INL/EXT-21-61529

Materials and Fuels Complex FY-21 – FY-25 Five-Year Investment Strategy

March 2021

Idaho National Laboratory

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INL/EXT-21-61529

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FY-21 – FY-25
Five-Year Investment Strategy

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http://www.inl.gov

Prepared for the
U.S. Department of Energy
Office of Nuclear Energy
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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ACRONYMS

AFF	Advanced Fuel Facility
AL	Analytical Laboratory
AMWTP	Advanced Mixed Waste Treatment Project
ANL	Argonne National 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
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
ISA	Idaho Settlement Agreement
LA	laser ablation
LEU	low-enriched uranium
LFTD	laser-flash thermal-diffusivity
LLW	low-level waste
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	National TRU Program

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–Generally engineering judgement estimates for conceptual purposes with a range of -50%/+100%. Used as a placeholder prior to initiating planning activities.
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
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 RD&D enabling test bed at Idaho National Laboratory (INL) and is an integral part of a National Reactor Innovation Center (NRIC) strategy. MFC facilities 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 plan 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, cost, 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 Lab Agenda and DOE-NE programs.
- The 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.

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 Agenda.

MFC's core research and/or production competencies exist in the following areas:

- Nuclear fuels fabrication
- Fuel characterization
- Characterization of radiation damage in cladding and in-core structural materials
- Fuel recycling and nuclear nuclear material management
- Transient irradiation testing
- Nuclear nonproliferation and nuclear forensics
- Space nuclear power
- Isotope Production
- Radioanalytical chemistry
- Focused basic research

The investment strategy for MFC entails 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 areas of emphasis for this strategy include the following:

- Base Operations including plant health – This emphasizes executing efficient base operations as a core foundation to RD&D execution excellence. Plant health refers to additional investment beyond basic preventative and corrective maintenance that addresses revitalization and refurbishment activities focused on improving facility reliability and accelerating research throughput. This supports DOE-NE programmatic objectives by maintaining and improving existing test bed infrastructure and constructing new support infrastructure, as needed, to ensure the safe operation of MFC.
- Mission Enablement – 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 test bed systems and infrastructure. 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 research infrastructure to ensure available 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 enablement ensures reliable state-of-the-art research capabilities are available to effectively operate and maintain a test bed capability as envisioned by GAIN and serves as a foundation of the NRIC. Full cost recovery from research programs for costs related to executing mission related RD&D support activities is still part of the financial model.
- Instrument Science – This area emphasizes RD&D development where MFC has a core strength. This includes collaborating with the Nuclear Scientific Users Facility, INL Nuclear Science and Technology (NS&T) programs, National Homeland Security (NHS) programs, NRIC, 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 enhancing relationships and furthering partnerships with DOE-NE's extended research network to fill capability gaps that will not be added to MFC. This area 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 RD&D capability supporting current programs 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 B
- Detailed descriptions of Transient Reactor Test Facility (TREAT) instrument capability activities in Appendix C.

NOTE: *The cost estimates listed in this document in the tables in Sections 2 and 3 are based upon best engineering judgement at the time the scope was identified by the Mission Directors. In every case the cost estimates will change as work proceeds through planning and then 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. This commitment is not taken lightly. As with any investment, a return on that investment is expected. Implementing this strategy will result 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.

MFC performance metrics focus on factors important to enabling and monitoring MFC's nuclear energy RD&D mission. Metrics (current or being developed) will target the following areas:

- 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
  - Positive feedback from customers (e.g., NS&T, NHS, external industry, small business, and university users)
- Compliance with regulatory requirements, ensuring commitments are understood and met.

1.3 Funding

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 and position this 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 and mission enablement areas 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.

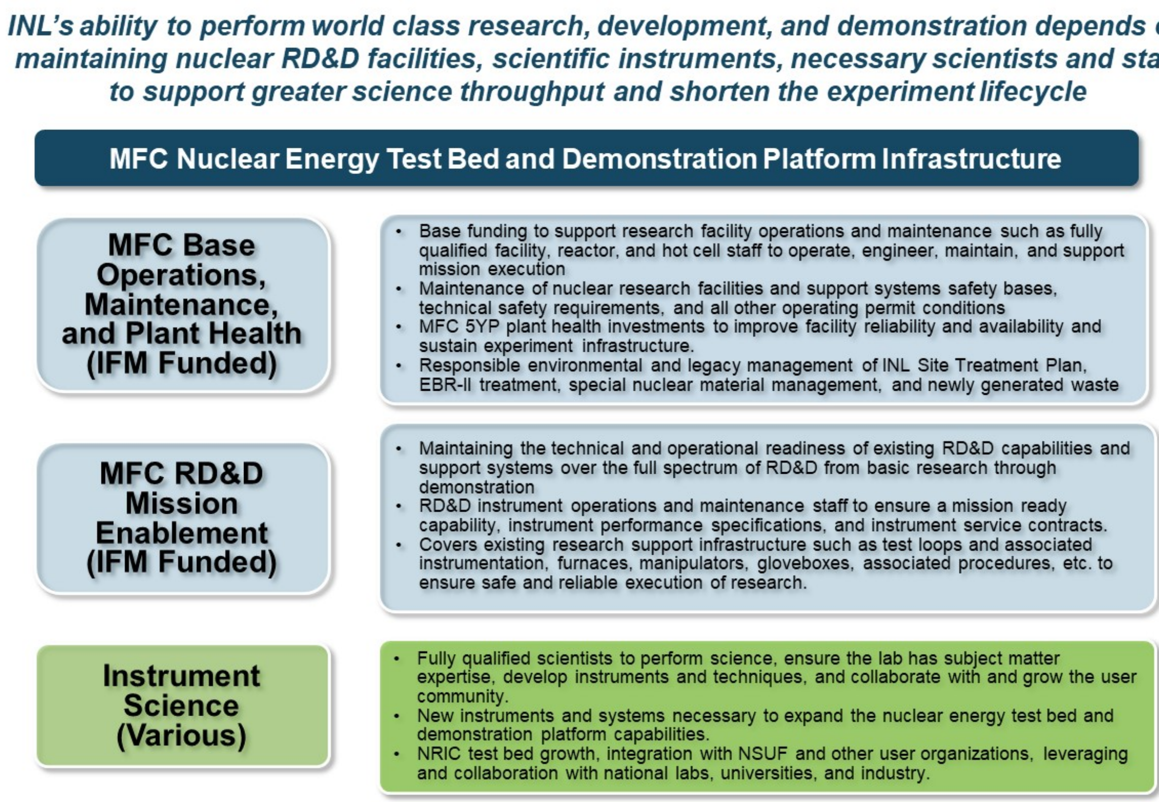


Figure 1. DOE-NE Test Bed and Demonstration Platform Funding Strategy.

