC-752 L&O, MFC-753 U&IS & MFC-725 Fire Station II. The HVAC equipment is not reliable, when running, equipment cannot physically keep up with the demand, especially during extreme heat or cold periods. Due to the age of the equipment and the refrigerant type (R-22) repair or like for like replacement is very difficult and extremely expensive. U&IS Department has developed an HVAC replacement strategy document that details installation of a transition facility, individual area engineering requirements, and estimates replacement costs. The approach taken to date is to continue to repair the equipment, however a comprehensive replacement execution strategy is preferred and should be considered.

Benefit

Reliable HVAC equipment is paramount especially with projected growth MFC is anticipating over the next five years. Being able to keep and maintain U&IS Facilities in a tenantable condition, managing interior space temperature so that tenants can be focused on missions and not concerned about being too hot or too cold.

Facility Risk

HVAC equipment has reached and is beyond its useful life expectancy and should be replaced. Not being able to maintain facilities in a tenantable condition adds stress on the population which ultimately affects MFC Mission.

ROM Cost Estimate: \$12M.

Appendix C

Detailed Descriptions of Instrument Capability Activities

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1. Fission Gas Mass Spectrometry

Description

The gas mass spectrometer (GMS) provides sensitive and precise measurement of permanent gas species. A static sample introduction system allows for grab samples of gases taken from other locations to be analyzed in the Analytical Research Laboratory (ARL), even if the sample is extremely small or at low pressure. During analysis, gas species are ionized using an electron impact source and separated by their mass-to-charge ratio in a magnetic field. Detectors used in these instruments have been shown to be extremely linear over their detection ranges with fairly high sensitivities. This allows species to be reported as their mass-to-charge ratio or by the element's isotopic composition. The analysis and reporting of gaseous species mass-to-charge ratio is not possible by any other instrument currently employed in the ARL. Further specificity in the instrument design can provide multi-collection (MC), increased sensitivity, high resolution, dynamic range, and/or increased sample type (organics, entrained gases, semi-permanent gases) capabilities in addition to those listed above.

Benefit

The major benefit of a new instrument is an increase in the reliability of our current analytical capabilities. A new MC-GMS will provide a capability that the laboratory does not currently have by allowing for high-precision isotopic ratio measurements of noble gases. Isotopic data of fission-produced gases can provide a range of information on the process and environment in which they were generated. The proximity of the ARL to the Hot Fuel Examination Facility (HFEF) also provides unique analysis opportunities for gases generated during nuclear fuel irradiation and captured using the GASR instrument in HFEF's hot cells. In addition, the ARL will be able to accept work that has previously been performed at recently decommissioned laboratories within INL, such as the Analytical Laboratory at RWMC.

ROM Cost Estimate: \$2.65M.

2. Multi-program U/Pu Synthesis Glovebox (Multi-Function Glovebox)

Description

There is currently a need to synthesize multi-Kg quantities of uranium-based fuel and plutonium-based fuel for demonstrating and testing different reactor concepts. In fact, fuel production is a key need for supporting nearly all reactor demonstration projects being considered for placement at INL, however there is no available glovebox space to meet this need. This request proposes to revise an existing plutonium glovebox conceptual design and procurement specification to incorporate multi-purpose furnace wells for general purpose, initiate the procurement, start the facility modification design, perform the necessary facility and safety basis modifications, and to install the gloveboxes. The capability could potentially serve production of any fuel type other than TRISO particle fuel. This investment would establish the glovebox capability; program-specific synthesis needs would be established in the future. With this glovebox available, any follow-on program would need to address only their specific fabrication and synthesis needs by installing the production components, consumable materials, handling equipment, and furnaces required to meet their fuel specification.

Benefit

The vast majority of industry reactor designs, proposed NASA concepts, proposed DARPA concepts, and designs originating from national laboratories require engineering-scale, campaign-style synthesis of significant quantities of their fuel for testing and demonstration. There is a gap between the DOE and industrial infrastructure to provide this capability. Pu capability is unavailable for this purpose, and capability for U over 5% enrichment is extremely limited. Installing the proposed multi-purpose glovebox

shell would fill this gap in the near term. With planning and coordination, the glovebox would meet both uranium and plutonium needs. Future partners working under the NRIC framework, GAIN, NASA, DARPA, or the upcoming DOE Demonstration Reactor FOA would benefit through substantial schedule improvement, reduction in overall project risk, and reduction in cost uncertainty. In most cases, this would contribute to an estimated 2-year reduction in the time to demonstrate these critical experiments and reactor concepts.

ROM Cost Estimate: \$6.4M.

3 AFF High Temperature Furnace

Description

Fuel is one of many essential elements of a reactor demonstration but is unique because the facilities to manufacture are both very limited and can be prohibitively capital intensive to establish. Other than modest quantities of TRISO and LALEU UO₂, MFC has perhaps the only facilities in the U.S. that can produce even a single sample of the broad diversity of fuels being pursued by reactor developers. Even to reproduce MFC's limited pilot or demonstration fuel fabrication capabilities would cost time and money outside the scope of even the largest ARDP programs, let alone the various smaller microreactor or more preliminary concepts. Instead, developers continue to seek to leverage MFC facilities and expertise for this activity, yet for anything more than a modest demonstration MFC is limited by furnace capacity. Our laboratory furnaces are small, in some cases not even big enough to handle the smallest fuel article of interest, and otherwise can only process a few grams of fuel per run (which may range from a few days to weeks), so even planning 24/7 operations has in the past been schedule prohibitive.

This item includes both a furnace and an inert atmosphere glovebox that will house the furnace, and is scheduled to be deployed in AFF in late FY-24.

Benefit

This furnace will result in diverse opportunities for INL, that have and will continue to come up routinely. The impact will benefit advanced nuclear development in general. This supports pilot scale testing, development, and development of fuel fabrication and instead reduce the substantial risk that comes with building a Hazard Category II facility and the first-of-a-kind manufacturing process inside it at full scale. Smaller microreactor programs, such as MARVEL, will continue to see their only U.S. manufacturing operation consist of INL conducting years of 24/7 operations pulling a few grams at a time out of laboratory-sized furnaces. Developers with uniquely large fuel items will continue having no viable option for even making a single fuel article for demonstration or irradiation testing. MFC will continue to have only a limited opportunity to pursue UO₂ engagement, even with compelling INL-invented UO₂ innovations.

ROM Cost Estimate: \$1.5M.

4. FASB HIP Upgrade

Description

A new HIP is being pursued to allow for expanded fuel fabrication capabilities. This HIP features a graphite furnace capable of up to 2200°C which can be interchanged with a tungsten furnace capable of up to 1900°C and a wider range of atmospheric conditions.

Benefit

The HIP previously housed in FASB was removed in FY-23 as it had outlived its useful life and was no longer functional. This item adds hot isostatic pressing as a capability to the MFC fuel fabrication portfolio.

ROM Cost Estimate: \$700K.

5. NRAD Imaging System Upgrades

Description

These upgrades include materials (e.g., optomechanics, shielding materials, camera box architecture) and labor for scientific design, engineering design, fabrication, installation, testing at NRAD, and qualification of the system for programmatic use. There are two imaging systems that will be established through this investment:

1. High-resolution nCT system covering a 3 cm field of view (FOV) and target ~20 μm resolution.
2. Interchangeable FOV digital imaging system including 10 cm, 20 cm, and 60 cm FOVs.

These two nCT systems provide capabilities that span the highest possible resolution to the largest possible FOV using NRAD's beams.

Benefit

Funding corrects capability gaps, namely by providing digital neutron imaging systems that accommodate a wide range of sample sizes and spatial resolution requirements to meet INL and DOE mission needs.

Potential users (e.g., INL Programs, University partners, other national laboratories, and industrial collaborators) keep asking if existing neutron computed tomography (nCT) capabilities can accommodate their applications. While the existing digital nCT system can accommodate many users' applications, others with significant scientific and mission-significant impacts are missed. This investment would provide capabilities that address scientific and material qualification programs that are currently left unanswered.

ROM Cost Estimate: \$1.25M.

6. HFEF 2nd Manipulator Repair Glovebox

Description

This will be a second glovebox to address maintenance on the manipulators in HFEF. It is functionally equivalent to the current repair glovebox.

Benefit

The existing slave manipulator repair glovebox/containment is limited to the number of remote manipulators it can accommodate. The addition of a new repair box will increase maintenance capability to increase the number of remote manipulators available for replacement, thereby decreasing facility downtime and increasing R&D productivity.

ROM Cost Estimate: \$2M.

7. Upgrade NRAD North Beam Shutter to Include Aperture and Filter Drum

Description

Replace the current neutron beam shutter of NRAD's north neutron beam. The new shutter will be more robust to attenuate the neutron beam to nearly-zero when closed and include a filter drum and wheel to condition the neutron beam. Radiation transport modeling will inform the geometry and materials of the new shutter, and engineering will address the structural, motion, control system, and interlock issues. The materials will be purchased, and components fabricated according to the designed specifications and installed. Beam parameters (e.g., neutron energy & flux, gamma content) will be measured before and after installation of the shutter.

Benefit

This will enhance the NRAD beam line capabilities to support higher resolution and mission support efficiency.

ROM Cost Estimate: \$1.3M.

8. Oxy-Gon Hot Press Furnace

Description

Multiple programs are increasingly interested in studying material interaction experiments and characterizing material behaviors. Existing static jigs used to maintain sample pressure during heating are inadequate and cannot accommodate thermal expansion of the samples. A hot press furnace equipped with the ability to apply a consistent pressure on samples during heating is a far superior approach to this kind of experimentation. In addition, INL is experiencing an increase in demand for furnaces. This combined with supply chain and repair issues leads to numerous situations in which there are not enough furnaces for the current and expected workload. This furnace expands on research capabilities, powder manufacturing techniques, and provides redundancy to further help relieve demand for existing furnaces. This furnace is in addition to the "red devil" replacement furnace that has already entered the procurement process. This equipment was purchased in FY-23 but was damaged on delivery, and the cost estimate below is for repair and remaining installation costs pending recovery of damages from shipper.

Benefit

The benefits of this system include improving process efficiency for diffusion couple testing by eliminating steps in the experiment assembly process. This system provides redundancy for high temperature testing of materials in a controlled atmosphere environment, improving the ability to meet multiple programs goals. This versatile system is also of interest for a variety of programs as an efficient alternative for small-scale powder manufacturing applications. Hot pressing methods improve the handling and manufacturing of ceramic, metal, and composite materials that utilize powder feedstock. Hot pressing can produce higher density samples than the cold-press and pressure-less sintering methods currently used.

ROM Cost Estimate: \$250K.

9. EFF Radiological EDM Capability Upgrade

Description

As the existing EDM continues to serve as a workhorse for many programs, its continued use increases the chances of it failing to a point beyond repair. Procurement and installation of a new wire EDM (electrical discharge machine) with fourth axis, and disposal of existing wire EDM. The existing wire EDM system has outlived its useful life and is experiencing more downtime requiring FFNMM staff to adapt on the fly to troubleshoot and repair the system or consider alternative processing schemes. The nature of the radiological work performed within the EDM precludes significant maintenance activities given the equipment is contaminated itself and also that it resides within a contamination area. That is, refurbishment or any repair beyond basic repair is not a viable option for the current EDM system.

Benefit

This is a critical capability for which there is not an available substitute for approximately 90% of the work performed on it. The majority of metal fuel development and fabrication efforts utilize the EDM as does a majority of space propulsion research efforts for processing of its fuel forms. If a replacement EDM is not installed there is a significant risk of being unable to perform research and development in support of these major programs, among other more incidental work.

ROM Cost Estimate: \$700K.

10. CNC for Experiment Disassembly and Sample Preparation Throughput Increase at Window 3M

Description

This will address procurement and in-cell installation, including engineering modifications and qualification, of a computer numerical controlled (CNC) device.

Current experiment disassembly and complex-geometry samples are achieved with the use of a manually operated conventional mill. The current system relies heavily on operator skills; hence it is time consuming and more prone to errors that could jeopardize the integrity of the experiments.

Benefit

The upgrade of the equipment to a CNC-based machine would remove some of these hazards and increase throughput exponentially. DOE fuel qualification programs, NNSA fuel qualification programs ARDP awards, DOD material qualification programs, work-for-others contracts are current and potential customers that will benefit from this capability upgrade. This replaces labor-intensive and error-prone equipment and will support increasing demand and timeline acceleration requested by the customers.

ROM Cost Estimate: \$1M.

11. AFF Spherodizer

Description

A TEKNA 15 Plasma Spherodizer is being pursued through the aLEU program to be deployed in AFF. This system allows for processing of powder fabricated via atomization to be post-processed and improve powder sphericity and consistency.

Powder spheroidization is a process in which coarse or irregularly shaped powder is melted and re-solidified in flight to produce spherical particles. Many powder production methods such as crushing/milling or hydride-dehydriding of uranium result in inconsistent particle geometries, which can lead to defects in consolidated materials. Even processes, such as atomization, that produce rounder particles can have a significant yield of irregular particles.

Benefit

The ability to process angular, rounded, or otherwise non-spherical powder into spherical form supports multiple fuel fabrication techniques. From pressing powder into pellets for sintering, to providing high-quality feedstock for AM techniques, to providing equivalent high quality powder for SPS applications, many fuel processing schemes rely upon powder feedstock. The unique nature of fuel research requires powder feedstock to be created and processed in-house. This equipment complements the existing small scale atomizer located in FASB and also the gas atomization system being installed in EFF.

ROM Cost Estimate: \$650K.

12. 2/4Hi Combination Rolling Mill

Description

A combination 2/4Hi rolling mill is being pursued by the aLEU program for installation. This rolling mill allows for fabrication of fuel concepts with geometries not easily made through powder metallurgy processes alone.

This item is currently funded by the aLEU Program.

Benefit

Procurement and installation of this system represents both a capability addition and a more efficient utilization of highly valuable radiological facility space by allowing the removal of the FASB rolling mill and associated plate furnace. This equipment improves efficiency of developing rolling methods by providing versatile operation modes with a reduced footprint that can be accommodated into a dedicated programmatic space. The combination mill adds the ability to switch between 2Hi and 4Hi modes. Other additional capabilities, such as heated rollers and digital controls with additional sensors and feedback, improve the reproducibility of the process. The heated rollers will also improve the rolling efficiency by reducing the reheating required during the process and minimize the impacts the stress induces in the rolled material.

The implementation of a combination rolling mill in AFF provides more flexible operation and enable versatility in the application. This equipment could also be used for programs such as HPRR and other advanced fuel form development programs.

ROM Cost Estimate: \$850K.

13. AFF Sodium Room Upgrade

Description

The former sodium storage room in AFF is being refurbished and upgraded under the aLEU program to support program-specific fuel needs. This activity includes adding key infrastructure and utilities within the room to allow for installation of future research equipment and other upgrades.

Benefit

This upgrade provides a discrete area tailored to specific needs that can't currently be met with existing radiological facilities. This room has recently been cleared of depleted uranium feedstock and other material with limited research uses. This space is much more effectively utilized in support of direct program research. This activity stages the area for installation of fuel fabrication equipment needed by future programs to allow MFC to effectively support their needs.

ROM Cost Estimate: \$1,000K.

14. UO₂ Precipitation Capability (1666)

Description

INL currently has no way of synthesizing UO₂ powder that is active enough to yield high quality UO₂ pellets. However, such pellets with tailored enrichments are an ever-present need for the ATF program and others, particularly with TREAT restart and the I-Loops in ATR coming online. We can use commercial powder, but not in enrichments > 5%; or more highly enriched powder from our inventory, but that yields poor quality pellets. Even enrichments lower than 5% are produced commercially at only a handful of specific enrichments, and is only practically available for purposes specifically aligned with the supplier's priorities. MFC has made outstanding strides in just the past few months creating world-class pellets from commercial powders, and UO₂ precipitation has been the industry standard way of synthesizing ceramically active powder over many decades. There already exist a number of programs that can take advantage of this capability immediately.