2. TEST BED FACILITY INFRASTRUCTURE

Facility Infrastructure has been divided into four primary components:

1. MFC Base Operations and Maintenance – This area 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 RD&D Mission Enablement – This area provides funding above compliance level that provides the technical staff 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 reliability and availability and 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.

B&RC	FY-20 Appropriation Level	FY-21 Appropriation Level	FY-22 Proposed Level	FY-23 Proposed Level	FY-24 Proposed Level	FY-25 Proposed Level
MFC Reactor Operations						
NRAD Operations and Maintenance	2,200	2,266	2,334	2,404	2,476	2,550
TREAT O&M	24,400	25,132	25,886	26,663	27,462	28,286
MFC Reactor Operations Total	**26,600**	**27,398**	**28,220**	**29,067**	**29,939**	**30,837**
MFC Base Operations & Plant Health						
MFC Base Operations & Maintenance	85,867	88,443	91,096	97,829	108,764	112,027
MFC 5 Year Plant Health Investments	15,468	11,206	30,000	30,000	30,000	30,000
MFC Mission Enablement	40,300	41,509	62,754	64,637	66,576	68,573
SNM Program/Processing	4,244	4,371	4,502	4,637	4,776	4,920
SPL OPC's		500	3,450	5,950	6,000	
Total MFC Base Operations and Plant Health	**145,879**	**146,029**	**191,802**	**203,053**	**216,116**	**215,520**
MFC Regulatory Support						
INL Regulatory Compliance	1,447	1,447	11,490	11,535	11,881	12,237
EBR II	8,228	8,228	8,475	8,729	8,991	9,261
MFC Regulatory Support Total	**9,675**	**9,675**	**19,965**	**20,264**	**20,872**	**21,498**
Total MFC Operations	**182,154**	**183,102**	**239,987**	**252,384**	**266,927**	**267,854**
Line Item Construction						
Sample Preparation Laboratory	25,450	26,000	40,650	8,500		
Reactor Fuels Research Laboratory				8,100	30,000	30,000
Construction Total	**25,450**	**26,000**	**48,750**	**38,500**	**30,000**	**30,000**
GRAND TOTAL	**207,604**	**209,102**	**288,737**	**290,884**	**296,927**	**297,854**

2.1 MFC Base Operations and Maintenance

Base operations 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).

Execution within the base operations framework includes managing 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:

- Performing 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
- Ensuring compliance with state and federal environmental and operating permit requirements
- Performing the engineering for structure, system, and component (SSC) modifications and upgrades necessary to ensure safety and functionality
- Enabling 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
- Ensuring enabling infrastructure such as fuel handling capabilities, a full suite of waste disposition pathways, and integrated cask management is available to support the mission
- Additional engineering and other technical support resources needed to address the technical issues associated with operating multiple shifts in aging facilities to meet mission demands.

2.2 MFC RD&D Mission Enablement

Implementing a sustainable and reliable nuclear RD&D capability requires a funding model that supports effective and efficient management of research instruments and research facilities critical to execution of the current DOE-NE research portfolio and in support of an expanded mission anticipated through the GAIN initiative. RD&D Mission Enablement 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 RD&D mission enablement activities support technical and operational readiness of RD&D capabilities (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
- Upgrade and develop 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 usage
- 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 enablement 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 enablement 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

2.3.1 MFC Plant Health

MFC plant health investments are a key aspect of a healthy and efficient NE RD&D test bed model required to support NRIC. This requires dedicated and sustained funding to address MFC's plant health needs. Targeted major maintenance and repair addresses system and equipment degradation increasing facility availability and throughput. Targeted major maintenance and repair efforts (described in Section 3) include hot cell window replacements, next-generation manipulators, and Analytical Laboratory (AL) HVAC replacement. These upgrades will result in a reduction in MFC deferred maintenance (DM) and key repair needs (RN). 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 Tables 2 and 9.

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 the Materials and Fuels Complex (MFC) uses to identify, evaluate, monitor, maintain, repair, and upgrade site Structures, Systems, and Components (SSCs) important to safe and reliable facilities operation and to meeting the mission goals of the facilities and MFC as a whole. This utilizes the Long Term Asset Management (LTAM) component of the ER Suite software. It addresses key aspects necessary for the CHC to prioritize MFC plant health needs with 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 Hot Fuel Examination Facility (HFEF) is DOE-NE’s core post-irradiation examination (PIE) facility originally commissioned in 1974. This five-year strategy 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. Equipment such as the 40-ton high bay crane has recently been overhauled to address frequent failure and address risks to facility reliability.

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.

Key equipment such as the HFEF polisher/grinder, a gateway piece of equipment supporting sample preparation for all in-cell microscopy, have been replaced. The Gas Assay Sample and Recharge (GASR) system, an aging, unique, and critical piece of R&D equipment and is being replaced with a new unit currently in qualification testing. HFEF is also in the process of replacing aging back-up power generators that will be relocated to a pre-engineered electrical building 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.

The Analytical Laboratory (AL) is MFC’s principal facility for conducting analytical chemistry and experimental data analysis on nuclear fuels and materials. AL received its first hot fuel sample from the Experimental Breeder Reactor-II in 1964 and has been in continuous operation since. AL is a Hazard Category (HC)-3 Nuclear Facility with approximately 10,000 ft^2 of laboratory space. The AL HVAC system is no longer capable of supporting additional research or analytical capability and currently operates at maximum capacity. The HVAC system is being refurbished and upgraded to support growth in RD&D capabilities and increase facility reliability. AL is also executing lab renovations and fume hood replacement throughout the facility to modernize the labs and increase operating efficiency.

Four of the gloveboxes in use at AL (casting lab, special projects, waste form testing, and radiochemistry) need either replacement or significant overhaul. Part of the comprehensive plant health strategy includes addressing these gloveboxes to ensure the facility is in the best possible condition to support new fuels development in their pre- and post-irradiated forms, fuel separations, and waste form development.

The HFEF, FCF, and AL 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. 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 that are currently in production. Addressing the manipulators is phased over several years and will eventually result in replacement of all manipulators with reliable next-generation and more ergonomic equivalents.

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 AL hot cell windows.

FCF priorities include addressing the facility control system for hot cell operations and for in-cell process equipment. The first phase, funded in FY-19, replaced the small logic controllers for the system. These were producing spurious failure notifications decreasing facility reliability and requiring significant time and effort to troubleshoot and address. Follow on phases will include facility programmable logic controllers and other process control systems. The reliability of the high bay crane will be addressed in the future.

FMF and ZPPR facilities are replacing the current criticality alarm systems (CAS). These were funded in FY-19 and scheduled for completion in FY-20. The FMF HVAC system also needs refurbishment. FMF and ZPPR roofs are aging and requiring significant resources to address infiltration of precipitation during different parts of the year and design is underway to address replacing FMF in FY-20 and ZPPR roof will be repaired pending identifying potential new missions (NRIC) for this facility.

Many legacy items in the research facilities and support areas can be removed and dispositioned. This increases overall mission execution efficiency and frees up additional critical nuclear facility RD&D space to support test bed growth. The FMF Waste Characterization Glovebox and the Argonne Fast Reactor Source in Electron Microscopy Laboratory (EML) were removed in FY-19 while the Radioactive Liquid Waste Treatment Facility (RLWTF) and FCF are in the process of repurposing footprint using DOE-EM funding.

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 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.

2.3.2 MFC Recapitalization

An option MFC is developing to address plant health and facility reliability is the concept of a line item MFC recapitalization project(s). A recapitalization project would enable the existing NE test bed to continue to support important nuclear energy technology development and growing advanced reactor demonstration capabilities for the next decades. Recapitalization will focus on aging infrastructure supporting MFC core research facilities HFEF, IMCL, TREAT, FCF, FMF, and ZPPR. This includes comprehensive recapitalization of electrical infrastructure, HVAC systems, subsurface piping and cabling, roofs, pneumatic shuttle (rabbit) system, etc. The need for recapitalizing this infrastructure goes beyond the annual plant health funding proposed and is envisioned to be in the $100M-$200M range. Several key areas are being considered as recapitalization candidates including:

- General infrastructure including electrical distribution, paving, sewer, drainage, fiber, steam, cooling water, etc.
- Anchor tenet research facilities (prioritized as HFEF, FCF, TREAT, AL, ZPPR/FMF/AFF, and IMCL/EML) that will include in-cell handling equipment, roofs, rabbit shuttle, hot cell windows manipulators. HVAC, etc.

- R&D capability recapitalization including glovebox replacements, instrument updates, furnace replacements, etc.
- Environmental justice (protection of the aquifer), which includes SCMS Site Treatment Plan (STP) backlog and facility decommissioning and other environmental liabilities

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

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
1	AL	Replace or Upgrade the AL HVAC System	No	$900	$1,500	$2,838	$8,056	$1,350					$14,644
1	AL	AL EIFS Installation - **Complete**	No		$700	$404							$1,104
1	AL	Lab B-103 Refurbishment - **Complete**	No		$700	$610	$5						$1,315
2	AFF	AFF Modifications (HVAC) - **Complete**	No		$700	$1,655	$505						$2,860
3	HFEF/ FCF/ AL	Manipulator Refurbishment and Replacement Campaign in HFEF, FCF, and AL	No	$800	$1,000	$2,300	$400	$3,000	$3,000	$3,000	$3,000		$16,500
4	HFEF/ FCF/ AL	Window Replacement Campaign in HFEF, FCF, and AL	Yes	$500	$800	$464	$100	$1,000	$1,000	$1,000	$1,000		$5,864
5	HFEF	Argon Cell Temperature and Pressure Controls	No	$100	$1,200	$725	$125						$2,150
6	FMF	Replace the Criticality Alarm System (CAS) in FMF	No	$17	$231	$402	$675						$1,325
7	ZPPR	Replace the Criticality Alarm System (CAS) in ZPPR - **Complete**	No		$194	$1,005	$60						$1,259
8	HFEF	Facility Out-of-Cell 40-Ton High Bay Crane - **Complete**	Yes	$448	$2,625	$144							$3,217
9	HFEF/ IMCL	Compressed Argon Supply System - **Complete**	Yes	$500	$300	$287							$1,087
10	FCF	Multi-Function Furnace	New	$333	$1,795	$2,589	$2,783						$7,500
11	HFEF/ FCF/ AL	Radioactive Liquid Waste Treatment Facility Process/Storage Tanks Replacement	Yes	$400	$400	$218	$2,482						$3,500
12	HFEF	Small and Large Transfer Lock Doors and Drive Control System Upgrade	Yes		$200	$485	$415						$1,100
13	HFEF/ FCF	Electro-mechanical Manipulator, Cranes, Hoists and other in-cell handling Equipment Refurbishment and Replacement	No	$100	$1,400	$1,266		$4,000	$4,000	$3,000			$13,766
14	MFC	Legacy Materials Disposition	No	$269	$2,396	$710	$389						$3,764
15	FCF	New SCRAPE Cathode Module for FCF Electrorefiner	No	$47	$549	$783	$1,421						$2,800
16	FCF	Integrate Bottle Inspection w/ Wire Removal Process Improvement	No		$1,000	$497	$703						$2,200
17	FCF	Replace FCF Facility Control System	Yes	$388	$1,235	$681	$196	$1,500	$1,000	$3,000			$8,000
18	FMF/ ZPPR	Roof – Replacement	Yes		$410	$1,390	$3,600						$5,400
19	AL	AL Lab Space Renovations	No		$450	$182	$468	$1,000	$1,200	$1,300			$4,600
20	IMCL	Noise Reduction Modifications - **Complete**	No			$148							$148
21	IMCL	Fixed Air Sampling System	No		$100	$450	$25						$575
22	IMCL	IMCL facility ventilation system optimization - **Complete**	No		$86								$86
23	IMCL	IMCL facility manipulator repair	No			$297	$753						$1,050