Some synthesis efforts have already been successful at CFA supporting fuel recycling activity, but they were not intended nor optimized for ceramic processing and have not yielded satisfactory pellets. These efforts and the work that underlies it will be extended to establish a dedicated fuel fabrication capability focused on powder with the properties needed for ceramic processing. The equipment is simple and the planned scale will provide multi-kg capabilities.

Benefit

Our commercial powder supply is very limited in quantity and enrichment and has contractual restrictions. When that powder is not available, we'll likely not be able to sinter high-quality UO₂, and they will likely continue to contain bulk defects (cracks, delaminations, etc.) that limit their utility and applicability.

ROM Cost Estimate: \$300K.

15. JOEL Benchtop SEM (1674)

Description

This is a basic-capability SEM to complement the full-size JEOL JSM IT500HR SEM already in use in FASB. It replaces (or supplement, pending space availability) the FASB Phenom, which supports nearly all of the research programs our division contributes to and provides critical data for innumerable scientific publications. While the full-size SEM provides higher quality images and data, it is used heavily and frequently has a deep sample backlog when the basic imaging quality of a desktop SEM is sufficient. The Phenom has dutifully filled this role for years, but is approaching obsolescence and is frequently unavailable. It requires frequent repairs with only limited vendor support available.

The proposed microscope also offers a low vacuum feature not shared by the existing Phenom, allowing examination of non-conductive samples without coating and offering an even faster option for such samples. Finally, it features a modern software suite with features that are now common even in such basic SEM imaging devices, such as integrated data management and archiving, topography mapping and depth information, etc. This rapid-turnaround imaging capability fills an important gap between optical microscopy and the full size SEM and has become a core element of our fresh fuel characterization suite.

Benefit

Samples that don't require the imaging quality of the JEOL can be transferred to other facilities for analysis with similar instruments when the Phenom is unavailable (an increasingly frequent occurrence). An estimate of the cost impact of such transfers, based on the frequency of use of the Phenom, anticipated escalated outage frequency, and average transfer costs is \$105K annually. In practice, this often isn't time-responsive to project needs and the data simply go uncollected when neither SEM is available.

ROM Cost Estimate: \$175K.

16. Improved Electronic Interface for Hot Cell Scales and Balances

Description

The balances and scales in the HFEF cells are still using the MTG. The balances and scales need an improved electronic interface with facility software to support improved material tracking in-cell.

Benefit

An improved capability to interface more directly with facility material management software will increase operational efficiency and reduce opportunities for error. The current system requires manual entry of data into the material tracking system after measurements are taken. This slows work progress and introduces risks of error.

ROM Cost Estimate: \$400K.

17. Automated Sample Prep/Dissolutions

Description

Update ARL capabilities to include automated sample preparation and sample dissolutions.

Benefit

Automatic sample preparation and dissolution capabilities increase laboratory operations efficiency and reduce the number of personnel required for these steps. This frees up personnel to run and monitor research equipment and provide data analysis.

ROM Cost Estimate: \$750K.

18. Atomic Force Microscope (AFM)

Description

There has been increasing interest in studying the surface science of nuclear materials. Because most material degradation initiates at the surface of a material, it is incredibly important to understand how these processes occur at the outermost atomic layers of the surface. This field of study has historically been very underrepresented in the field of post-irradiation examination. Within the U500 division we realized this and started to initiate a program in surface science. To advance this program a base set of instrumentation is needed and one of these is an atomic force microscope (AFM). An AFM is capable of imaging material surface topography by rastering a probe over the material. In this way it generates a 3D image of a materials outermost surface with a lateral resolution down to the atomic scale. In addition to topography there are many other modes of operation that can provide information on a materials surface electronic, magnetic, thermal, and mechanical properties within a single instrument. The addition of this instrument to INL will put us in a unique position to provide first of a kind measurements on fundamental mechanisms of material degradation at surfaces. These measurements will be of tremendous importance to the development of advanced reactors, where materials will be subjected to new environments and degradation mechanisms may change.

Benefit

With the increased rate of development of small modular and micro reactors this AFM capability is very important. Without this instrument INL will be lacking in its ability to provide data on material degradation at surfaces. This instrument will help jump start INL in the field of surface science as applied to irradiated material.

ROM Cost Estimate: \$1M.

19. Visual Mount Inspection System in the HFEF Containment Box

Description

The primary function of the containment box in the Hot Fuel Examination Facility (HFEF) is to prepare mounted ceramic or metallic samples for materialography. Materialographic sample preparation involves subsequent steps of mechanical material removal of each deformation layer from the previous step to reveal the true microstructure of the mounted material. Prior to proceeding to the next step of mechanical material removal the mounted sample must be inspected to ensure the surface finish is free of deformation from the previous material removal step and that the sample is free of preparation artifacts (i.e., scratches, smearing, edge rounding, etc.).

If the surface finish of the mounted sample is not properly inspected prior to materialography and is determined to be unacceptable during light microscopy, costly rework, scheduling, and material transfers must occur. It is estimated that each mounted sample with an unacceptable surface finish costs approximately 20 man hours of operations time to rework the preparation steps. Currently, this inspection is accomplished by the use of a Kollmorgen Model 894 Hot Cell Periscope.

Benefit

A visual system to inspect mounts during sample preparation is necessary to ensure the efficiency of containment box operations.

The Kollmorgen Model 894 Periscopes were procured and installed in HFEF in the mid-1970s. The Kollmorgen Model 894 Hot Cell Periscope has performed satisfactorily for the purpose of inspecting mounted samples, though it is experiencing intermittent failures from age and extensive use. Repairs to the periscope were completed in 2008, but the repairs have not restored full system capability.

Kollmorgen has ceased manufacturing of hot cell periscopes and a very limited supply of replacement parts is available. The inspection of mounted samples during sample preparation is key to efficient materialography operations. Failure of the Kollmorgen Hot Cell Periscope would leave containment box operations at HFEF in a vulnerable state.

ROM Cost Estimate: \$1.5M.

20. Multi-Function Furnace #2

Description

The electrometallurgical treatment process used to neutralize the sodium component of irradiated EBR-II elements includes a salt distillation step as part of the process. The Cathode Processor (CP) is 25-years old and the only means of performing this salt distillation requirement from uranium dendrite or other process materials in the FCF argon cell and is experiencing failures indicative of the end of its useful life. When maintenance needs arise, repairs to this unit must be performed remotely which results in extended treatment process downtime. The addition a second distillation capability via a new high temperature vacuum atmosphere furnace in the FCF argon cell will enable salt distillation requirements to continue when the Cathode Processor is unrepairable and will help to alleviate the bottleneck at this process step associated with higher throughput rates. Additionally, this new furnace will be designed to support expanded missions beyond salt distillation to include cladding hull consolidation, sodium contaminant distillation, as well as uranium consolidation.

Benefit

Increase in overall treatment system reliability and process rate efficiency, while expanding capability in enhancing uranium product and process waste stream disposition

Facility Risk

The single point failure associated with the current treatment system limits the rate of treatment. Past operational conditions provided some flexibility to store dendrite on an interim basis until the Cathode Processor was available, however future operating requirements will significantly restrict this capability, resulting in shutting down the process until repairs can be made.

The workload at the CP is increasing, while equipment availability has been decreasing in the recent past due to unplanned component failure related to the age of them.

ROM Cost Estimate: \$2.5M.

21. Develop NRAD Neutron Diffraction Capability in HFEF

Description

This project designs and installs a neutron diffraction system that will quantitatively improve irradiated material characterization. The diffractometer will be installed at NRAD (Neutron Radiography reactor) north beam line.

Benefit

Neutron diffraction is a powerful tool that is complimentary to e-beam methods for the characterization of nuclear materials. At the INL, advanced microscopy techniques are used to characterize the crystal structure of irradiated nuclear fuel and materials. These methods provide detailed microstructural information on a very small sample, but require difficult sample preparation. Neutron diffraction provides more precise information on lattice parameters, atomic positions, and the stress state in a bulk material. Neutron diffraction and data analysis can generally be conducted in less time than electron microscopy.

The use of neutron powder diffraction at NRAD has the potential to significantly enhance the basic and applied science of nuclear fuels for current DOE programs as well as scientific and commercial customers.

The capability for neutron (or x-ray) diffraction of high activity materials and irradiated fuels does not exist in the United States, and only at a few places in the world. Current neutron diffractometers rely on high flux sources (the HFIR and NBSR reactors and the SNS, for example) at user facilities that do not accept high activity materials or fuel. Since neutron flux at the sample location of NRAD north beam line is low relative to these reactors, a polychromatic (white) beam diffraction approach has been selected in consultation with neutron scattering scientists at ORNL and MIT. The use of a white beam provides many diffraction events simultaneously and uses an analyzer crystal to select the specific neutron wavelengths that are collected by the detectors.

Neutron diffraction coupled with simultaneous neutron imaging will provide closely correlated information about material structure and performance.

The feasibility and system design of neutron diffraction using the NRAD reactor is currently being explored with MIT and ORNL. Design concepts and feasibility studies will be completed in FY-17.

ROM Cost Estimate: \$2.5M.

22. IMCL High Throughput Sample Preparation Capability for Nuclear Fuel (Laser)

Description

Sample machining technology based on femtosecond lasers provides the opportunity to rapidly and precisely prepare intermediate-scale samples (50 micron to millimeter) for characterization. This project couples commercially available laser sample preparation capability with a radiological contamination control system and light shielding, and installs the system in IMCL.

Benefit

Micro-scale samples for characterization and mechanical testing are currently fabricated using FIB (Focused Ion Beam) instruments. FIBs are dual-purpose instruments, used for both sample analysis and sample preparation. FIB sample preparation is extremely precise, but time consuming. Commercially available laser-based sample preparation tools have been demonstrated to produce high-quality samples much more rapidly than FIB. These systems are also capable of producing larger-scale samples, which provide material property data more representative of bulk material. Use of a less expensive, dedicated laser-based system for sample preparation allows FIB instruments to focus on sample analysis instead of sample preparation, increasing data generation and contributing to shorter nuclear technology development timelines.

ROM Cost Estimate: \$1M.

23. Installation of a Pneumatic Transfer System in the Irradiated Materials Characterization Lab (IMCL)

Description

Install a pneumatic transfer system between the confinement boxes in IMCL to support material transfers throughout the facility. The system would utilize the EPMA Glovebox as the hub for the system which would have a pneumatic transfer line to the Plasma Focused Ion Beam (PFIB) Glove Box, Focused Ion Beam (FIB) Glove Box, Thermal Properties Cell (TPC) and the Shielded Transfer Cell (STC). The pneumatic transfer station at the STC would be equipped to utilize a future pneumatic transfer line from HFEF.

Benefits

There are several benefits associated with moving radiological materials with a pneumatic transfer system VS glove box bag out, French Can or ISC for performing material transfers which include:

- Higher efficiency in the time required for a transfer (reduced cost to programs)
- Significantly reduces the FTE support required for a material transfer (reduced cost to programs)
- Significantly reduces radiological risk to the worker. Every transfer between confinements we do now essentially breaches a Class A glovebox (nonessential personnel and tours are restricted in IMCL due to this risk or, the transfers are delayed which delays mission progress).
- Expect a significant reduction in radiological dose to workers as a pneumatic sample transfer requires less personnel contact with the materials.
- Significantly reduces ergonomic & industrial hazards to personnel (personnel would no longer manually push a 3,000lb ISC and cart around the facility in tight spaces).
- Significant increase in facility availability for material transfers. ISC #1 has needed core internals changed out since 2017. This slide mechanism is difficult to operate and has resulted in contamination events when the manipulator slides off the internal slide handle when trying to extract the slide. We have new internals fabricated but with the multiple issues with ISC #2, system leaks and ISC #2 alignment to Alpha Ports, we have not been able to perform the internals replacement on ISC #1.
- Reduced burden on IFM dollars. The pneumatic transfer system is more cost effective to maintain than the ISC(s) and significantly reduces the amount of radiological waste generated from the transfer process.

Risks

Increasing facility mission and workload is challenging our current material transfer methods. Performing material transfers via bag out, French can or ISC take a large number of resources, restrict facility access, increase dose to workers and are very inefficient.

After we have increased the number of transfers using the ISC, we have experienced an increased amount of required maintenance where the ISC or its transfer system has become inoperable. This down time has resulted in approximately 3 to 4 months of down time for the ISC in FY 2023. At this current time, neither ISC #1 nor ISC #2 are fully functional. The ISC design is difficult to use, difficult to maintain and is proving to be an unreliable transfer system.

ROM Estimated Cost: IMCL Facility FY-24 4.3M, IMCL-HFEF FY-25 3.2M.

24. Design & Install a Rotation Stage in the ERS Elevator to Enable Neutron Tomography of Fuels

Description

Design, build, and test a rotation stage for the East Radiography Station (ERS) elevator at HFEF to enable neutron tomography of specimens inside the HFEF main cell. The stage should include an encoder for reliable and repeatable positioning. The control system for the rotation stage should be user-friendly and capable of being interfaced with the neutron imaging system control software. The rotation stage should be able to accommodate virtually any specimen inside the HFEF main cell that can fit into the ERS elevator. The rotation system would build upon the experience of the AFIP-7 tomography fixture designed and used in 2015, and the imaging techniques developed in the TREAT SETH program in the north radiography station.

Benefit

Neutron computed tomography (nCT) is now available for imaging low-activity specimens in NRAD's North Radiography Station. However, to examine highly-radioactive specimens, a nCT system must be installed in the ERS to have access to specimens in the main cell via the elevator. For nCT to work, the specimen must be able to rotate and the angle be controlled by the imaging control system. Such a rotation stage does not currently exist, but would enable nCT of irradiated fuel, which is of vital interest to fuel R&D programs.

ROM Cost Estimate: \$750K.

25. HFEF ECP/EBLM Refurbishment

Description

The Element Contact Profilometer/Element Bow and Length Measurement instrument is original equipment to HFEF. Multiple failures have occurred, the bow and length measurement function is not operable, and the system is unreliable, requiring increasing repair. Some functions cannot be repaired or replaced in-situ due to age and obsolescence. This project will refurbish the instrument, restoring full functionality and updating it to modern components.

Benefit

This refurbishment will restore full functionality and improved reliability to a PIE instrument that is part of routine, baseline non-destructive examinations. This is a key measurement for medium- and full-size fuel pins which will be more common as we look towards industry partnerships.

Facility Risk

Without this project, HFEF will not be able to offer a key PIE technique for light water reactor fuel PIE and other medium- to full-size fuel pins and will lose work to laboratories who can complete this measurement.

ROM Cost Estimate: \$1M.

26. HFEF/NRAD Digital Imaging Studio

Description

Convert Photolab space (Room 121 and 124) into digital imaging laboratory. Modification would include PFCN ties for high speed data collection and transmission, high resolution scanners and processing

computers in room 121, and a large viewing display for presentations in room 124. New access to the NRS Highbay may also be included to allow quick access to imaging equipment in the basement and NRS Highbay workspaces.

Benefit

Image processing equipment to enable neutron CT, Tomography, and diffraction real-time data analysis. More presentation-worthy display equipment for PIs and professional-looking tours in room 124.

Facility Risk

Without digital imaging equipment space, time will be lost transferring information to other data analysis spaces, and reactor run time is wasted if rework is required for imaging.

ROM Cost Estimate: \$500K.