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		capability											

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		IMCL facility manipulator repair capability											
24	IMCL	IMCL Communications Infrastructure - **Complete**	No		$278								$278
25	IMCL	IMCL Material Transfer Optimization	No		$16								$16
26	Sitewide	Radiation Monitoring Updates - **Complete**	No	$1,500									$1,500
27	AL	ENU Replacement - **Complete**	No		$160	$303	$1,140						$1,603
28	HFEF	Exterior roof/stack access stairs - **Complete**			$250								$250
29	HFEF	Argon compressor removal				$581							$581
30	HFEF	Argon regeneration valves				$44		$500					$544
31	RCL	Convert heating from steam to electric - **Complete**				$647							$647
32	FCF	Design, fab, and install feedthrough in FCF to support CO_2 cold jet decon system				$332	$120						$452
33	HFEF	MET Box refurb - purification system replacement - **Complete**				$455	$295						$750
34	HFEF	Containment Box lid seal & hoist	No			$267	$258						$525
35	EBR-II	Continued EBR-II Dome test bed platform refurbishment (carryover)			$1,226	$1,627							$2,853
36	HFEF	HFEF Standby Diesel Generator Removal & Replacement		$200	$900	$800	$2,600						$4,500
37	FASB	Install Equipment Enclosure and North Side Upgrades					$500						$500
38	HFEF	HFEF hot cell chiller replacement						$700	$1,200				$1,900
39	FCF	Refurbish FCF Air Cell Transfer Hatch RAM						$800					$800
40	FCF	MTG Revision and user interface update	No			$500		$1,250	$1,250	$1,500	$1,500	$750	$6,750
41	AL	Ultra Pure Water Stations	No					$300					$300
42	TREAT	Replace TREAT Loop Handling Cask Winch System						$100					$100
43	AL	AL Hot Cells 1 and 3 reconfiguration						$1,500	$1,500	$500			$3,500
44	IMCL	Contamination control upgrades	No					$800					$800
45	HFEF	Pneumatic sample transfer systems overhaul						$850	$1,500				$2,350
46	NRAD	NRAD Fuel						$1,300	$1,300	$1,300	$1,400		$5,300
47	TREAT	TREAT Flex Test 40 Controllers						$350					$350
48	Nuke/Rad Facilities	Roof repairs for nuke/rad facilities (HFEF, FASB, EML)	Yes					$1,150	$1,500	$1,500			$4,150
49	HFEF	Building lab exhaust fan replacement						$300	$850	$850			$2,000
50	HFEF	HFEF decon cell fire suppression system						$750	$2,500				$3,250
51	AL	Analytical Lab Process Management System						$250	$1,000				$1,250

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		Upgrade											

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		Analytical Lab Process Management System Upgrade											
52	MFC	Cask integration, management, and capability sustainment	No					$1,000	$1,000	$1,000			$3,000
53	TREAT	Upgrade TREAT Experiment Support Building (TESB) HVAC and Door Seals						$650					$650
54	TREAT	TREAT Dedicated Microprocessor Tester Installation						$150					$150
55	FMF	FMF Ventilation System – HVAC/Suspect Exhaust	No					$2,500					$2,500
56	AL/ RCL	RCL Backup Power	No					$1,500					$1,500
57	FCF	FCF HRA reactivation	No					$1,450	$3,500				$4,950
58	MFC	Fire barrier refurbishment for MFC Nuke and Rad Facilities	No						$2,000				$2,000
59	TREAT	TREAT Crane Rail Alignment							$100				
60	TREAT	TREAT Filtration Cooling System VFD Replacement							$300				
61	HFEF	Replace HFEF Freight Elevator							$300	$1,700			$2,000
62	TREAT	TREAT Diesel Generator Replacement								$200			
63	HFEF	Facility Electrical Distribution System Refurbishment	No							$500	$2,000		$2,500
64	FASB	Upgrade FASB Ventilation System	No							$500	$1,500		$2,000
65	AL	AL Multi-Zone System Overhaul								$1,500	$2,500		$4,000
66	HFEF	HFEF Hot Cell HEPA Replacement								$500	$3,500		$4,000
67	FCF	Replace FCF Argon Cell North Recirc Blower and Purification Monitoring								$1,200			$1,200
68	FCF	Replace FCF Process Control Systems Equipment	Yes							$900	$4,650		$5,550
69	HFEF	HFEF Truck Lock Floor Repair								$3,500	$ –		$3,500
70	TREAT	TREAT Critical Spares								$400			
71	NRAD	NRS Elevator and Cask Interface Up Grade								$700	$700		$1,400
72	IMCL	New instrument room and storage mezzanine								$450	$1,100		$1,550
73	FCF	In-cell Periscope and Camera System Replacement	No								$2,500		$2,500
74	HFEF	In-cell compressed argon manifold supply and associated controls									$500		$500
75	HFEF	Decontamination Spray System	Yes								$1,200		$1,200
76	MFC	Interfacility pneumatic shuttle transfer system refurbishment									$1,000	$4,000	$5,000
77	ZPPR	ZPPR Vault Cooling System Upgrade									$750	$1,000	$1,750
78	AL	AL Hot Cell 4, 5, and 6 Upgrades									$1,200	$4,200	$5,400
79	AL	Replace AL Backup Diesel Generator										$2,500	$2,500

MFC Overall Priority	Asset Name	Name	DM	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
80	AL	Removal of abandoned lines and associated equipment										$1,500	$1,500
81	FCF	FCF In-Cell Lighting Upgrade										$1,500	$1,500
82	FMF/ ZPPR	Implement uniform SNM containers and design verification										$2,500	$2,500
83	FMF	New Decon Fume Hood for Container Examination										$250	$250
84	FMF/ ZPPR/ SSPSF	Compressed Air Supply System	No									$4,000	$4,000
85	FASB	Remove RERTR Glovebox										$1,000	$1,000
86	MFC	Install Perma-Con containment to replace aging waste management tent workrooms	No									$3,000	$3,000
87	TREAT	Replace TREAT Control Rod Segments										$2,000	$2,000
		TOTALS		**$6,502**	**$22,801**	**$26,086**	**$28,074**	**$30,000**	**$30,000**	**$30,000**	**$30,000**	**$28,200**	**$230,663**
		Total FY IFM Funding Authorized		**$40,300**	**$21,850**	**$15,650**	**$11,206**						**$89,006**

Note: Costs Funding levels reflect actual costs through FY-20 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.	
Green shaded represent scope authorized to proceed	The ranking priority of scope in the "Outyear" column is subjective and will certainly change as emergent scope is identified and priorities evolve

2.4 Waste and Materials Management

2.4.1 Newly Generated Waste Management

MFC manages various newly generated and legacy research-related 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.

All newly generated waste is managed under an INL service center full cost-recovery program that ensures waste costs are paid for by the generating programs or facilities and funding is available in the future for disposition of all waste types. The INL Waste Management Program (WMP) administers two site-wide service centers. The INL Waste Generator Services service center collects revenue and pays disposition costs for waste with a readily available disposition path and establishes disposition paths for new waste streams prior to generation. The INL RH Waste Service Center collects revenue for newly generated RH waste that are dispositioned at the INL RHLLW Disposal Facility or will be dispositioned when the backlog at Waste Isolation Pilot Plant (WIPP) is eliminated after reopening.

Currently BEA is using the EM ID Idaho Cleanup Contract contractor capabilities and WIPP certified transuranic (TRU) program certification for disposition of contact-handled (CH) and RH-TRU. The current version of the 5-year plan assumes this pathway exists through May 2021. In light of the recent DOE EM decision to close the Advanced Mixed Waste Treatment Project (AMWTP) at the end of 2019, BEA is developing a plan to establish a TRU program to support ongoing newly generated TRU. This plan will address increased waste generation due to new and emerging programs such as the Versatile Test Reactor (VTR) and high assay low enriched uranium (HALEU) programs, assess what is needed to support waste certification and characterization, and investigate siting options for this capability. AMWTP provided critical characterization, certification, and transportation support for BEA-generated CH-TRU waste. A major capability of AMWTP facilities was waste conditioning and waste repackaging. This capability will not be needed for BEA-generated CH-TRU waste. BEA’s TRU program planning will 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. In addition to this TRU program planning activity, BEA is also taking leadership in the formulation of a Battelle community of practice specifically addressing TRU waste disposition as analogous situations exists at other Battelle-managed national laboratories.

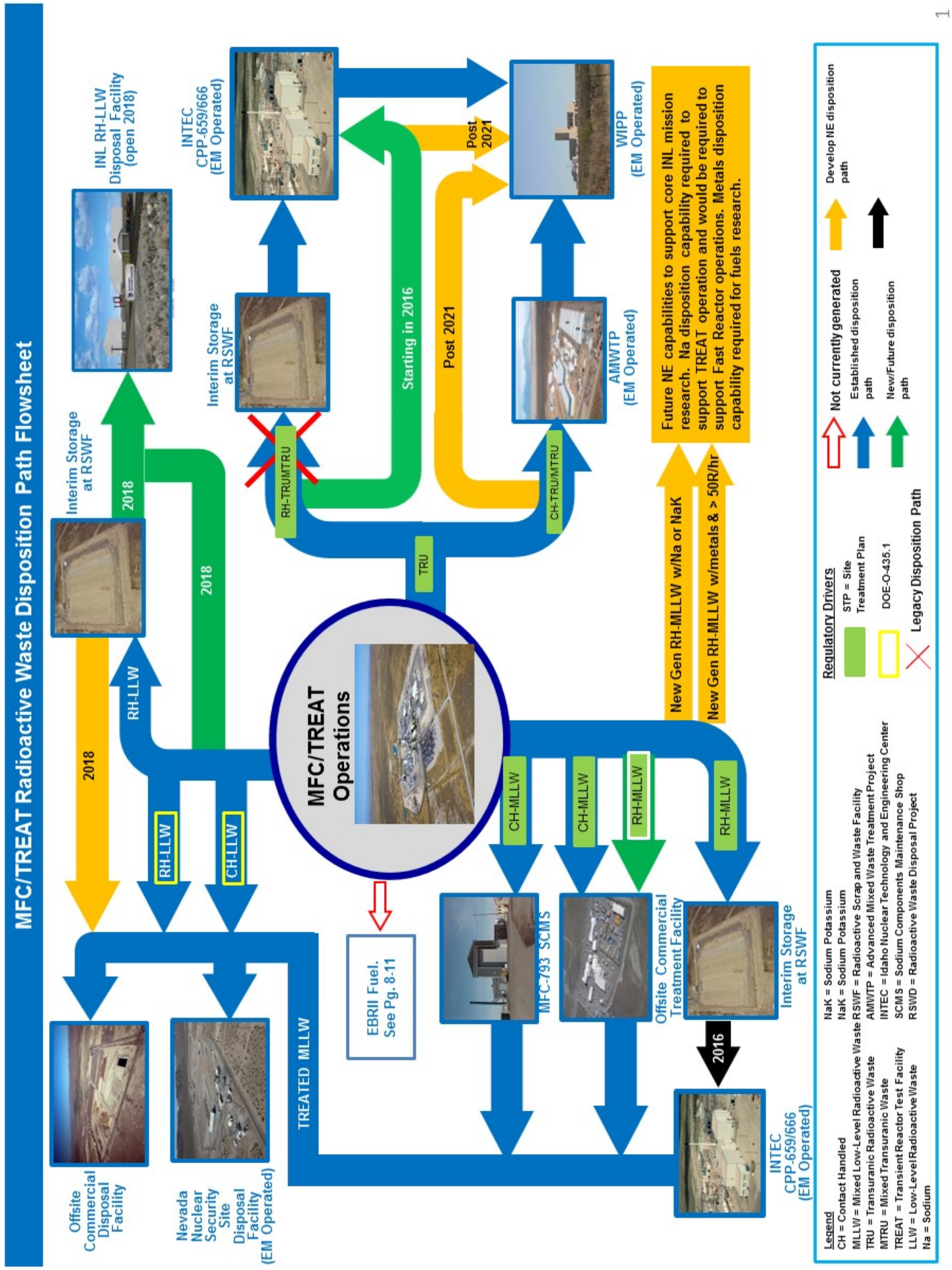


Figure 2. MFC/TREAT Radioactive Waste Disposition Path Flowsheet.

2.4.2 Legacy Materials Management

DOE-NE is responsible for the storage, management, and disposition of a number of legacy waste 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), RH mixed low-level waste (MLLW), CH-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, Rev 2, October 12, 2020. See Table 3 for a summary. These liabilities are currently being addressed with several different funding sources as discussed below.

Table 3. INL Other Legacy Environmental Liabilities, LST-1149 Summarized.

Other Legacy Environmental Liability Title (LST-1149)	FY-20 Estimated Cost to Address ($M)	Current Status
EBR-II Spent Fuel and Related Materials	$850	EBR-II Na bonded driver fuel SNF being treated with incremental annual operations funding. Alternative analysis needed for blanket fuel to comply with current agreement requirement timelines.
Excess Contact-Handled Special Nuclear Material	$973	Contact handled SNM disposition being addressed with incremental annual operations funding.
Remote-Handled Low-Level Waste Stored at MFC	$102	This involves a current total of 301 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	$14	Post-irradiation examination and lab related misc. waste streams (irradiated experimental component debris, HEPA filters, PPE, sample waste, etc.) includes legacy of 1 drum in HFEF Argon Cell, 4 drums in AL vault, 4 drums in RSWF SSA, 6 SLSFs in RSWF, and 3 HFEF-5s in RSWF.
ZPPR Reactives Inventory	$10	Disposition efforts associated with characterizing, packaging, and shipment of excess reactive ZPPR materials from MFC to an off-site facility for treatment and disposal. Legacy material being addressed with indirect lab investments.
Site Treatment Plan Consent Order MLLW/RHLLW	$1,120	CH MLLW – This inventory (SCMS Backlog) consists of primarily sodium and sodium-potassium alloy contaminated irradiated material that must be treated prior to disposition. The current disposition is being addressed with regulatory compliance incremental annual funding. RHMLLW– The waste consists primarily of sodium contaminated irradiated metals and research material that must be treated prior to disposition (RWDP Backlog). The potential transfer of this liability to EM is documented in the May 4, 2009 Ines Triay memorandum, with the condition that EM will not accept this inventory of waste until EM receives the baseline funding needed to perform the work, as documented in the February 20, 2009 Ines Triay to Robert Johnson memorandum.
Total Estimated Costs ($M)	**$3,069**	

2.4.2.1 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 goal 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.