27. Hydrogen, Inert, And Vacuum Atmosphere Furnace For Creep Testing Systems

Description

Item description: The research item consists of high temperature (1200°C) controlled atmosphere (Ar, He, N₂, H₂) and vacuum (10⁻⁶ torr) chamber and mechanical pumping system. The system will be fit with one of the ATS creep testing frame available at the Research Collaboration Building (RCB). A roughing pump combined with a diffusion pump will be installed to achieve the desired vacuum level inside the furnace chamber. The chamber can be evacuated by means of the vacuum system and then back-filled with the desired inert gas. For operation in hydrogen, the system includes hydrogen ignitor and burn-off, which is located after the relief valve of the furnace chamber. It is used to ignite and reignite flammable gases coming from the chamber. The furnace system will be used to perform high temperature mechanical testing under hydrogen, inert, or vacuum atmosphere. The capability will enable us to investigate the environmental effects (hydrogen and oxygen) on the creep performance of materials.

Benefit

The U.S. Department of Energy's Energy Earthshots initiative aims to make breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. Under this initiative, the Hydrogen-Shot program has been launched to reduce the cost of clean hydrogen by 80% to \$1 per 1 kilogram in 1 decade. One of the major components in achieving this goal is hydrogen production using nuclear energy via thermochemical treatment. During this production process, structural materials are exposed to hydrogen under high temperature and pressure conditions. These conditions degrade the mechanical performance of structural materials leading to premature failure during service. It has been shown that creep life of engineering components is significantly reduced under hydrogen atmosphere. Considering the motive for higher temperature processes to increase the efficiency, the creep performance of materials will play a significant role in achieving economical operation of the hydrogen production plants. Furthermore, deeper understanding of hydrogen effects on creep and qualification of advanced materials for serving under hydrogen atmosphere warrant advanced capabilities for materials testing. This furnace that can provide not only hydrogen atmosphere, but also vacuum and inert atmospheres to creep testing equipment at MFC will be a significant step in boosting our capabilities to cater to the research and development requirements in this field.

Risk

- DOE Office of Science funded Early Career Research Program currently running at MFC has work scope to study the basic creep mechanisms in structural alloys under hydrogen environment. The hydrogen atmosphere furnace is an essential capability for successfully conducting this program.

- DOE is investing huge R&D funding to enable low-cost hydrogen production. For instance, the President's budget request for the DOE hydrogen program in FY 2024 is \$381 million dollars. With this new capability, MFC will be poised to participate in R&D programs such as Advanced Research Projects Agency (ARPA-E) to study hydrogen effects on materials performance.
- Accident tolerant fuels program studying coated cladding materials such as Cr coated Zr will benefit from this capability to study hydrogen pick up and its effect on cladding's creep life.
- INL is undertaking fusion materials research for developing and qualifying advanced materials for fusion reactors. Investigation of Hydrogen interaction with materials and its effect on creep under fusion conditions will require this hydrogen atmosphere furnace capability.

ROM Cost Estimate: FY-26 – 475K.

28. Powder Bed Additive Manufacturing

Description

A powder bed additive manufacturing system would be deployed in an MFC radiological facility for use with uranium and uranium-bearing materials.

Benefit

The INL currently does not have a powder bed 3D printing apparatus for use with uranium-based metals. This capability would give us an expanded number of options available to fabricate fuel using additive manufacturing techniques, including geometries that can't be made using traditional subtractive manufacturing processes. This capability expansion would enable unique R&D opportunities and support innovative fuels research.

ROM Cost Estimate: \$2M.

29. Argon Atmosphere Capability in the IMCL Shielded Sample Preparation Area

Description

The SSPA (Shielded Sample Preparation Area), a small hot cell used for mounting and polishing of irradiated samples in IMCL (Irradiated Materials Characterization Laboratory) will be converted from an air atmosphere to an inert argon gas atmosphere.

Benefit

The SSPA is currently limited in its ability to prepare air sensitive metallographic samples. This lack of capability results in a continued backlog of samples, extra sample transfers, higher net operational cost, and lack of efficiency that contribute to long nuclear material development cycle times.

Sample preparation is a bottleneck in the characterization of nuclear fuels and materials that is important to understanding irradiation behavior. This SSPA works in concert with the HFEF (Hot Fuel Examination Facility) containment box to provide these samples. Converting SSPA to operate in an inert argon atmosphere will expand the range of samples that can be prepared and help to reduce the time required for analysis, decreasing development and qualification cycle time.

ROM Cost Estimate: \$1.5M.

30. NRAD NRS Elevator Replacement

Description

The NRS elevator, originally designed to radiograph large TREAT loops, is non-functional and needs to be replaced. The replacement would require a more precise specimen positioning stage and accommodate larger diameter specimen.

Benefit

The NRS space is ready to demonstrate neutron diffraction, neutron CT, TREAT experiments, and is slated to perform TREAT loop radiography in a few years. An elevator replacement would allow better remote positioning of specimen for radiography and neutron CT of full TREAT loops. In addition, new business opportunities could be developed if the design doubles as a diffraction sample stage, and is wide enough to accommodate barrel-scanning operations using X-ray or neutron beams (e.g., waste characterization).

Facility Risk

The current system is degraded, requiring operator workarounds such as manual placement of specimen and test radiographs to confirm positions prior to program radiography. Elevator vertical movement, rotation, clamping, and carriage motion components and associated position indications are all currently non-functional. Upgrade would consider system redesign to accommodate larger specimen since current conceptual TREAT designs are too large for the elevator to accommodate.

ROM Cost Estimate: \$1M.

31. NRAD Sample Preparation Glovebox

Description

Set up a sample preparation glovebox at NRAD for preparing fresh and lightly irradiated fuel samples for in-core irradiation. The targeted place for this equipment is room 029 (old argon compressor room) in the basement of HFEF.

Benefit

The single largest use of small research reactors worldwide is neutron activation analysis. Instrumental NAA (INAA) offers such benefits as low detection limits, minimal sample preparation, and the possibility of measuring analytes that are prone to interferences in more traditional techniques, such as mass spectrometry and optical emission spectroscopy. Developing and enhancing NRAD's sample preparation and in-core irradiation capabilities will take advantage of its co-location with the HFEF hot-cell. It would allow for researchers to use INAA to look at the composition of materials, to explore the behavior of small amounts of materials in a neutron flux, and to perform basic nuclear measurements to improve knowledge of cross-sections or half-lives. Several programs across INL who are working to develop the next generation nuclear materials would be able to take advantage of this technique to measure analytes that do not currently have established methods, with the appropriate detection limits and precision, available in the Analytical Research Laboratory (ARL), such as bromine and chlorine. An in-house sample preparation and counting area would minimize transfer paperwork and manual material handling of fueled material.

Facility Risk

The NRAD reactor currently does in-core irradiations inefficiently. Each sample is prepared in another nuclear facility and must be transferred individually and hand-loaded into the core.

ROM Cost Estimate: \$500K.

32. Laboratory Robotics/Automation for Analytical Research Laboratory (ARL) Processes

Description

Currently, there are no processes in the ARL that are fully automated or utilize robotics. The scope of this will prioritize and add these capabilities to the processes that are the most likely to benefit from robotic automation. There are many applications that would benefit from robotic automation including remote handling of samples and reagents via manipulators. Weighing and labeling of sample bottles, heat treatment and sampling of dissolutions, and performing auto sampling/loading for analytical instrumentation.

Benefit

Laboratory robotics is the practice of using robots to perform or assist in the laboratory tasks. While laboratory robots have been applied in diverse industries and sciences, pharmaceutical companies have used them more than any other group. Many laboratory processes are suited for robotic automation as the processes are composed of the repetitive movements. Robots can pick/place the liquid & the solid additions, they can heat/cool, mix, shake & test.

One of the most rapidly growing areas in the laboratory automation is the use of the robotics for sample preparation as the manual preparation of samples has remained a time-consuming problem. Advanced laboratory robotics can be used as auto-samplers as their main task is to provide continuous samples for the analytical devices. Laboratory robots have arms, hands, and fingers. These components can be programmed to repeat sample preparations previously performed by laboratory technicians. These robots can be programmed to perform many different tasks such as sample preparation and handling. Laboratory robots can dispense acids, mix, heat, centrifuge, filter, and weigh samples.

Laboratory robotics offer high speed, high efficiency, minimal wastage, task reproducibility, and enhance safety of laboratory personnel. Laboratory robotics can withstand adverse environmental conditions. Because sample preparation requires the use of hazardous chemicals, robots minimize the human exposure to these chemicals. Robots provide consistency in sample preparation and they improve the precision of the data. The repeatability and the reproducibility are improved as the automated systems are less likely to have variances in the reagent quantities and less likely to have variances in the reaction conditions. Efficiency will be improved as the robots can work continuously and they can reduce the amount of reagents that are used to perform the reaction. This also reduces the amount of waste produced in a process. Automation can establish safer working environments since the hazardous compounds do not have to be handled. The automation also allows staff to focus on other tasks which are not repetitive.

Risk

The physical space constraints within the ARL and the ever increasing workload requires significant change to the traditional way of performing laboratory work. Many routine, repetitive tasks can be improved upon by utilizing robotic automation. Human constraints and errors will always exist when a person is performing these tasks. Costs will continue to increase and productivity from human based work cannot match that of automated processes. Automation will also improve data precision and repeatability.

ROM Cost Estimate: \$5M.

33. ARL Liquid Scintillation Capabilities

Description

The ARL currently houses 2 liquid scintillation counters that are key to the success and efficiency for gross alpha and beta samples. One of the instruments is about 9 years old and will require replacement over the next few years, as the instrument bearing typically wear out around year 10-12.

Benefit

Liquid Scintillation Counters are the instruments that are constructed to hold a magazine of samples and rotate them through the counting apparatus. Liquid Scintillation is a counting technique that measures light that is generated when radioactivity interacts with special organic molecules. The amount of light, or photons, that are generated is directly proportional to the energy of the radioactive particles that cause it, so can be translated into a spectra and quantified. This measurement can approach 100% efficiency. Use of this capability streamlines laboratory operations and increases efficiency and reduces variation.

ROM Cost Estimate: \$600K.

34. Integrated Gas Supply, Collection, and Distribution System in HFEF for Mechanistic Source Term and Component Pressure Testing at HFEF

Description

As the laboratory moves forward with goals for developing numerous advanced reactor and advanced fuel concepts the need for testing reactor and fuel components in transient heating and high-pressure environments will greatly increase. Rather than each development project developing its own unique system, it makes sense for INL to invest institutionally in a system that can support the needs of multiple programs.

The gas system will be designed to be able to couple with existing and new furnaces in HFEF to enable either the supply of high-pressure inert gas for pressure/burst testing of irradiated structural components, or the collection of fission gas from transient heating furnace which can be used to determine mechanistic source term release fractions. The time frame for execution is approximately 3 years including design, HFEF modification and equipment procurements, and deployment. DOE fuel qualification programs, ARDP awards, NRC licensing activities, and commercial work for others are potential customers.

Benefit

If not funded this could result in significant delays of numerous advanced nuclear technologies or in the application of unnecessarily restrictive limits placed upon their operation impacting their cost competitiveness. Individual programs may invest in similar systems that are limited to their specific program. This would place an unnecessary burden on the engineering, hotcell space, and waste management resources at INL through the proliferation of numerous (and nearly redundant) systems instead of addressing the testing need holistically.

ROM Cost Estimate: \$6M.

35. ZPPR Multi-purpose Uranium Processing And Synthesis Glove Box Chain

Description

There is a continually increasing need to handle and synthesize multi-Kg quantities of uranium-based fuel for demonstrating and testing different reactor concepts. Fuel production remains a key need for supporting nearly all reactor demonstration projects being considered, as well as possible fabrication of targets for select irradiations. This request proposes building on the existing multi-purpose glove box design and procurement. Then install this new glovebox chain in the ZPPR work room. This new glove box would expand the functionality of the ZPPR work room and would provide more options for large quantity fuel processing.

Benefit

Would provide processing capability in ZPPR facility, branching outside of SNM disposition, NHS projects, and nuclear material management increasing overall value and usage of the ZPPR facility. Increases capability to support HALEU material availability and reduce our capability to support reactor demonstrations.

ROM Cost Estimate: \$6-8M over 3 years.

36. FMF Multi-purpose Glovebox And Fume Hood Combination (HEU Glovebox)

Description

There is a continually increasing need to synthesize multi-Kg quantities of uranium-based fuel and plutonium-based fuel for demonstrating and testing different reactor concepts. Fuel production remains a key need for supporting nearly all reactor demonstration projects being considered. This request proposes to build on the existing multi-purpose glove box design and procurement. The addition of a single glove box section with an attached fume hood. Would position FMF to be able to adapt to a number of conceived future expansions. With this glovebox available, any follow-on program would only be required to address specific fuel fabrication and fuel synthesis needs by installing program specific production components, consumable materials, handling equipment, and furnaces required to meet the program's needs. This new glove box and attached ventilation hood would fill the FMF south work room and complete the vision started years ago when D&D efforts were taken to improve the facility.

Benefit

The vast majority of industry reactor designs, proposed NASA concepts, proposed DARPA concepts, and designs originating from national laboratories require engineering-scale, campaign-style synthesis of significant quantities of their fuel for testing and demonstration. The lack of this capability causes a gap between the DOE and industrial infrastructure. This capability for Uranium fuels with an enrichment over 5% is extremely limited and is completely unavailable for Plutonium fuels. Installing the proposed multi-purpose glovebox shell in the Fuel Manufacturing Facility would allow upcoming projects to fill this gap in the near term. With planning and coordination, the glovebox would meet both uranium and plutonium needs. In most cases, this would contribute to an estimated 2-year reduction in the time frame typically required to demonstrate these critical experiments and reactor concepts. Increases capability to support reactor demonstrations.

ROM Cost Estimate: \$4-5M over 2 years.

37. NRAD Automated Computed Tomography System

Description

Design and install an automated neutron computed tomography system in the east radiography station (ERS). The system would require modification of the beam stop in the ERS cell and adjacent Subcell area to accommodate equipment. The system would tie the ERS elevator, rotation stage, beam tailoring, and shutter controls into a single automated system.

Benefit

An automated neutron computed tomography system would make NRAD the only system in the world that could offer neutron computed tomography of irradiated material and subsequent 3D reconstruction as a standard PIE practice for highly irradiated specimen. During installation of this system, a side benefit could be realized to optimize the shielding inside the ERS Cell to eliminate neutron streaming and resultant radiation areas in the normally occupied spaces of the HFEF basement.

Facility Risk

Neutron CT is an advanced capability for highly irradiated fuels. The ERS can function without this equipment.

ROM Cost Estimate: \$2.4M.

38. NRAD NRS Control Console Replacement

Description

NRS neutron shutter, gamma shield, beam shaping components, and aperture have been returned to service. However, the control system is obsolete and degraded and needs a replacement like the ERS control console.

Benefit

The NRS space is ready to demonstrate neutron diffraction, neutron CT, TREAT experiments, and is slated to perform TREAT loop radiography in a few years. An upgraded control system PLC would ensure reliability of the beam and transporter control equipment and remote monitoring capability.

Facility Risk

The current system is obsolete and degraded. It is composed of early 1980s chips and circuitry that are no longer available. Failure of the system jeopardizes all new work in the NRS.

ROM Cost Estimate: \$500K.

39. ARL HR ICP-MS

Description

Adding a new high resolution ICP-MS to the ARL RD&D capabilities

Benefit

The sensitivity of the HR-ICP-MS can be up to 50x higher when compared with the Q-ICP-MS, and the instrumental uncertainty can be as low as 0.025% which, in many instances, is a requirement in the development and certification of new and advanced nuclear fuels. The instrument will also help the ARL maintain its high sample throughput, help maintain high data quality as programmatic needs increase, and keep pace with technological advances in chemical and analytical metrology.

Risk

The HR-ICP-MS is used for the quantification of isotopes that do not require higher resolving power, but require a more sensitive or more precise technique.

ROM Cost Estimate: \$1.5M.

40. Multi-Purpose U Glovebox FASB Multi-purpose Uranium Glove Box Chain

Description

The RERTR glove box chain in FASB is over 20 years old, has been a “workhorse” glovebox that has supported several large advanced fuel programs and numerous smaller developmental programs. However, the glovebox has surpassed its useful service life and needs replacement. Currently two of four bays of the glovebox are no longer functional and the control and purification systems are no longer supported by the vendor. Complete failure of the system is imminent, likely in the coming year, and any remaining functionality is diminished by ongoing failures and obsolescence of remaining space.

In the remaining time before impending complete failure, the loss of half of the glovebox working space severely limits availability of high purity inert atmosphere processing which is needed for both advanced metallic and ceramic fuel development. Even when functioning, the RERTR box is expensive, time consuming to maintain and has difficulty maintaining required atmospheric conditions. Additionally, the configuration of the box no longer meets mission needs. The box has a relatively small interior space and does not allow many of the core capabilities needed for ongoing and future programmatic work. Currently, the PCG glovebox is utilized by other programs requiring increased height, well space, or length that the RERTR box cannot support. This significantly impacts other programmatic work in the PCG box, which is fully subscribed, and increases risks to experiments. The RERTR box is compartmentalized with small transfer ports limiting its functionality and movement of samples, materials and equipment between compartments. Moreover, the PCG glovebox does not have a clean section so, due to concurrent use of uranium powders, is unable to process items with stringent contamination requirements.

This system’s utility is rapidly atrophying and unlikely to do more than occupy valuable FASB space in the time period of this Investment Strategy.

Benefit

This is a modern glovebox, capable of maintaining atmosphere and quick recovery after glovebox shutdowns. It expands capability for controlled experiment assembly and increases capability to support R&D activities for metallic fuel experiments and out of pile testing during removal and installation. It allows continued support of ongoing and upcoming projects and maintains the vitality of otherwise oversubscribed space in FASB.

ROM Cost Estimate: \$5M over 4 years, including removal of existing RERTR glovebox.

41. NRAD Fuel for 1 MW Upgrade

Description

The additional fuel increases the power of the Neutron Radiography Reactor (NRAD) from 250 kW to 1 MW proportionally increasing the neutron intensity in both the NRAD core and its neutron beams. The higher beam intensity increases the neutron signal to the instruments using NRAD’s beams, improving data quality.

Benefit

The higher neutron intensity in the NRAD core will enable in-core, low-burnup irradiation experiments like those at the Advanced Test Reactor (ATR) but with direct access to post-irradiation examination capabilities at the Hot Fuel Examination Facility (HFEF). NRAD's direct proximity to HFEF enables fast and cost-efficient transfers to the hot cell. This also allows access to short-lived fission product behavior that is currently unavailable from experiments shipped from ATR. The new capabilities enabled by increasing NRAD's power to 1 MW will accelerate the discovery, development, and qualification process for new nuclear fuels and materials.

ROM Cost Estimate: \$5.1M.

42. Replace CNOH Glovebox and Instrumentation

Description

The CNOH instruments within the CNOH glovebox are near the end of life and well past their recommended life cycle. The instruments were brought over from FASB and have been in the Analytical Laboratory for about 5 years. The modifications made to the glovebox for the specific instruments were extensive. All of the feedthroughs and connections were modified for the current instrumentation.

Benefit

There is a large backlog of samples waiting to be processed through the instrumentation within the glovebox. Additionally, there is a lot of programmatic work expected for the next 10 years to be processed through these instruments.

Facility Risk

The analyzers within the glovebox are past their life expectancy. Any disruption to the ability to process samples would affect programmatic work and cause delays.

ROM Cost Estimate: \$5.5M.

43. Inert Glovebox Installation in B147

Description

B147 currently houses the casting lab glovebox. It is intended to tear out the glovebox once the capability is installed in HFEF, which is on the 5 year plan. The glovebox contains a large portion of the facility material inventory and operationally creates the highest risk within the facility.

The Analytical Laboratory is in need of an additional inert glovebox for processing samples due to the environment. The casting lab glovebox is set up for the instrumentation that is currently in there and the glovebox and associated gaskets, etc. are antiquated. Therefore, simply removing the instrumentation would still not allow for the glovebox to be used.

Benefits

The Analytical Laboratory continue to receive requests for samples and programs requesting analyses that cannot be processed anywhere other than in an inert environment due to pyrophoric and reactive materials. Installation of an inert glovebox with space for processing sample would be of great benefit to the programs and the AL.

ROM Cost Estimate: FY-26 \$1,000K, FY-27 \$3,000

44. Inert Glovebox Install in A-102

Description

The Analytical Research Laboratory has seen an increase in request for processing pyrophoric and reactive samples. These samples can only be processed in an inert atmosphere glovebox. A-102 houses the special projects and does not get used very often, and most of the work completed there could be completed anywhere. It is only used because there is space. The piping and ventilation is mostly in place and would only require minor modifications. The cost includes the waste disposal costs for the special projects glovebox.

Benefit

The ability to process samples that are both pyrophoric and reactive would help programs that are requesting the analyses. Installation of the glovebox would increase the capabilities of the ARL.

ROM Cost Estimate: \$4.5M.

45. Replacement of the ARL Thermal Ionization Mass Spectrometer (TIMS)

Description

The ability to perform precise and accurate analyses for Material Control and Accountancy (MC&A) samples is a vital part of several processes at MFC. The traditional method of performing those types of measurements at the INL and across the DOE complex is the TIMS. The instruments are simultaneous isotope ratio instruments that use very well characterized spike material (by New Brunswick Laboratory, NBL) and isotope dilution mass spectrometry to perform assays on Uranium and Plutonium. The total assay of a TIMS analyses for U and Pu is $< 0.5\%$, which is consistent with the international target values.

The current Triton TIMS unit has been in operation since 2009. While the instrument is currently functioning, it is nearing the end of its support from Thermo, the instrument manufacturer. In addition, new advances in detectors, ion optics and filament temperature controls make the current state of the art superior to the currently installed instrument. As the need for improved detection capabilities increases, and multi-laboratory exercises within the DOE complex continue, it is vitally important that the ARL have equivalent instrumentation and capability to perform on the same level as the other national laboratories. In addition, for programs that want data consistency, by consistent analyses since the 1980s, it is important to have the TIMS capability available. Hence, the replacement of the Triton TIMS units is necessary.

Benefit

The replacement of the TIMS unit will allow for better, timely, and consistent MC&A measurements for U and Pu. Another direct benefit of the addition will be the use of the Triton instrument for method development and fundamental research activities (while the instrument is functioning). The addition of another instrument will give flexibility for research activities that are not currently allowed because the instrument must be maintained for the MC&A activities. These could include advancements in sample introduction, method development for low level detection and modification of ion optics and detector assemblies for improved performance.

Status: A rough order of magnitude cost estimate has been developed. Lead time on the instrument is approximately 6 – 9 months after placement of the order.

ROM Cost Estimate: \$3M.

46. Upgrade the Visual Examination Machine (VEM) Camera Controls

Description

The Visual Examination Machine (VEM) represents a new in-cell high resolution imaging capability at the Hot Fuels Examination Facility (HFEF). There are currently two controls for the VEM, the camera position (magnification) and the focus, and each is controlled by a momentary switch. To improve the quality and reproducibility of imaging results gathered with this system, it is proposed that the camera controls be upgraded.

The camera in the VEM essentially uses a “prime” lens, which means that the focal length, which determines magnification, is fixed. This means that the size or magnification of subjects is determined by both the distance of the subject in-cell from the VEM feedthrough and where the camera is physically located on its “track” within the VEM feedthrough. The camera magnification momentary switch controls this latter function. The distance to a subject from the feedthrough wall in-cell may be estimated. However, the current controls give no way to determine where on the “track” the camera is located, beyond a lack of movement if the camera is at either “limit” of travel. Given that quantitative analyses is desired from this new system, consistency in imaging is desirable. An upgrade to this control that provides a user with an indication of the current location of the camera within the feedthrough is proposed such that imaging can be conducted at a consistent magnification.

The switch that controls the focus of the VEM camera is coarse while the depth of field, what is in focus, is narrow, resulting in a tedious, iterative exercise to focus the camera on small features (~50 μm in diameter). The control for the focus will be upgraded to include a “coarse/fine” toggle switch to alternate between coarse and fine focusing step sizes.

Benefit

This will significantly improve the speed and consistency of focusing the VEM camera. Without an indication of the camera’s position within the feedthrough, magnification can only be consistent by operating at the limits of camera travel, defeating the purpose of having a variable camera position control. Additionally, retaining the current coarse camera focus controls increases the difficulty in focusing on fine features, as the instrument was designed.

ROM Cost Estimate: \$250K.

47. High Capacity, High Temperature Furnace

Description

A high capacity and high temperature furnace significantly expands capabilities to process a wide variety of fuel forms. This includes sintering and heat treatment of fuel forms in support of NASA, AFC, and other DOE and industry-driven advanced fuel concepts. Potential fuel forms include UO₂ and UZrH (TRIGA).

This furnace has a 1,000 in³ uniform hot zone that can operate at temperatures up to 1,900°C. It can also operate in a variety of atmospheres including vacuum, inert gas, and hydrogen, both flowing and static. This project will install this furnace in AFF with a new glovebox in support of kg to multi-kg scale fuel processing.

Benefit

This furnace represents a step change in MFC's capability to sinter, heat treat, and otherwise process fuel for multi-kg and up to LTA-scale fuel fabrication campaigns. This closes a significant gap between MFC's current capabilities and ongoing and upcoming demands from industry, DOE, and other potential partners. This gap is currently leaving MFC behind, failing to capitalize on the other fabrication capabilities, facilities, fuel materials handling infrastructure, and human capital that have been built over decades as the industry strives towards dozens of demonstration reactors that need more fuel than MFC can make.

While the lab-scale powder blending/milling, pressing, and other process equipment is modest in scale, the long cycle times for thermal treatments make a larger furnace the single best way to extend MFCs reputation, build expertise, and position MFC with a minimal but credible demonstration-quantity fuel fabrication capability and support the coming generation of advanced nuclear reactor demonstrations. Notably, such a furnace need only be run a handful of times to capture these benefits of this leap and justify the investment, yet will offer an enduring and unique capability and bridge to a dedicated Reactor Fuels Research Capability.

Facility Risk

With the growing interest and demand for MFC to fabricate fuel for advanced reactor concepts, current facility capabilities are limited to smaller volume and less capable furnaces. This addition to the FFNMM equipment portfolio would allow for greater throughput with the large internal volume. This has obvious efficiency advantages, but it will also decrease risks associated with research quality or consistency by minimizing the amount of furnace runs required for a given fabrication campaign. While this furnace provides enhanced capabilities, it could also accept some of the work currently performed in the EFF HDF furnace, thus minimizing single-point-failure risks associated with the HDF furnace.

ROM Cost Estimate: \$3M.

48. EFF Radiological Machining Capability Enhancement

Description

This project would upgrade several of the machining capabilities currently located within EFF. EFF has both warm-machining capability to machine fuel-containing specimens, and also hot-machining capabilities to machine fuel specimens themselves. This project would upgrade several pieces of equipment in both the hot-machining and warm-machining areas in a phased approach, including: centerless grinder, Trak mill, CNC lathe, and CNC mill.

This upgrade includes removal and disposal of existing equipment, and engineering, installation, and commissioning of the new equipment.

Benefit

This represents an important investment in staying current with equipment technology advancements and the growing demand for fuel machining work, which has and will continue to increase in proportion to the demand for nuclear energy. Each of these pieces of equipment serves unique functions that often cannot be substituted with another piece of equipment or process. Each upgraded piece has specific benefits, but where these capabilities are complimentary, the most benefits are realized upon a significant capability investment. Specific benefits include increased precision and significantly decreased risk of equipment failure or its inability to meet throughput or tolerance requirements. Equipment upgrades also enhance our ability to machine unique geometries and the new technology on equipment allows for more efficient machining operations and tooling changeouts.

This is a substantial upgrade that will help MFC to maintain this important capability to support the current and future portfolio of nuclear fuel R&D needs for nearly all uranium-based reactor fuel concepts ranging from ceramic, to metal, to cer-met fuel forms.

The increased demand for aging equipment that is not duplicated anywhere else at INL leads to significant risk to a wide variety of programs and projects. NASA, AFC, aLEU, multiple ARDPs, LDRDs, and other advanced fuel concepts and their development and production efforts rely upon these machining capabilities to produce or prepare feedstock, interim fuel forms, or process final fuel forms.

The increased demand for fuel machining work has increased throughput thus accelerating machine aging. The precision required of the fuel outputs has also increased, in some cases beyond the ability of the equipment. The failure of any single piece of equipment in this list will have catastrophic effects on several programs, which would only be compounded through failure of multiple pieces of equipment.

ROM Cost Estimate: \$3.5M.

49. AFF Weld Characterization Suite

Description

This item stages several pieces of equipment in AFF to maximize throughput of projects relying upon the laser welding glovebox located in AFF. This includes mechanical property testing capability, along with additional optical analysis capability of weld samples. A tensile testing system and bend testing system would be located in AFF to qualify weld specimens, and additional microscopy and weld sample preparation equipment would be installed to allow for evaluation of welds during development iterations.

Benefit

An increase in ATR and TREAT irradiation tests in support of a wide variety of nuclear fuel systems, both for the current fleet of LWRs and for advanced nuclear reactor concepts, has resulted in a higher demand for specimen assembly via welding. Additionally, materials being welded as part of these efforts has expanded beyond historically standard materials, resulting in increased weld development efforts. These equipment additions would facilitate a significant increase in efficiency by staging all requisite development and qualification equipment adjacent to welding systems. It would also allow for more thorough characterization of weld samples to understand fundamental material behaviors.

The primary risk associated with not pursuing this equipment is related to the timescale to develop adequate welds and the overall quantity of work that can flow through the laser welding system. A robust weld characterization and evaluation capability is the main limiting factor in weld development timelines. Without this equipment in AFF, personnel time is spent performing characterization using less than ideal equipment or at areas outside of MFC.

ROM Cost Estimate: \$300K.

50. Cold Hearth Furnace

Description

This adds capability with a new furnace that would be installed in AFF. The cold hearth furnace allows for crucible-free casting of fuel material that have either high melting points or high potential interaction for standard crucible materials.

Benefit

This furnace represents a unique and niche capability to fabricate high-melting point fuel or fuel compositions that otherwise interact with typical crucible materials using existing capabilities. It is particularly ideally suited to high-Zr U-Zr alloys that are otherwise very difficult to fabricate with high purity and represent a notable gap in MFC's metal fuel capabilities. This capability would offer new and unique research opportunities to broaden MFC's and the industry's fuel composition portfolio.

This furnace would expand MFC metallic fuel fabrication capabilities beyond those that currently exist. Continuing to operate with the existing metallic fuel fabrication capabilities results in limitations on accepting work associated with high melting point fuels.

ROM Cost Estimate: \$2M over two years.

51. AFF Envelope Pycnometer

Description

An envelope pycnometer would be installed in AFF in support of particle size characterization. This pycnometer fills a gap by adding capability to measure density of samples containing >5% porosity and of irregular geometry.

Benefit

This pycnometer complements the existing He pyrometer and offers density measurement capability in AFF, reducing sample transfer requirements. Density is a critical parameter in fabricating ceramic and additive materials, however not samples are amenable to accurate geometric density measurements (e.g., SNP fuel) and He pycnometry can falsely report very high density in samples that are actually porous, an error of physical parameter conflation that can be difficult or impossible to reconcile ex post facto.

This capability fills a gap that currently exists at MFC in characterization of feedstock powder. Not addressing this gap increases R&D risks associated with powder-based fuel systems as feedstock cannot be fully characterized, potentially leading to development or qualification challenges.