Currently BEA is using the EM ID Idaho Cleanup Contract contractor capabilities and Waste Isolation Pilot Plant (WIPP) certified Transuranic (TRU) program certification for disposition of TRU waste; this pathway exists thru fiscal year 2021. MFC is currently packaging legacy RH-TRU/MTRU waste located in the HFEF and FCF Hot Cells, Analytical Laboratory 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. 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 reactives (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 (NTP), 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.

Identifying off-site treatment as the preferred approach considering 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 the VTR and other 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 4. NE Funded Environmental Liabilities and Proposed Funding to Address Them.

Activity	Description	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	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	$8,228	$8,228	$8,728	$8,991	$10,300	$10,600	$55,075
Site Treatment Plan/ Consent Order MLLW/ RHMLLW Backlog (NE-3)	Identified in the INL Site Treatment Plan as legacy contact-handled and remote-handled mixed low-level waste that contains sodium (Na), sodium potassium alloy (NaK), or a combination of both.	$1,447	$1,447	$10,000	$10,000	$10,500	$10,500	$43,894
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	$2,000	$2,000	$2,000	$8,000
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.	$4,120	$4,244	$4,329	$4,459	$4,593	$4,730	$26,475
Total Proposed NE-3 Funding		**$13,795**	**$13,919**	**$25,057**	**$25,450**	**$27,393**	**$27,830**	**$133,444**

2.4.2.2 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 5.

Table 5. Laboratory Funded Excess Material Disposition.

Activity	Description	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Total ($K)
Excess legacy material in cargo containers	Excess legacy materials which were used in programs, projects or facilities that are no longer in operation and no longer needed. This does not include excess material generated by existing programs.		$700	$500	$500	$500	$500	$2,700
ZPPR Reactive Material Disposition (Laboratory Funded)	Disposition efforts associated with characterizing, packaging, and shipment of excess reactive ZPPR materials to an off-site receiving or disposal site, along with clean-out of remaining contaminated equipment.	$3,000	$3,000	$2,000				$8,000
Total Proposed Laboratory Funding		**$3,000**	**$3,700**	**$2,500**	**$500**	**$500**	**$500**	**$10,700**

2.4.2.3 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 HQs that has resulted in partnering in development of technology solutions and knowledge enabling more effective and efficient management of legacy liabilities described in LST-1149. An example of this is BEA, using EM funding, executing a proof-of-concept demonstration with the objective of developing and demonstrating a prototype system to improve the RWDP liner retrieval process identified in Table 6. 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 proof-of-concept demonstration is scheduled to occur in FY-21 and will include a coupled demonstration of the advanced liner retrieval system and new off-site treatment options. 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 potential transfer of this liability to EM is documented in the May 4, 2009 Ines Triay memorandum, with the condition that EM will not accept this inventory of waste until EM receives the baseline funding needed to perform the work, as documented in the February 20, 2009 Ines Triay to Robert Johnson memorandum. The waste consists of primarily sodium contaminated irradiated metals and research material that must be treated prior to disposal.

Table 6. EM Funded Other Legacy Environmental Liabilities Dependent Upon Future Funding.

Activity	Description	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Total ($K)
RWDP Backlog -RH MLLW retrievals (DOE-EM funded)	RH MLLW stored at MFC is included in the backlog associated with the Remote Waste Disposition Project. This inventory of waste has been accepted by EM as documented in the May 4, 2009 Ines Triay memorandum with the condition that EM will not accept this inventory of waste until EM receives the baseline funding needed to perform the work.	$700						$700
RWDP Backlog – Proof of Concept Demonstration for RH MLLW Advanced Retrievals (DOE-EM funded)	DOE EM Technology Development One-Time Proof-of-Concept Funding	$4,500						$4,500
Total DOE-EM Funding to Date		**$5,200**						**$5,200**

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

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 highly 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. 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 4).

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.

In order to comply with the conditions agreed to by DOE, INL will need to accelerate treatment of the EBR-II Driver Fuel beginning in FY-24 beyond current 7d/12h work schedule and will hire and train additional personnel beginning in FY-22. 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 has initiated 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 in order 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 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, items 4 and 14). Additional plant health investments are funding 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 electrorefiners. These investments will help to eliminate existing single-point failures and increase operating efficiencies for the existing processing equipment.

2.4.3.1 Funding and Schedule Estimate to Achieve Desired Production Rate

The incremental acceleration and utilization of legacy inventory including treatment in the MK-IV electrorefiner along with 20 ingots recast in HFEF metal waste furnace from the legacy-recovered uranium inventory resultant from past EBR-II driver fuel treatment.

The strategy is summarized as follows:

- Continue processing EBR-II SNF at the current rate, complete processing improvements, including introduction of improved product form (~3kg ingots) and adding a new processing furnace to supplement the current cathode processor (~fall of 2021)
- Integrate recasting or isotopic cleanup of legacy product inventory using process enhancements to produce a smaller, lower-dose product
- Increased FCF's working schedule to 7 days/week, 12 hours/day in 2019, and further increase to 7 days/week, 24 hours/day by FY-24, with preparations beginning in FY-22
- Escalate required funds at 3%/yr 2019–2023, funding requirements will increase in 2024 for additional cost of retrieving EBR-II driver fuel from RSWF. Further cost increases will be observed in FY-22 to support acquisition and training of additional personnel associated with 24 hour/day operations
- Recast all legacy inventory by 2024. All driver fuel treatment complete by December 2028
- Have 5MT of HALEU feedstock available by December 2024.

Table 7. Baseline Schedule for Accelerated HALEU Production.

Estimated Accelerated HALEU Production from FCF					
	2020	2021	2022	2023	2024
EBR-II HALEU Cumulative kg/lb including prior 2019 levels	715/1576	1015/2237	1615/3560	2615/5765	4245/9358

Table 8. Accelerated HALEU Production Funding Profile required to support ISA supplemental agreement.