ROM Cost Estimate: \$75K.

52. AFF Muffle Furnace

Description

This furnace operates at a range from 800°C to 1200°C with an air or inert gas atmosphere and will be used to bakeout ceramic binders, resins, or other processing materials used in various fuel fabrication processing schemes. This furnace allows for an intermediary step before additional specimen processing in a high temperature furnace, which protects the insulation components, heating elements, and other components of the high temperature furnace from damage from specimen off-gassing.

Benefit

This muffle furnace benefits the longevity of high temperature furnaces through preventing their exposure to processing materials that are burned out of fuel specimens during their sintering or processing. Maintaining these high-temperature furnaces that are required for final fuel processing in as pristine of a condition as possible also ensures the highest quality of R&D throughput and minimizes risk of performance issues during processing large batches of fuel specimens.

The addition of a muffle furnace to AFF decreases risk of damage to high temperature furnaces by allowing an intermediary bakeout step in a furnace designed to accommodate offgassing. The risk of a fuel fabrication scheme that does not include this furnace is damage to the heating elements, insulation, or other components of the more precise and sensitive high temperature furnaces necessary for sintering or other final processing of fuel forms.

ROM Cost Estimate: \$400K.

53. High Capacity Press

Description

This multi-station, hydraulic-actuated, numerically encoded press supports rapid and consistent pellet pressing in multi-kg batch sizes. This high-capacity press serves as a complimentary capability to the numerous furnaces being installed, or proposed, to expand our capacity.

Benefit

The primary press supporting pellet fabrication efforts is staged in the HDF glovebox within EFF and is only capable of pressing a single pellet at a time after manually loading powder into the die. This high capacity press would allow for an order of magnitude increase in pellet pressing throughput over the current press in the HDF glovebox in EFF.

The primary risk of not increasing pelleting capabilities is the limited throughput and consistency of pellets pressed using the system currently in the EFF HDF glovebox. This results in the inability to produce high quantities of pellets (i.e., LTR or LTA quantities) in support of advanced nuclear fuel applications in a timely manner.

ROM Cost Estimate: \$1.5M over two years.

54. Replace IMCL SEM 7600

Description

For post irradiation examination (PIE), a high-resolution analytical SEM (Scanning Electron Microscope) is essential for bridging the information gap between the typical metallograph (from HFEF) and atomic scale resolution instruments such as atom probe and transmission electron microscope in IMCL. The SEM in IMCL is an integral part of the PIE characterization instrument suite for achieving important MFC missions such as nuclear fuel development/qualification and irradiated material performance evaluation. Several major DOE programs, including the United States High-Performance Research Reactor project (USHPRR), NSUF, AFCI, as well as industrial users such as Westinghouse and TerraPower, rely on this SEM for their microstructure characterization and chemical analysis needs. The current SEM in IMCL (JEOL JSM-7600F) has been utilized extensively and has exceeded the typical ten-year service life (11 years as of July 2022). The vendor no longer produces spare parts for the current instrument and has warned that if a major breakdown happens, replacement parts may not be available (i.e., on the JEOL legacy instrument list). The vendor also has the right to reject the service contract renewal simply based on their business considerations. A new unshielded EPMA will ensure that the IMCL (and INL) continues to provide governmental and industrial users uninterrupted support for their irradiated material characterization needs. This new EPMA will provide basic SEM functions to meet programmatic needs, and also has the abilities to detect and quantify light element analysis (e.g., Li, Be, B, C) that are critical for battery research and nuclear fuel qualifications.

Benefit

This instrument supports major programs from different DOE offices such as NE (FCRD, AGR, NSUF, LDRD), NNSA (USHPRR), Office of Science (TETI), and industrial projects such as Natrium. A reliable, uninterrupted SEM service at IMCL will ensure these programs meet their PIE mission needs and accomplish their milestones in a timely manner.

The current instrument is near end-of-life (11 years old, on the JEOL legacy instrument list) and experiencing a decrease in availability due to maintenance and stability issues. It is one of the heavily utilized instruments at IMCL and will have a significant impact on all major programs if it breaks. The whole replacement process (including bidding, ordering, manufacturing, delivering, installing, performance accepting, procedure approving, and operator training) typically takes at least 6 months (for example, it took more than 9 months for the recent Focus Ion Beam (FIB) replacement process in EML).

ROM Cost Estimate: \$2.5M.

55. Replace IMCL Shielded Ga FIB

Description

The IMCL Shielded Ga FIB is one of the most critical and utilized instrument for every program. It is primarily used to conduct sample preparation for TEM and APT, and micromechanical testing. The service contract expires in 2023, and there will be no parts or power supply available afterwards.

Benefit

The Ga FIB is a critical instrument for all programmatic work at IMCL.

Failure to replace this instrument will have detrimental impact on all programs, and all subsequent characterization and testing such as TEM, APT, micromechanical testing may be stopped.

ROM Cost Estimate: \$2.5M.

56. IMCL Simultaneous Thermal Analyzer (STA) Mass Spectrometer (MS) Replacement

Description

The throughput of measurements has drastically increased in the previous FYs. The rapid pace of measurement leads to significant exposure to radiation to the instrument components. Additionally, we expect higher burnup samples in the future, which will accelerate the degradation of instrument components. The STA instrument has modular components designed for replacement due to the high radiation fields it is exposed to. The primary failure modes include the mass spectrometer and components related to the furnaces experiencing radiation damage. Individual component failures will occur as soon as 2023 and are expected to occur continuously on a 2-year basis going forward.

Funding requested for this instrument will be used to replace the Mass Spectrometer and/or related components (currently the mass spectrometer is out of service), a mission critical component that allows the measurement of fission product release in heated fuel samples.

Benefit

The STA at IMCL is one of the premier instruments at INL for engineering scale measurement of specific heat and mass spectrometry of irradiated fuel materials. The hot cell STA is uniquely suited for measurement of one of the important thermal properties used for qualifying new and existing nuclear fuels. The measurements from the Differential Scanning Calorimeter are used to determine the specific

heat of the fuels, which informs our understanding of the thermal diffusivity and thermal conductivity of the fuel as it's temperature changes, an important quantity to understand for fuel qualification and performance modeling. The mass spectrometer is an important instrument for determining what elements are released as the temperature of irradiated nuclear fuels changes – giving information for how safely the fuel operates in nominal and adverse conditions. There are no backup instruments at MFC for measuring the engineering scale thermal properties of irradiated nuclear fuel, making the continued performance of the STA mission critical.

Without these upgrades to the STA components their continued use will cause significant increases in uncertainty of measurements and will leave the instruments inoperable. The requested use of the STA is continuing to increase as it is uniquely capable of critical measurements for nuclear fuel design and qualification. Given the expected increase in nuclear fuel research, we must upgrade the instruments to match current demand increases and prepare these instruments for the future to keep up with future demand.

ROM Cost Estimate: \$300K.

57. IMCL Thermal Conductivity (and Diffusivity) Microscope (TCM) Upgrade

Justification

High throughput of samples with an increase in measurements and improvement in data collection techniques have led to longer, unavoidable radiation exposure times for the instrument. Many components have suffered radiation damage which reduces the sensitivity of the instrument. Currently the thermal conductivity measurements are inaccurate due to the accumulated radiation damage. Multiple components need to be upgraded to return the TCM back to original specifications. Additionally, shielding for the instrument and samples to reduce radiation exposure for the TPC and TCM will be implemented.

The software used for the TCM was designed in lab along with the instrument and is severely outdated. There are multiple bugs and flaws in the software that have been found to slow down the operation of the instrument. If the instrument is to keep up the current pace of measurements and adjust to the increased number of projects interested in the use of its measurements, it will need to be brought up to date with modern programming and operational standards.

The other instruments located in the TPC – the LFA and STA – are capable of providing measurements at different temperatures using furnaces. However, the TCM is currently only capable of measurements at room temperature at the moment, despite being designed with heated measurements in mind. To address this, it will be necessary to implement a heating stage in the TPC, which will require safety reviews.

Funding will be used to replace critical components to restore the TCM to full operation along with additional protection from radiation. Due to the open nature of the TCM configuration, samples contribute significantly to the TPC background radiation dose rate. To reduce exposure of personnel, it is best to implement shielding partially isolating the instrument from the TPC. The software for the TCM is outdated, which limits the capabilities of the instrument and the speed of data analysis. To improve throughput and data analysis quality on the TCM, it is necessary to spend time bringing the software up to modern standards. Finally, the heating stage needs to be tested and needs to pass a Management Safety Assessment.

Benefit

The TCM at IMCL is the primary instrument at INL for engineering scale measurement of irradiated fuel materials. The TCM at IMCL in the TPC confinement is uniquely suited for localized spatial measurement of the microstructural thermal properties used for qualifying new and existing nuclear fuels. The thermal conductivity and thermal diffusivity measurements dictates the critical fuel safety margins including the fuel centerline temperatures. Additionally, the thermal diffusivity and thermal conductivity measurements are used to determine fission gas swelling, release and rod pressurization – all of which are critical to the operation of nuclear fuel rods. There are no backup instruments at MFC for measuring the microstructural scale thermal properties of irradiated nuclear fuel, making the continued performance of the TCM mission critical.

Without these upgrades to the TCM, its continued use will cause significant increases in uncertainty of measurements and will leave the instrument inoperable. The requested use of the TCM is continuing to increase as it is uniquely capable of mission critical microscale measurements of thermal diffusivity and thermal conductivity for nuclear fuel design and qualification. Given the expected increase in nuclear fuel research, we must refurbish and improve the instrument to match current demand increases and prepare these instruments for the future to keep up with future demand.

ROM Cost Estimate: \$350K.

58. IMCL Laser Flash Analyzer (LFA) Laser and Power System Replacement

Description

The laser flash analyzer is one of the most well-renowned instruments in IMCL, used for bulk measurement of thermal diffusivity of irradiated samples. The LFA has a very high throughput of sample measurements and produces consistently reliable results. However, these measurements require the detector to be exposed to the full surface of irradiated samples with little protection. The high individual sample radiation fields and throughput of samples in the LFA is leading to an increase in radiation exposure from previous years. The laser and power components are experiencing declining sensitivity, with individual component failures occurring as soon as 2023, and are expected to occur continuously on a 2-year basis.

Funding for this instrument will be used to purchase a replacement for the vital laser and power systems. Without these components the instrument will be nonfunctional, as such these components are of the highest priority. The funding will also be used for the installation of the new systems and obtaining the necessary vendor support.

Benefit

The LFA at IMCL is uniquely suited for measurement of the most important thermal properties used for qualifying new and existing nuclear fuels. The thermal diffusivity measurements from the LFA are used to dictate the critical fuel safety margins including the fuel centerline temperatures. Additionally, the thermal diffusivity measurement and resulting thermal conductivity calculations are used to determine fission gas swelling, release and rod pressurization – all of which are critical to the operation of nuclear fuel rods. There are no backup instruments at MFC for measuring the engineering scale thermal properties of irradiated nuclear fuel, making the continued performance of these instruments mission critical.

Without these upgrades to the LFA laser components their continued use will cause significant increases in uncertainty of measurements and will leave the instruments inoperable. The requested use of the LFA is continuing to increase as it is uniquely capable of mission critical measurements for nuclear fuel design, qualification, and performance modeling. Given the expected increase in nuclear fuel research, we

must upgrade the instruments to match current demand increases and prepare these instruments for the future to keep up with future demand.

ROM Cost Estimate: \$250K.

59. Analytical Lab Laser Flash Analyzer (LFA) Laser and Power System Replacement

Description

The laser flash analyzer is one of the most well-renowned instruments in IMCL, used for bulk measurement of thermal diffusivity of irradiated samples. The LFA has very high throughput of sample measurements and produces consistently reliable results. However, these measurements require the detector to be exposed to the full surface of irradiated samples with little protection. The high individual sample radiation fields and throughput of samples in the LFA is leading to an increase in radiation exposure from previous years. The laser and power components are experiencing declining sensitivity, with individual component failures occurring as soon as 2023, and are expected to occur continuously on a 2-year basis.

Funding for this instrument will be used to purchase a replacement for the vital laser and power systems. Without these components the instrument will be nonfunctional, as such these components are of the highest priority. The funding will also be used for the installation of the new systems and obtaining the necessary vendor support.

Benefit

The LFA at IMCL is uniquely suited for measurement of the most important thermal properties used for qualifying new and existing nuclear fuels. The thermal diffusivity measurements from the LFA are used to dictate the critical fuel safety margins including the fuel centerline temperatures. Additionally, the thermal diffusivity measurement and resulting thermal conductivity calculations are used to determine fission gas swelling, release and rod pressurization – all of which are critical to the operation of nuclear fuel rods. There are no backup instruments at MFC for measuring the engineering scale thermal properties of irradiated nuclear fuel, making the continued performance of these instruments mission critical.

Without these upgrades to the LFA laser components their continued use will cause significant increases in uncertainty of measurements and will leave the instruments inoperable. The requested use of the LFA is continuing to increase as it is uniquely capable of mission critical measurements for nuclear fuel design, qualification, and performance modeling. Given the expected increase in nuclear fuel research, we must upgrade the instruments to match current demand increases and prepare these instruments for the future to keep up with future demand.

ROM Cost Estimate: \$250K.

60. IMCL TPC Shielding For Reducing Exposure To Personnel

Description

Due to the high concentration of instruments in the cell and the engineering scale measurements performed in the TPC there is a nearly constant high radiation background in and around the cell. To address this, we want to implement intracell shielding that will allow modular separation of instruments during measurements. This will reduce effective dose to instrument scientists and operators, as well as protect instruments from radiation fields that can lower the instrument lifespan. The funding will be used to request engineer designs for shielding that can be moved using manipulators, and to fund the purchase and installation of the solution.

Benefit

This will reduce effective dose to instrument scientists and operators, as well as protect instruments from radiation fields that can lower the instrument lifespan.

ROM Cost Estimate: \$100K.

61. User-facility Data Analyses Station for FIBs, SEM, TEM, XRD, PGS, Thermocalc, and Aviso License

Description

Data and imaging processing require licensed software and high-speed computing resources. As the PIE users continue to grow, the availability licenses and computational resources become very limited. It is more efficient to establish a center stations with high speed computing clusters and all licensed software to perform data and imaging analysis. This center station can be linked to the center data storage for rapid data transfer and reduction.

Benefit

The center station will provide better user experience and will reduce cost to purchase individual licenses and computers.

ROM Cost Estimate: \$400K/year initial, then \$100K/year.

62. Remote Control and Advanced Data Analytics for PIE and Advanced Characterization

Description

Advanced characterization of irradiated nuclear fuel, cladding, and structural materials creating valuable microscopy and spectrum data collected at a speed of ~ 10 gigabytes every day. Enormous amounts of information is stored in the collected data, but the full usage of data remains yet to be achieved. The analyzing capability is significantly limited by the time and resource of staff scientist and the efficiency of data transfer and management. Utilization of machine learning and artificial intelligence models will increase the efficiency of data collection, boost the security of data management, and enhance data analysis efficiency. Most importantly, with the involvement of experience research staff at INL, Machine Learning and Artificial Intelligence models will provide quantitative and unbiased assessment of nuclear material's behavior.

Benefit

Remote Control and Advanced Data Analytics will put INL at the cutting edge for nuclear fuel and materials development and qualification. While other national laboratories are actively investigating the application of ML/AI models into their daily operation, INL will lose the advantages on nuclear materials research if such capabilities are absent. All the science programs, including the emerging capabilities INL is trying to establish will have significant setbacks.

ROM Cost Estimate: \$3-5M.

63. Replace IMCL Shielded Electron Probe Microanalyzer (EPMA)

Description

An electron probe microanalyzer (EPMA) shielded to 3 Ci of 0.75 MeV is integral to post irradiation examination of highly irradiated fuels and other reactor materials. The demand for the present shielded EPMA is such that the instrument is already booked out for the next 14 months – into February 2024.

INL is unable to meet this demand because the current shielded EPMA is not reliable, having been down 50% of CY 2022. A new shielded instrument is sought to provide irradiated fuel analysis for Natrium, NSUF, AGR, BANR, LDRD, and other programs projected to have future quantitative post-irradiation examination needs. This capability will replace the current shielded EPMA, and to the extent possible, interface with the present glovebox and external shielding system. No service contract will be provided for the current EPMA after 2030. Giving the long lead time to install a shield EPMA, the acquisition should start as early as FY-25.

Benefit

EPMA is an essential instrument to generate qualitative chemical composition and fission product data to support nuclear fuel qualification. Due to the current EPMA's unreliability, it is impossible to assure a client or program that milestones can be met, or to secure new work, because we cannot promise that we can deliver. Additionally, parts for the current EPMA are not guaranteed to be available beginning in 2030. Failure to replace this instrument will likely result in the loss of significant programmatic funding, external funding, and will be a vital capability that INL will have lost.

ROM Cost Estimate: \$6M.

64. IMCL LEAP5000 APT Major Components Replacement

Description

The major components such as laser source, power supply, and detection system for LEAP5000 needs to be replaced typically every 4 years.

Benefit

The IMCL LEAP5000 system is the most advanced APT used for nuclear fuel and materials research, and is being utilized nearly 100%, supporting all science programs and NS&T programs. Any failure of those components may cause the system to be inoperable for a significant period of time, and the impact to programs cannot be recovered.

ROM Cost Estimate: \$500K.

65. Replace IMCL Shielded G3 PFIB

Description

The IMCL Shielded G3 PFIB is recognized by everyone at INL as the most critical and utilized instrument for nuclear fuel and materials research for every program. It is primarily used to conduct sample preparation for TEM and APT, and used as SEM with analytical capabilities such as EDS and EBSD for highly irradiated fuels and materials. The service contract is expected to continue for at least 5 years to 2027. After that, we need to replace this PFIB with a new PFIB. In addition, this is one of its kind instrument used for highly irradiated nuclear fuel and materials research, and the impact of radiation on its lifetime can't be accurately estimated.

Benefit

The IMCL Shielded G3 PFIB is recognized by everyone at INL as the most critical and utilized instrument for nuclear fuel and materials research for every program. Failure to replace this instrument is not acceptable as it will have a detrimental impact on all programs for INL.

ROM Cost Estimate: \$2.5M.

66. IMCL ZEISS X-ray Microscope X-ray Source Replacement

Description

The X-ray source typically lasts about 5 years so it is due replacement in FY-28. The X-ray microscope is expected to be operated and serviced until FY-32. INL's current ZEISS 520 Versa X-ray microscope (XRM) provides spatially-resolved 3D imaging of internal defects, inclusions, cracks, and voids. By investing in this capability, INL has been able to provide critical 3D, nondestructive information for both internal and external R&D programs that would otherwise require destructive characterization methods.

Benefit

The ZEISS Versa XRM in IMCL has been used to image a variety of nuclear fuel and materials, such as U-10Zr, U-10Mo, TRISO, SiC cladding, graphite, and a variety of non-nuclear materials such as bio-fuels, batteries, fossils, coal, etc. It is one of most advanced PIE technique IMCL developed in the past couple years, leading the NDE community for fuel PIE. If not funded, the x-ray source may be serviced by the vendor and if it fails all program work has to stop and the lead time to procure a new x-ray source may take up to 12 months.

ROM Cost Estimate: \$500K.

67. PI-98 Nanoindenter Upgrade for Micro-mechanical Testing for IMCL

Description

PI89 gives us future access to XPM (high speed indentation), SPM imaging, 1000C high temperature heating stage, advanced Rotation/Tile stage, and 3.5N high load stage (sold separately based on our need in future). Upgrading to pi89 takes \$68,360. Pi88 and pi89 share several core components. The upgrade could build our nanoindenter into a multifunctional platform.

Benefit

This new nanoindenter will replace the current PI-85 and all programs will benefit from the high throughput characterization and expanded temperature testing range.

ROM Cost Estimate: \$70K.

68. High Temperature Laser Flash Apparatus

Description

The nuclear fuel community need thermophysical property data at a very high temperature range such as thermal conductivity, capability, emissivity, and melting point.

Benefit

Benefit for major programs cannot be realized, such as ATF and space reactor fuels.

ROM Cost Estimate: \$600K.

69. Micro-XRD Analyses Upgrade

Description

The chemical and structural change of nuclear fuel and reactor cladding materials tend to be heterogeneous in very small scales, on the order of micrometer and nanometer. High-quality observations of these micro-features are critical to nuclear technology development and nuclear safety. Microbeam techniques such as the Transmissive Electron Microscopy (TEM) helps with our understanding of these heterogeneity at the scale of a few nanometer to 20 micrometer, while bulk X-ray Diffraction (XRD) analysis (what we are equipped with at IMCL and FASB currently) provide information at the scale of 10-15 millimeter. There is a lack of analysis capability at INL for obtaining chemical and crystal structural information in the range of 100 micrometer to 5 millimeter, which is critical to a whole-picture understanding of nuclear materials.

Benefit

The proposed addition of microbeam capability on the XRD will be able to provide high resolution structural and chemical information of nuclear materials at 100um to mm range. With the ongoing development to analyze irradiated fuel samples at high-temperature in-situ on the XRD, micro-beam capability will enable analysis of regional phase and structural transition during the high-temperature experiments. This capability is not available in any other research laboratories in North America. Therefore, this upgrade will strengthen our capacity as a user facility, as well as better facilitate the cutting-edge research that is critical to the innovation of nuclear technology that is much needed in our rapidly changing world.

ROM Cost Estimate: \$100K.

70. HC#6 Glovebox ICP-AES

Description

The Analytical Research Laboratory (ARL) purchased and installed a replacement Teledyne Leeman Labs Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) glovebox system in FY-19. The instrument purchased and installed was “like for like” replacing the original install dating from approximately 2008. The glovebox is a harsh environment for the instrument to operate in. The original install began experiencing issues in approximately 2017 resulting in frequent failures preventing sample analysis. Failure to maintain the ICP-AES glovebox system makes the lab vulnerable to loss of sample throughput, which in turn affects several programs at the INL. With this knowledge, the ARL anticipates needing to replace the glovebox ICP-AES within the next 5 – 6 years.

Benefit

The purchase and installation of a new ICP-AES glovebox system will ensure the latest technology is incorporated into the instrument and allow uninterrupted processing of samples using this capability. A “like for like” replacement instrument ‘s lead-time for manufacture, test, install, and startup is 8 – 10 months. Replacement prior to intermittent failure will allow continuous reliable functionality and reduce the risk of irreparable issues occurring that impact programmatic needs.

ROM Cost Estimate: 1M.

71. ICP-ToF-MS

Description

The ARL purchased and installed a TOFWERK GmbH Time-of-Flight Mass Spectrometer (ICP-ToF-MS) in FY-19. Where typical mass spectrometers must calibrate in different mass ranges, the ICP-ToF-MS simultaneously measures all isotopes. This enhances sample throughput and decreases sample preparation; analysis times and produces less waste.

Currently, the ARL has coupled the ICP-ToF-MS with LA-LIBS. The laser ablates a material of interest to generate a plasma plume. ARL researchers then use argon as a sweep gas to carry the plume to the ICP-ToF-MS for isotopic analysis.

To mitigate negative impacts to programs the ARL has a replacement schedule for this instrument. Deferring replacement will increase the risk of instrument failure. Maintaining this capability in the ARL is critical to meeting programmatic needs and a leading role in nuclear research.

Benefit

The ICP-ToF-MS instrument records a complete mass spectrum that doesn't miss an analyte or interference signal. The instrument is high resolution allowing for separation of interfering ions. The ICP-ToF-MS has a robust sample introduction interface allowing for multiple sample introduction techniques. In addition to the LA-LIBS, the ICP-ToF-MS can also couple with gradient polymer elution chromatography (GPEC), multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS), high-performance liquid chromatography (HPLC), etc., enhancing the R&D capabilities of the ARL. Surface profiling using the LA-LIBS as the sample source to the ICP-ToF-MS gives information on homogeneity of how the composition of a substance varies by depth.

ROM Cost Estimate: 1M.

72. Single Quadrupole ICP-MS

Description

The Analytical Research Laboratory (ARL) purchased and installed two PerkinElmer single quadrupole Inductively Coupled Plasma Mass Spectrometers in FY-21. The ICP-MS is the most requested sample analysis capability by programs sending samples to the ARL for analysis. Most samples processed through an ICP-MS instrument require only a bench-top configured instrument. However, approximately 10% require more robust containment such as an instrument coupled with a fume hood or physically located within a fume hood environment. Therefore, the first instrument was installed in a bench-top configuration and the second was placed into an oversized fume hood. Given the volume of samples processed using the ICP-MS instruments, the instruments begin to experience intermittent failures. The ARL anticipates the need to replace the individual ICP-MS instruments every 8 – 10 years due to obsolescence of components, user interface software becoming unsupported and/or because of heavy use of the instrument. Currently there is redundancy in this capability allowing for a staggered replacement schedule.

Benefit

Purchase and install of a new ICP-MS instruments will ensure the latest technology is incorporated into the instrument and allow uninterrupted processing of samples using this capability. Maintaining this capability in the ARL is critical to meeting programmatic needs and a leading role in nuclear research.

ROM Cost Estimate: 1M.

73. LA-LIBS

Description

The ARL purchased and installed an Applied Spectra Laser Ablation-Laser Induced Breakdown Spectrometer (LA-LIBS) in FY-19. The LA-LIBS is capable of isotopic and elemental surface profiling of irradiated fuels and cladding. ARL researchers designed a sealed sample chamber allowing the instrument to be installed and operated on a bench top with connection to suspect exhaust.

Currently, the ARL has coupled the LA-LIBS with ICP-ToF-MS. The laser ablates a material of interest to generate a plasma plume. ARL researchers then use argon as a sweep gas to carry the plume to the ICP-ToF-MS for isotopic analysis.

To mitigate negative impacts to programs the ARL has a replacement schedule for this instrument. Deferring replacement will increase the risk of instrument failure. Maintaining this capability in the ARL is critical to meeting programmatic needs and a leading role in nuclear research.

Benefit

Surface profiling using the LA-LIBS as the sample source to the ICP-ToF-MS gives information on homogeneity of how the composition of a substance varies by depth. Additionally, the LA-LIBS system allows for a near layer-by-layer reconstruction to be performed and compared to theoretical gas generation predictions that are currently utilized by reactor design models. The LA-LIBS provides an expanded capability for nuclear research programs and avenues for INL research publications.

ROM Cost Estimate: 1M.

74. Plasma 3 MC-ICP-MS

Description

The Analytical Research Laboratory (ARL) purchased and installed a Nu Instruments, LLC Plasma 3 Multi-Collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS) in FY-19. The Plasma 3 instrument was installed in room B-159 with a fume hood interface. These instruments have an approximate 8 – 10-year life expectancy. Technological advancements rapidly make the instruments obsolete. As the instrument ages there is risk of increased downtime for repairs because parts become difficult to find and interface software being no longer supported. To mitigate negative impacts to programs the ARL has a replacement schedule for this mission critical instrument. Maintaining this capability in the ARL is critical to meeting programmatic needs and to maintain a leading role in nuclear research.

Benefit

The purchase and installing a new MC-ICP-MS will ensure the latest technology is incorporated into the instrument and allow uninterrupted processing of samples using this capability. A replacement instrument's lead-time for manufacture, test, install, and startup is 12 – 18 months. As the current multi-collector reaches end-of-life, having the ability to operate both instruments at the same time gives ARL research personnel the opportunity to qualify the new instrument prior to taking the old out-of-service.

ROM Cost Estimate: 2M.

75. Gas Chromatograph

Description

Gas chromatography (GC) coupled with a range of possible detection techniques, such as thermal ionization, flame ionization, and mass spectrometry, provides the ability to measure gaseous elements and compounds, as well as volatile liquids and solutions of solids. GC instrumentation is standard in most analytical laboratories and provides access to measurements currently outside the capabilities of the Materials and Fuels Complex Analytical Research Laboratory (ARL). The GC chromatograph consists of one or more coiled separations columns that are housed in an oven providing the temperature control necessary to fine tune separations and maintain the gaseous state of the species under investigation. The columns themselves are highly customizable, also contributing to the ability of GC to effect difficult separations. The separated analytes, as they elute from the column, are then identified and characterized by the detection techniques mentioned above.

Benefit

The ARL currently operates a high-resolution gas mass spectrometer (GMS), some of whose functions overlap with those of a GC. There are some important differences, however, that make having both types of instruments advantageous. For example, the GMS requires an additional, expensive heated inlet system for the measurement of volatile liquids, and the introduction of these types of samples presents technical challenges. On the other hand, rapid introduction of volatile liquids to a GC is straightforward because of its simple oven apparatus and preheated columns. Furthermore, the measurement of solutions containing solids with molecular masses up to c. 300 daltons is possible in GC instruments but not possible for the GMS. The ability to measure such solutions provides a powerful tool that the ARL does not currently possess for the characterization of small molecules. The ability to measure small molecules by GC opens opportunities for collaborations on research and development on speciation studies, particularly pertaining to the complexation of actinide elements critical for environmental remediation and decontamination efforts.

Measurement of species in the GC mass range fills a gap in capability between atomic species, currently measured by a suite of inductively-coupled-plasma (ICP) instruments in the ARL, to molecules heavier than 300 daltons, which are able to be characterized by the ARL's high performance liquid chromatograph (HPLC).

ROM Estimated Cost: \$400K.

76. MKS VISION 2000-P XD

Description

The MKS model Vision 2000-P XD is a high sensitivity, low resolution gas mass spectrometer. This spectrometer is a compact piece of equipment which utilizes the small size of a quadrupole and its oscillating electric fields to quickly separate gas ions based on their mass to charge ratio. This technology is robust and has been well developed within the field of analytical chemistry. With a minimal power requirement and lack of moving parts, the instrument is mounted on a mobile cart and can be moved to a process or gas source requiring analysis with minimal efforts.

Benefit

The combination of mobility and gas analysis capabilities is something that the Analytical Research Laboratory has not previously possessed. A mass range of 1-300amu and ppb detection levels make this an ideal instrument for analysis of noble gases such as xenon and krypton. A mass unit resolution will allow for isotopic analysis of these gases and is a complementary method to the newly installed gas chromatograph in the ARL. An eleven order of magnitude detection range gives the instrument the flexibility to measure pure gases as well as sub-ppm impurities and a 10-150torr inlet pressure range gives it similar sampling capabilities to previous gas instrumentation in the ARL.

ROM Estimated Cost: 100K.

77. Large Casting Furnace

Description

This system is for casting slugs of metallic fuels such as U-10Zr and other compositions, using the manufacturing methods employed to produce fuel for EBR-II and other SFRs. It is a large injection casting system sized to the criticality safety limit for 20% enriched material, capable of casting approximately 200 slugs per batch. This design is similar to the casting furnaces used to produce EBR-II fuel, but incorporates a number of design improvements adopted as part of design work for the Versatile Test Reactor program, which yielded a completed, final design.

Benefit

This system permits casting of large quantities of fuel slugs to support engineering-scale manufacturing of fuel. This capability is required for future anticipated work such as lead test assemblies for planned demonstration reactors, as well as for supporting manufacturing development work for manufacturing capabilities already in place or planned for construction across the world in the coming years. Additionally, operating such a system would be an essential element to achieve initial production capability within a Reactor Fuels Research Laboratory and would thus allow mitigation of one of the most important risks to that facility in parallel with the design and eventual construction of it.