Activity	Description	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Total ($K)
HALEU Production (NE-4)	Accelerating EBR-II treatment while recasting EBR-II spent fuel treatment product to support HALEU feedstock development for advanced reactor fuel.	$8,000	$10,000	$17,500	$25,750	$26,600	$27,400	$115,250
Total Proposed NE-4 Funding		**$8,000**	**$10,000**	**$17,500**	**$25,750**	**$26,600**	**$27,400**	**$115,250**

3. INSTRUMENT SCIENCE

RD&D capability sustainment includes the scientific infrastructure (instruments and support systems), dedicated instrument science teams, and new instrumentation that, when coupled with base operations and mission enablement, 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 within the industry matures and develops. This area recognizes INL commitment to sustaining world-class nuclear RD&D capabilities across MFC's current areas of expertise. This includes investment in research and development of prototype analytical and PIE systems that will be referred to in this strategy as RD&D capability development. 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.

AL scientific infrastructure currently includes replacement and addition of mass spectrometry capabilities. This strategy includes replacement of an aging, single-point-failure risk ICP-MS that is considered a work-horse instrument that is currently being installed in AL. Another AL 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. Additional needs include critical fission gas analysis capability to support advanced nuclear fuel development and advanced automated sample preparation and robotics.

Advanced manufacturing for extreme environments is identified as a major science and technology initiative for INL. Significant investment in FY-18 and FY-19 added new advanced manufacturing capabilities for nuclear fuel fabrication. This includes zone refining, melt pool crystal grower, dry bag isostatic press, casting furnace, laser welder, and 3D printing capabilities. Many of these are first-of-a-kind capabilities for nuclear fuels and reactor materials development. HVAC modifications in the Advanced Fuels Facility (AFF) have also completed and support capability growth in this important test bed arena. Additional needs include furnaces to support sintering and post-processing of advanced nuclear materials and components.

HFEF RD&D sustainment activities includes refurbishing the NRAD (Neutron Radiography Reactor) East Radiography Station elevator which was still original equipment installed in 1980 and has no commercially available spares. 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 area 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 a beam line RD&D.

Replacing the SEM at FASB ensures this critical capability, currently 100% fully utilized at MFC, is available to support increasing RD&D work requests. This also provides a redundant capability increasing experiment throughput and reliability.

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 sent 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 laboratory 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 a mission of developing exploratory fuel compositions, forms, and shapes are 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 are needing hot cell and laboratory space for their secure missions. FCF intends to fulfill some of those missions maximizing nuclear research facility capacity and capabilities

3.2 Instrument Science Teams

A dedicated cadre of scientists, engineers, and technicians is critical to enable efficient generation of high-quality information that moves innovative concepts up the scale of technology readiness. Instrument scientists and engineers are responsible for:

- Ensuring that each research tool is performing at its peak level and seeking world-leading innovations in data analysis and instrument hardware
- Achieving scientific excellence as part of collaborative teams and serving the user community as a subject matter expert on instrument techniques and data analysis
- Helping build the user community by seeking opportunities to apply instrument techniques in unique and innovative ways to nuclear materials and fuels challenges.

These scientists, engineers, and technicians require a specialized skill set to operate sophisticated research instruments, interpret data, and safely and effectively conduct research in nuclear facilities. Instrument science teams publish extensively to ensure dissemination of knowledge gained from their instrument.

These skills are acquired and honed by training and experience over several years. As MFC research facilities extend capabilities and operating hours to deliver on increasing requests for research, additional instrument scientists and support staff will be required. In order to be effective in helping drive innovation, these staff must be able to focus in a manner that allows them to be world-leading experts. MFC is experiencing a steady increase in research requests that have exceeded the existing staff's ability to support. Experiment receipts have increased over 300% since FY-17. A user facility model for developing personnel must be cultivated that allows both hiring in advance of the need and more efficiently and effectively increasing, introducing, and reinforcing the core principles and critical skills required to build competence.

Part of the instrument science function (scientific excellence) is currently supported by DOE programs; however, these programs are focused on efforts directly related to their specific research needs. Stable funding for instrument scientists allows focus on instruments, measurement techniques, and analysis methods enabling existing characterization and post-irradiation examination instruments to meet user needs and provide world-class data. This is the gap between compliance level base operations and full cost recovery from programs for supporting research that the user facility-like model addresses.

A wide range of instruments and techniques are required to execute the nuclear technology development cycle, including skill sets that are not typically represented by instrument-focused research. Fabrication specialists and material scientists, for example, develop and fabricate experiment capsules, fuel prototypes, and material specimens that are a necessary part of the development cycle. Other areas include mass spectrometry, fission gas, optical and electron microscopy, radiochemistry, advanced characterization, and a multitude of other instrument science teams critical to the NE mission.

3.3 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 occurs. Understanding at this scale, 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 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 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 cooled for long periods, have not been exposed to high neutron fluence, or have not been irradiated in a prototypic neutron environment, and 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 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.

3.3.1 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 2021 – 2025 include:

- High spatial resolution thermal conductivity measurement system to measure the change in thermal conductivity across a fuel pellet.
- High-resolution multi-collector inductively coupled mass spectrometers that provide extremely accurate isotopic analysis in a fraction of the time of previous technology. This is needed for improved fuel burnup analyses and fission gas/product measurements.
- A second shielded cell for performing irradiation assisted stress corrosion cracking (IASCC) growth rate measurements.

- Femto-second laser that allows rapid and quantitative chemical and isotopic analysis of nuclear materials without chemical dissolution.
- 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 programs that are 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 $10M annually over the next five years. At the end of FY-22, MFC will be equipped with a solid base of research instrumentation readily available to the broad nuclear energy research community. Beyond FY-22, a continued steady-state funding level of $10-$15M per year will expand the DOE-NE NRIC test bed capability and ensure that the suite of instruments remains current, reliable, and upgraded to meet user needs.

Table 9 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 B.

Table 9. Summary of FY-18 – FY-25 instrument development strategy and ROM cost estimates ($K).