ROM Estimated Cost: 2.5M.

78. Irradiation Experiment Equipment Deployment and Resiliency

Description

A Swagelok welding system would be deployed in FMF in support of irradiation experiment efforts to replace the current system which has become dated and unreliable. The equipment was procured under a previous indirect purchase but not installed at the initially targeted location. It is now intended for installation in FMF to align with programmatic needs. Additionally, critical spares and additional hardware/components for research equipment would be procured to ensure research equipment downtime is minimized.

Benefit

Deploying the new Swagelok system in FMF would replace the existing unreliable system, significantly decreasing the chance of having to rework rodlets or capsules containing transuranic specimens for irradiation experiment purposes. Several of these equivalent Swagelok systems have been deployed at other locations at INL, including TTAF and EIL, primarily in support of non-fueled work. Additionally, the same system was deployed in AFF to support assembly of uranium-bearing irradiation experiments, but transuranic fuel cannot be handled here. The benefits are multifold by replacing an old system and also consistency in equipment deployment across many INL locations.

The critical spares component of this item includes establishing an available supply of items that facility, research, and engineering personnel identify are most likely to fail or need replaced in research equipment. For example, solenoids in gloveboxes, hardware constituents of polishing systems, or other items commonly identified that need repaired, replaced, or deployed. These are often long lead items and have months-long effects on research throughput as they are not currently procured until a failure is identified. This will also cover upgrades and additions in minor laboratory equipment such as balances or organization and storage equipment.

ROM Estimated Cost: \$300K.

79. Powder Testing Center

Description

This is a compact, self-contained system used to measure physical properties and pressing characteristics of ceramic powders. It measures and logs properties such as bulk density, tap density, angle of repose; and pressing characteristics during test pressings including load profiles, die wall friction, compression coefficients, green density, and compact strength. It's designed to support ceramic process development, optimizing powder properties for fabricability and pressing parameters to be transferred to larger-scale R&D or even production operations. The equipment has been used for decades in the nuclear industry to support development, qualification, and optimization of UO₂ production.

Benefit

With MFC's expanding ceramic capability into a broader range of diverse ceramic nuclear fuel materials, and a growing need to move beyond fabrication demonstrations toward process optimization for manufacturing scale-up, there's a growing need to enrich our capabilities with equipment to support a more scientifically robust and data-driven approach to process development. This capability will help to differentiate INL from other labs pursuing development of newer and more advanced ceramic fuel materials, with higher operating temperatures and more challenging fabrication conditions.

ROM Estimated Cost: \$310K.

80. FFNMM Radiological Facility Nuclear Material Inventory and Storage Enhancements

Description

The continuously increasing demand for nuclear fuels research has stretched nuclear material inventory processes and storage schemes within MFC's radiological facilities beyond what the existing infrastructure was intended to support. The wide variety of DOE programs, DOD programs, industry and commercial interest, university partnerships, and other strategic fuel research activities has resulted in an unprecedented demand for radiological facility capability.

This item covers several specific investments that will result in a more robust capacity to meet growing demand on fuel research inventory and administrative infrastructure. It includes funding for the following items:

- Continued software upgrades to NUTRON to allow the material tracking software to better support efficient material tracking and transactions and increase usability [resulting in fewer error-likely scenarios]

- Material storage solutions within FASB, EFF, and AFF that offer enhanced material access and security. Computerized lockers or key box type systems will allow for increased control on which users have access to which areas, and also allows for robust tracking of anytime material is accessed and by which user
- Additional IT infrastructure within FASB, EFF, and AFF to allow researchers that process nuclear material better and more accessible options to view and update inventory in as close to real time as possible
- This funding also supports investigation of an enhanced material labeling system which would incorporate barcoding systems into NUTRON for more automated material transaction processing.

Benefit

FFNMM radiological facilities see hundreds to thousands of material transactions each month. Every action performed on nuclear material results in the need to update the facility-level inventory. For obvious reasons there is zero room for error when it comes to nuclear material storage and inventory maintenance. The growing number of nuclear fuel research efforts serves to benefit both in accuracy and efficiency through an investment in related infrastructure. These items above decrease the likelihood of human performance discrepancies having any effect on material storage/transactions by creating a more robust framework for material handling.

An additional MBAC supports the increased number of material movements and transactions, which ultimately have to flow from researcher, through the facility MBAC, to Safeguards personnel. The nature of working with these materials and the associated rulesets create a significant administrative burden that taxes current MBACs and further hampers research activities in the event an MBAC is out of the office.

The proposed storage improvements with NUTRON software enhancements result in better methods of controlling nuclear material. Making software more user-friendly decreases the likelihood of an error occurring, and also allows for research activities to happen more rapidly. Implementing more user-specific access controls allows researchers access only to the materials they are using and tracks any access instances, resulting in a more robust material security posture.

Investigating a barcode system for future investment is the next step in material tracking. Barcode or QR inventory systems are in wide use commercially to allow real-time updates to inventory and locations, and it's only natural to implement this improvement to nuclear material transactions within radiological facilities where stringent inventory requirements are in place.

Facility Risk

Without additional investments in infrastructure related to nuclear material storage and transactions, the ability to handle and process these actions becomes the limiting factor in the ability to conduct fuels research. Process steps and material transfers or movements become delayed until the requisite administrative activity is performed to update inventory or transaction approval.

A wholistic approach is required to upgrade multiple elements of material storage and transacting to enhance resiliency. Given the nature of research efforts and the unique ways nuclear materials are processed in support of these endeavors, it's impossible to remove the human element. However, these proposed steps significantly decrease the risk of an error occurring and further, they decrease the consequences of a human-caused error when transacting with nuclear material.

ROM Cost Estimate: \$2.5M.

81. AFF Pelletizing Equipment

Description

This item would deploy equipment required to fabricate fuel pellets in the new inert glovebox in AFF. The glovebox and a furnace will be installed in FY-24, and adding sieving, milling, and pressing equipment will complement the capabilities currently housed in the HDF glovebox in EFF to fabricate uranium-bearing nuclear fuel pellets.

Benefit

A new glovebox and furnace are funded IPL items planned to be installed in AFF in FY-24. To further make use of these capabilities, pelleting equipment would be procured and installed within this new glovebox. This would essentially double the fresh-fuel pellet throughput capacity at MFC, allowing better support for collaborators and customers pursuing quantities of pellets that exceed current lab-scale abilities.

ROM Estimated Cost: \$250K.

82. Non Rad Inventory Tracking System

Description

This system includes several automated features to help remove opportunities for human error when maintaining an accurate inventory of materials. It includes features to manage secure storage of materials in lockers and other storage locations, such as maintaining complex access lists and logging access to storage locations. It also improves functionality of sample labels and incorporates mobile computing aids to allow inventory system interaction at the same locations where samples are stored and used. Finally, this system is designed to maintain compliance with applicable quality assurance requirements.

Benefit

A robust and purpose-deployed system is required to ensure quality materials are handled and inventoried in compliance with quality assurance requirements. The last 5 years have seen a significant increase in piece-count of items that require special storage and tracking, significantly increasing the administrative burden to maintain an inventory in a dated Excel-based system. Additionally, this system will allow for live updates and maintaining material history and tracking as material is consumed or assembled from individual components into assemblies, thus decreasing the likelihood of human error associated with manual entry processes.

ROM Estimated Cost: \$250K.

83. CryoMill

Description

The Retsch 2012 CryoMill is a powerful cryogenic grinding apparatus for ball milling at extremely low temperatures (-196°C). Through use of liquid nitrogen, the mill jar is continually cooled, causing embrittlement and preservation of volatile compounds within the sample material. The system allows for samples up to 20 mL in volume, and interchangeable media and jar materials to tailor to project needs.

Benefit

This is beneficial in the size reduction of metallic powder feedstocks such as Al, Fe, Zr, and U based alloys. Reduced particle size is an ever-growing demand for the sintering and additive manufacturing industries, not to mention the mechanical alloying capability for normally ductile materials. This allows for the formation of engineered nanostructures homogeneously across an atomic matrix. This capability would also allow for the formation of compounds that could not be formed at room temperature.

ROM Estimated Cost: \$250K.

84. Fuse 1 SLS Printer

Description

This widely used by highly capable additive manufacturing system produces high-quality components in nylon and offers capabilities well beyond plastic 3D printers at MFC. It is simple to use with low maintenance requirements, but quickly and reliably produces parts with sufficiently fine detail for nearly all anticipated applications, and with the structural strength to confidently withstand physical handling for evaluation.

Benefit

It will simplify and streamline work already occurring to quickly produce physical demonstrations of components and systems to support design as well as communication on complex designs and showcasing ongoing work. It will also complement existing machining capabilities to quickly produce physical prototypes for testing and evaluation where rapid, iterative design is important such as fixtures, tooling, etc. Finally, expanded use of such capabilities by Advanced Manufacturing personnel withing FFNMM will support familiarity with other AM systems that are more expensive and/or more difficult to reliably operate, and help them stay proficient in a rapidly evolving industry.

ROM Estimated Cost: \$110K.

85. Fueled Experiment Brazing Capability

Description

This brazing equipment would include 2 systems; one high energy and one low energy. The equipment would be located in AFF where both systems will fit on one benchtop taking up an approximate footprint of 3'x 6'. The systems each include a power supply box, a remote heat station, and a water circulating reservoir. 2 systems are necessary to provide high or low energy brazing appropriate for large and small vessels respectively. This equipment provides the capability to seal complex instrumentation into most experiment geometries currently being assembled at MFC.

Benefit

Irradiation experiments are increasingly demanding incorporation of instrumentation packages into the fueled portion of the assembly to allow for in-situ measurement of irradiation performance data. This is especially true for TREAT experiments where PIE data may not be conclusive when the intent of the irradiation test is to bring the specimen to failure. ATR tests are also seeing an increased demand for active instrumentation to allow for real-time monitoring of temperature or other performance characteristics. Current sealing methods typically rely on mechanical gland seals. INL has gained significant experience with these since the 2017 TREAT restart, realizing the limitations and risks associated with their hermeticity and reliability. Brazing capability provides a robust sealing option for metal and dissimilar metal seals and joints, but INL lacks robust brazing capabilities in radiological facilities. This capability is critical to ensure INL can incorporate instrumentation into fueled experiments to gather real-time performance data and ensure experiment objectives are met.

Facility Risk

Without pursuing this capability, irradiation experiments and other applications that demand a robust hermetic feedthrough of instrumentation will continue to be at high risk of leaks, failure, or the inability to integrate instrumentation packages into fueled specimens. This includes assembling future irradiation

experiments for TREAT as part of the Halden gap closure efforts, and the ability to incorporate instruments into current and future ATR tests, especially as the ATR I-loop capability is established.

ROM Estimated Cost: \$175K.

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Appendix D

Detailed Descriptions of TREAT Instrument Capability Activities

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1. Transient Testing Experiment Preparation and Handling

Description

TREAT experiment vehicles are complex systems that require dedicated equipment to support assembly and checkout, post-test disassembly characterization of low-activity experiments, preparation of high-activity experiments for transfer to INL PIE facilities, and remote loading and assembly of experiment vehicles in the Hot Fuel Examination Facility (HFEF).

Repurposing of and modifications to the TREAT Warehouse (MFC-723) are underway to establish the TREAT Experiment Safety Building (TESB), co-located adjacent to the TREAT Reactor Building (MFC-720), ideal for cross-cutting TREAT experiment support. TESB facility projects include:

- Installation of a building HVAC system and sealing of building doors to provide building climate control for year-round use and to reduce dust entry into the facility.
- Reinforcing selected locations on the building floor (a concrete slab), construction of a separately ventilated confinement room for installation of heavy equipment, and establishment of the TESB as a Hazard Category 3 nuclear facility, to allow experiment preparation with previously irradiated fuel rods.

TREAT experiments continue to grow more complex, as expected, and require specialized skills and equipment for assembling experiment vehicles. Experiment assembly and disassembly equipment is proposed to be acquired in a manner to add increasing functionality at the times when developing experiment programs will need it. Specific equipment acquisitions proposed for multi-mission experiment capability include:

- Procurement and placement of equipment needed for simple experiment assembly of fresh fuel tests, including an inert atmosphere glovebox.
- Procurement and installation of equipment, including a tall inert-atmosphere glovebox, for closing and assembling larger fresh fuel tests, such as would go into the TWIST capsule or TWERL loop for simulated LOCA testing of LWR fuel.
- Procurement and installation of equipment needed for closure of experiment capsules requiring light contamination control.

Functionality to support LWR fuel testing, and perhaps fast reactor fuel testing, includes:

- Procurement and installation of a shielded cell and glovebox, named the Experiment Preparation and Inspection Cell (EPIC) for remote installation of instrument sensors onto previously irradiated fuel rods intended for irradiation the Advanced Test Reactor (ATR) and transient testing in TREAT (a key capability for backfilling the loss of the Halden Test Reactor).
- Design, fabrication, procurement, and assembly of the fuel rod instrumentation bench that will be located inside EPIC for instrumenting previously irradiated fuel rods.

Larger experiment vehicles, such as the TWIST capsule and the TREAT flowing sodium (Mk-IIIR) loop (described in Sections D.2 and D.3, respectively) require a larger outer container than the 4-in.-by-8-in. Broad Use Specimen Transient Experiment Rig (or BUSTER container) design used following TREAT restart in 2018. So, during FY-1023 TREAT transitioned to the Large Experiment Capability, which provides a 10-in.-dia. irradiation position in the core center, which accommodates large, cylindrical experimenter containers, such as the current Big BUSTER container. The Big BUSTER container configurations require fixtures for temporary storage of experiments in TREAT storage holes and modifications to experiment handling and support equipment, such as the TREAT Loop Handling Cask

and the TREAT Neutron Radiography Stand. Some of that effort was completed in FY 2023, but more remains for FY 2024 completion.

Other capabilities supporting multiple programs and sponsors are being established or are proposed. The TREAT Neutron Hodoscope is a unique capability that allows time-dependent sensing of fuel motion during transient tests, and further investment in modern hardware and imaging techniques will allow better information to be obtained from tests. That capability is being brought up to 1980s functionality, but with modern instrument electronics and computer data acquisition. Additional work is proposed to push the hodoscope techniques and hardware to greater functionality, allowing experimenters to obtain higher-resolution images of real-time fuel motion. Other work underway and proposed seeks to apply new sensing technologies to TREAT experiment instrumentation so that experimenters can obtain all the measurements possible and monitor all the phenomena possible.

Benefit

Many TREAT experiments will be conducted on low activity samples (fresh fuel or small samples) that will require minimal shielding during post-transient handling. Within the TESB, a specialized test train assembly facility supporting TREAT, similar to the Advanced Test Reactor (ATR) Test Train Assembly Facility (TTAF), built and equipped in Phases 1 through 3 will provide equipment and space for rapid assembly, modification, and repair of test rigs prior to installation in the reactor. Currently, assembly of TREAT experiment vehicles is performed ad hoc in temporary spaces in the Experimental Fuels Facility (EFF) or the Advanced Fuels Facility (AFF) and in part on the TREAT operating floor. A dedicated space adjacent to the TREAT Reactor Building will allow timely and efficient experiment preparation and will reduce the opportunity for experiment damage due to transfer from facilities inside the main MFC fence.

The installation and equipping of EPIC will provide a key component of INL Halden replacement capability. Again, co-location of this area within vicinity of MFC fuel fabrication facilities is important to timely and efficient support of experiments and integration of system design and performance testing with ATR and TREAT operations staff.

Investments in experiment monitoring and instrumentation, as described above, will enable increasing amounts of information to be gleaned for transient tests, maximizing the value of the value obtained from resources spent on transient testing.

ROM Cost Estimate (TESB modifications and experiment prep equipment): Based on conceptual and pre-conceptual designs available to date, for FY-24 to FY-28 (to be proposed from multiple funding sources).

- TESB Building Modifications \$3.8M (excluding the EPIC cell and specialized equipment; see the next section in this appendix)
- Multi-mission experiment assembly/disassembly equipment \$2.5M
- EPIC procurement and installation \$7.8M
- EPIC instrumentation equipment \$3M.

Cost Estimate (Large Experiment Capability fixtures and modifications in the TREAT facility): \$1.15M, for FY-24

ROM Cost Estimate (Next-Generation Hodoscope and In-Pile Instrumentation): \$11.7M, for FY-24 to FY-28.

2. LWR/ATF Fuel Testing

Description

Equipment needed to test current and developmental LWR fuel designs, including Accident Tolerant Fuels (or ATFs) is distinguished from other TREAT test equipment by providing static or flowing water environments. The targeted temperatures in such testing, typical of LWR accident conditions, are lower than in testing of other fuel types (e.g., fast reactor fuel designs), so the experiment hardware is not usually challenged temperature but is necessarily designed to maintain internal pressure typical of water and water-steam mixtures at those temperatures.

Because nuclear fuels are most susceptible to failure in their degraded end-of-life condition, access to and use of this material type is crucial to the success of any transient testing program. Testing of irradiated LWR fuel samples in TREAT (or ATR) requires removal and resealing of samples extracted from full-length fuel pins irradiated in commercial power reactors. Because LWR fuel rods are typically 10 to 12 feet long, the capability to shorten the fuel rods to fit into TREAT and ATR test vehicles is necessary. Testing plans also call for incorporation of instrumentation into the previously irradiated test rods, which requires a small, shielded hot cell equipped for remote attachment of instrument sensors and leads to fuel rods and experiment vehicles. Although this capability is expected to be requested for testing of fast reactor fuels in flowing sodium loops as well, at this time only the LWR test program requires this capability.

Devices of this type have been developed for use by virtually all peer nuclear testing institutes around the world and can be procured for use. Two versions of these specialized devices are planned to enable this process at INL, which is essential for INL to fulfill its mission to test accident-tolerant fuel design and high-exposure fuel designs for LWRs. The first device targeted for HFEF, the **Re-Fabrication Bench**, simply allows for rod sectioning, extraction of excess fuel pellets, installation of new end plugs, and re-pressurization of the pin. A second device, the **Fuel Rod Instrumentation Bench** intended for the EPIC cell in the TESB, provides equipment for the installation of instrumentation necessary for scientific studies and fuel qualification testing.

Facility assessment and cost estimates for the shielded instrumentation capability were completed in FY-17 and are documented in TEV-3093. The design and acquisition of this equipment is currently supported by the Advanced Fuels program. Equipment and irradiation vehicles needed for LWR fuel testing, including equipment needed for post-irradiation examination and for fuel rod refabrication in HFEF, have been designed and procured (to date) using funds from DOE-NE programs. Similarly, the tests used to commission the experiment vehicles have been funded by DOE-NE programs. However, other funding sources might be appropriate for selected test capabilities that will support multiple users, and specific instances of test hardware will be funded by individual test sponsors.

Other needed capability includes design, first assembly, and commissioning of LWR experiment vehicles and the fixtures and equipment needed to load and unload the vehicles in HFEF. Specific experiment vehicles include:

- **Transient Water Irradiation System in TREAT (TWIST)** – Adaptation of the MARCH-SERTTA vehicle to allow testing of single fuel rods under loss-of-coolant accident (LOCA) conditions. Will have the capability to perform Loss of Coolant Accident's (LOCA's) and Reactivity Initiated Accident's (RIA's) with side loading of fuel capability to remove interference of the cable heaters and TC support arms.
- **TREAT Water Environment Recirculating Loop (TWERL)** – Based on systems used in INL's Power Burst Facility in the 1970s and 1980s, this loop will accommodate small bundles of fuel rods up to 1.2m in active fuel length for testing under full forced convection. The test layout enables in-situ heat balance measurements for increased confidence in core-to-specimen power coupling for

high-value pre-irradiated specimens where uncertainties in end-of-life isotopic composition can increase uncertainty in nuclear heating predictions. Will have the capability to perform Loss of Coolant Accident's (LOCA's) and Reactivity Initiated Accident's (RIA's) with prototypic coolant flow conditions, necessary for assessing time-dependent phenomena and post-failure fuel behavior.

Reestablishing TREAT loop handling testing capability will require an assembly and checkout station to support water and sodium loops in HFEF. Flow tube assembly will be performed at HFEF Stations 5D and 4D. Loop assembly will be performed directly into the cask container. The loop station will support full operational testing of the loop before shipment to TREAT for transient testing.

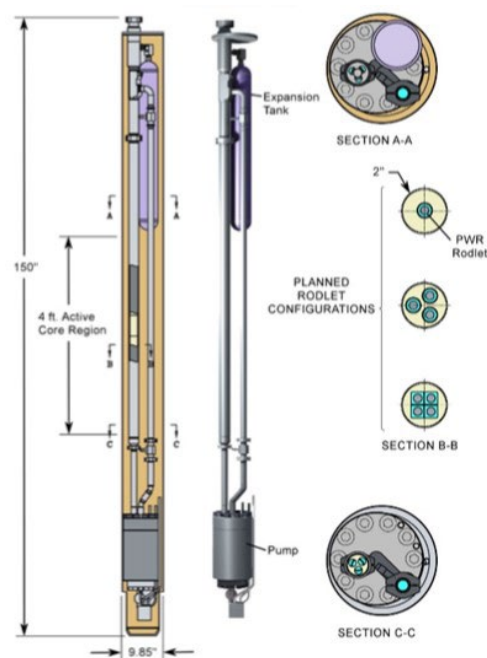
Another important experiment system needed to simulate LWR accident conditions is a ^3He injection system, used to clip TREAT transient pulses more quickly than possible with the TREAT Transient Rod Drives. The **Helium-3 Enhanced Negative Reactivity Insertion (HENRI)** system is being designed to provide pulse width (full-width half-maximum) narrowing to as low as 40 msec, enabling power pulses of the type expected for PWR and BWR Reactivity Accidents (RIAs). (See later in this appendix for more on HENRI.)

Benefit

Testing of new and advanced LWR fuel designs, including ATFs, was one of the objectives that motivated TREAT restart. The collaboration between DOE and industry in the ATF program has successfully brought forward several designs with prospect for greatly improved behavior in severe accidents and for possible burnup extension (which would improve LWR fuel cycle economics by increasing fuel utilization). Establishing beneficial behavior during design basis accidents and postulated severe accidents is key to claiming the benefit of new fuel designs, and TREAT offers what could well be the best transient testing capability for that purpose, augmenting the capabilities provided by ATR and other steady state irradiation reactors in backfilling the loss of the Halden Test Reactor. Completion of the infrastructure needed for LWR fuel testing will allow INL and TREAT to provide test data and to meet key expectations that motivated restart.

Further, the irradiated fuel rod instrumentation capability is needed for fuel testing I-loops being built for insertion into ATR, and will thus comprise part of INL's post-Halden capability.

ROM Cost Estimate: Roughly \$33M over FY-21 to FY-25.



**TREAT Water Environment
Recirculating Loop (TWERL)**

3. Fast Reactor Fuel Testing

Description

Equipment and irradiation vehicles needed to test fast reactor fuel designs is distinct for providing high-temperature testing environments that can simulate the time-dependent temperature experienced by fast reactor fuel rods in either static capsules or flowing coolant loops. Targeted test temperatures are relatively high, 500 to 700°C for sodium cooled fast reactor (SFR) fuel and higher for other coolants such as lead or molten salt. Test vehicle pressures for these coolants, with their relatively high boiling temperatures, are near ambient. Currently, only static capsules and flowing sodium are planned for transient testing of fast reactor fuel designs, and those capabilities are adaptable to investigate some aspects of fuel behavior for fuel designs intended for lead-cooled fast reactors and gas-cooled fast reactors. But environmental effects and higher test temperatures would require differently designed loops. Design and commissioning the sodium loop capability is supported by three DOE-NE offices, but specific applications of the capability and expendable components are funded by individual test sponsors.

The experiment vehicles planned for testing of fast reactor fuel design include:

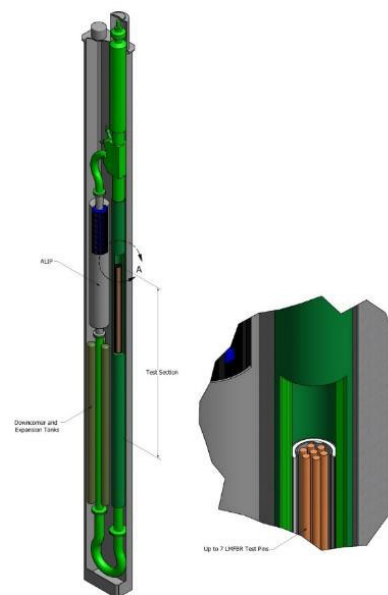
- **Temperature Heat-sink Overpower Response module (THOR)** - Simulates fuel temperature response during early stages of overpower transients in SFRs. The device will be used for Fast Reactor safety research, phase-based properties measurement, and power-to-melt studies for enhanced thermal conductivity fuel.
- **TREAT Flowing Sodium Loop (Mk-IIIR Loop)** - Updated version of the historic TREAT Mk-III sodium loop design with forced convection, for testing small bundles of fast reactor fuel rods in flowing sodium coolant. This capability is essential for assessing time-dependent safety-related fuel behavior and fission product release under design-basis accident conditions, for assessing consequences of post-failure phenomena, and for demonstrating certain passive safety features of metal fuel designs (such as transient axial expansion that inserts negative reactivity during a transient overpower event).

Other projects are underway or planned to establish the infrastructure at INL to support sodium test loops (i.e., test loops for testing and calibrating instruments, sodium loading and unloading) and to load and unload experiments from the Mk-IIIR loop inside the Hot Fuel Examination Facility (HFEF).

Benefit

Testing of new and advanced Fast Reactor fuel designs, particularly for advanced reactor concepts under development such as the Traveling Wave Reactor or Natrium (both by TerraPower) or GE Hitachi's PRISM, was an objective that motivated TREAT restart. The U.S. DOE, and its predecessor agencies, invested considerably in sodium-cooled fast reactors over many decades, and now industry is pulling that technology from the labs and DOE and configuring it in new plant designs to bring to market. Demonstrating safety-related reactor and fuel behavior remains a key need for license approval by regulators. TREAT testing can resolve key issues and quantify fuel failure thresholds to inform those licensing decisions at relatively low cost.

ROM Cost Estimate: Roughly \$17M over FY-21 to FY-25.



TREAT Mk-IIIR Sodium Loop

4. He-3 Injection System Final Design and Hardware Procurement

Description

The Helium-3 Enhanced Negative Reactivity Insertion (HENRI) is a gas injection system designed to inject He-3, a neutron poison, into the TREAT core to terminate a transient pulse more quickly than the TREAT Transient Rod Drives can be inserted, for the purpose of achieving a narrower pulse width. Narrow transient pulses are of interest to sponsors of LWR testing, to be more consistent with conditions expected in postulated LWR reactivity insertion accidents (RIAs), and to Lawrence Livermore National Laboratory (LLNL) and Los Alamos National Laboratory (LANL). RIAs are a class of events to be addressed in regulatory approval of new LWR fuel designs, and testing under representative conditions (i.e., time-dependent deposited energy and time-dependent heat removal) is important to ensure that phenomena of interest are adequately represented. Pulses that are too wide would present a non-conservative assessment of relevant phenomena, while too-narrow pulses would unnecessarily exacerbate phenomena and possibly lead to overly conservative interpretation of results.

Benefit

Completion and installation of HENRI will place TREAT as the only operating transient test facility in the world capable of providing representative LWR RIA test environments. Results from such tests will be important to regulatory approval of new fuel designs, particularly approval to operate reactors in manner that takes advantage of new fuel characteristics. These results would be one piece of the case that allows new fuel designs, such as Accident Tolerant Fuels (ATFs), to be utilized in a manner to reduce LWR fuel cycle cost. In addition, better providing test conditions of interest to LLNL and LANL will open possibility for increased TREAT utilization for NNSA programs, increasing the diversity of TREAT program sponsors and stakeholders.

Facility Risk

If TREAT is not equipped with He-3 capability, then TREAT RIA tests will be less effective for addressing regulator questions about new LWR fuel designs, possibly leading to greater conservatism or fuel cycle penalty imposed on reloads with new fuel designs. Such regulatory could impede introduction of new fuel designs into LWRs. TREAT testing would also be less attractive to LLNL and LANL experimenters, limiting TREAT utilization by those sponsors.

ROM Cost Estimate: \$0.846 spent in FY-23; \$1.445M estimated cost to complete in FY-24.

5. Other Program Investments

Description

Early in its restart life TREAT has been enlisted to assist fuel development and demonstration for nuclear thermal propulsion (NTP) reactors intended for space vehicles. Testing already underway (in the Sirius-2 test series) is assessing the ability of fuel designs to retain form and integrity through expected power-duty cycles, using the Minimal Activation Retrievable Capsule Holder (MARCH) irradiation vehicle system and a capsule design unique for the Sirius test series.

Completion of the Sirius-4 test series calls for prototypic testing in a flowing hydrogen test system (beginning with Sirius-5), something new for TREAT. The system is being designed by a collaborative team of INL and NASA personnel. Specific expertise provided by each organization include INL's expertise in experiment vehicle design and nuclear operations and NASA's expertise in hydrogen safety. The system is comprised of any components, but at its simplest consists of a flowing hydrogen test vehicle connected into the Gaseous Hydrogen (H₂) Supply and Exhaust System is a flow-through system that can supply H₂ (and possible other gases) to experiments and release exhaust gases to atmosphere, and

consists of hydrogen and inert gas storage, gas control panels for the hydrogen and inert gas, gas lines connecting supply to the panels, and the exhaust lines from the experiment. Installation of the supply and exhaust system began in FY-23 and will complete in FY-24. The system design and assembly has been funded by NASA and is scheduled to be available with the Sirius-5 test vehicle in FY-25.

Other investment is needed to modify the TREAT Reactor Building to support micro-reactor demonstrations (see Section 2.6.2.3). The proposed project will equip the TREAT micro-Reactor Experiment Cell (T-REXC, the North High Bay 10-ft pit) with basic infrastructure needed for small (10s of thermal kilowatts) micro-reactors. This includes installation of shield blocks for the north storage pit, installation of industry standard I&C infrastructure, electrical power infrastructure, control room infrastructure, a T-REXC HVAC system, a fire suppression system, and a Reject Heat/Load Bank system. These permanent modifications are required to support any small micro-reactor testbed installed in T-REXC. This project excludes scope for specific reactor systems.

Benefit

Completion of the hydrogen test loop and its installation in TREAT for testing will address many open questions about fuel and material behavior during service while exposed to flowing hydrogen. There is currently no reactor with a flowing hydrogen capability to perform these tests.

The TREAT facility provides operating infrastructure needed for the quickest possible accommodation of shorty-lived, very small micro-reactor demonstrations and tests. Adding the basic infrastructure listed will complete the test bed and minimize the facility work needed for a successful demonstration project. NRIC is pursuing similar, though much larger, modifications to the EBR-II Dome and the ZPPR Reactor Cell for the same purpose of establishing rapid demonstration test beds to facilitate development of new reactor technologies.

ROM Cost Estimate (Hydrogen Test Loop): Roughly \$12M over FY-21 to FY-25 (complete in FY-25 with insertion of the Sirius-5 test).

ROM Cost Estimate (T-REXC): Roughly \$10M over FY-23 to FY-25 (complete in FY-25).