No.	Facility Name	Capability	Sustainment /Development	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
1	IMCL	Install Thermal Properties Cell and Glovebox (laser flash, DSC, thermogravimetric, and dilatometry)	Development	$600	$2,800								$3,400
2	AFF	Expanded Fuel Fabrication Capability	Development	$300	$3,200	$514							$4,014
3	AL	Mass Spectrometers for AL (Quad/ToF-MS/LA-LIBS/Counting Room)	Sustainment	$130	$2,304	$1,544	$537						$4,515
4	HFEF	Complete GASR and Polisher/Grinder Refurbishment	Sustainment	$1,700	$1,300	$1,400	$200						$4,600
5	HFEF	TREAT Experiment Handling Support at HFEF	Sustainment	$100	$600	$383	$70						$1,153
6	HFEF	HFEF East Radiography Station Elevator Repair	Sustainment	$200	$200	$182	$320						$902
7	HFEF	North Radiography Station Footprint Repurpose	Sustainment	$100	$500	$208	$295						$1,103
8	AL	Multi-Collector ICP-MS	Sustainment		$800	$1,225	$375						$2,400
9	TREAT	Re-establish TREAT Na Loop Capability	Development		$1,391	$4,190	$2,500	$1,920					$10,001
10	FCF	Establish NDA capabilities in FCF	Development		$625								$625
11	AL	B-116 Gas chromatograph	Development			$289							$289
12	IMCL	Secondary Ion Mass Spectrometry (Lab Investment)	Development		$500	$100							$600
13	IMCL	Atom probe tomography instrument (Lab Investment)	Development		$3,290	$457	$10						$3,757
14	HFEF	Replace LEICA metallograph	Sustainment				$300						$300
15	IMCL	In-situ mechanical testing for Titan TEM	Development		$300	$512	$30						$842
16	IMCL	Second Plasma FIB in IMCL	Development		$2,500	$470	$100						$3,070
17	EML	Replace Quanta Focused Ion Beam	Sustainment			$1,075	$170						$1,245
18	AL	Expanded CNO capability	New			600	$250						$850
19	AL	Fission Gas Mass Spectrometry	Development					$500	$2,500				$3,000
20	FASB/ HFEF	Digital Image Correlation for Mechanical Testing	Development		$170								$170
21	AL	B-wing ICP-OES (non-rad)	Sustainment					$500					$500
22	FASB	Tailored enrichment capability demonstration - aqueous precursor	Development				$1,500						$1,500
23	HFEF	Improved electronic interface for hot cell scales and balances	Sustainment					$200	$200				$400
24	HFEF	Visual Mount Inspection System in the HFEF Containment Box	Development					$500	$1,000				$1,500
25	AL	Replace TIMS	Sustainment							$2,000			$2,000
26	FMF	Multi-program U/Pu Glovebox	Development			$1,700	$3,700						$5,400
27	IMCL	In-situ testing stage for Titan and Talos transmission electron microscopes	Development			$450	$650						$1,100
28	HFEF	Eddy Current Head for Oxide Determination in HFEF	Sustainment			$75	$75						$150
29	AL	Ion Chromatography-Prep-Fast attachments to	Sustainment					$150					$150

No.	Facility Name	Capability	Sustainment /Development	**FY-18**	**FY-19**	**FY-20**	**FY-21**	**FY-22**	**FY-23**	**FY-24**	**FY-25**	**Outyears**	Est. Total Cost
		AL ICP											

No.	Facility Name	Capability	Sustainment /Development	**FY-18**	**FY-19**	**FY-20**	**FY-21**	**FY-22**	**FY-23**	**FY-24**	**FY-25**	**Outyears**	Est. Total Cost

No.	Facility Name	Capability	Sustainment /Development	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		Ion Chromatography-Prep-Fast attachments to AL ICP											
30	AL	Automated sample prep/dissolutions	Development						$750				$750
31	HFEF	Update PGS in HFEF	Sustainment					$500	$1,000				$1,500
32	HFEF	Replace Leitz Metallograph in MetBox with SEM	Sustainment					$1,500					$1,500
33	NRAD	Develop neutron diffraction capability in HFEF (NRS)	Sustainment					$1,000	$1,000	$500			$2,500
34	IMCL	Ion Mill (PIPS-II) for Sample Preparation	Development					$300					$300
35	TREAT	Shielded Experiment Preparation and Inspection Cell (EPIC) - Procurement and installation into TESB						$2,300	$4,000	$1,500			$7,800
36	AL	Triple quadrupole ICP-MS							$1,000				$1,000
37	AL	AL HR ICP-MS								$1,500			$1,500
38	IMCL	Comprehensive Mechanical Testing Capabilities for Light Water Reactor Fuel				$450	$400						$850
39	IMCL	Three-dimensional strain mapping for improved understanding of material behavior				$150							$150
40	IMCL	Plasma cleaner for IMCL				$100							$100
41	IMCL	Benchtop optical microscope for IMCL				$130							$130
42	IMCL	High throughput sample preparation capability for nuclear fuel (laser)								$1,000			$1,000
43	EML	Replace EML SEM	Sustainment					$900					$900
44	FASB	Replace dilatometer in FASB	Sustainment			$155							$155
45	NRAD	Design & Install a Rotation Stage in the ERS Elevator to Enable Neutron Tomography of Fuels	Development					$750					$750
46	AFF	Versatile fuel form capability - powder handling	Development							$3,000			$3,000
47	HFEF	ECP/EBLM refurbishment	Sustainment							$250		$750	$1,000
48	AFF	Powder Bed Additive Manufacturing	Development							$1,000		$1,000	$2,000
49	HFEF	Digital Imaging Studio	Development							$500			$500
50	FASB	Differential scanning calorimetry instrument	Development							$300			$300
51	NRAD	NRS Elevator Upgrade	Sustainment								$2,000		$2,000
52	NRAD	NRS Sample Preparation Glovebox	Development								$500	$1,000	$1,500
53	EML	Replace EML SEM	Sustainment								$1,500		$1,500
54	IMCL	Argon atmosphere in Shielded Sample Preparation Area (SSPA)	Development								$1,500		$1,500
55	FASB	Shielded cell for Corrosion Testing in Extreme Environments	Development								$1,000	$7,500	$8,500
56	NRAD	NRS Control Console Replacement	Sustainment									$1,000	$1,000
57	NRAD	NRAD Automated Computed Tomography system	Development								$2,400		$2,400
58	AL	Robotics design and install	Development								$500	$2,500	$3,000
59	AL	AL Liquid Scintillation									$600		$600

No.	Facility Name	Capability	Sustainment /Development	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		Capability											

No.	Facility Name	Capability	Sustainment /Development	**FY-18**	**FY-19**	**FY-20**	**FY-21**	**FY-22**	**FY-23**	**FY-24**	**FY-25**	**Outyears**	Est. Total Cost

No.	Facility Name	Capability	Sustainment /Development	FY-18	FY-19	FY-20	FY-21	FY-22	FY-23	FY-24	FY-25	Outyears	Est. Total Cost
		AL Liquid Scintillation Capability											
60	AL	Gas mass spectrometer	Sustainment									$3,000	$3,000
61	FASB	Oxide reduction furnace for Pyrochemical Glovebox (PCG) - (Program Funded)	Development									$300	$300
62	FASB	Electrorefiner for PCG - (Program Funded)	Development									$300	$300
63	FASB	Distillation furnace for PCG - (Program Funded)	Development									$200	$200
64	FASB	Fermi MEDE furnace for PCG - (Program Funded)	Development									$2,000	$2,000
65	FASB	MK 1 multi-function furnace for PCG - (Program Funded)	Development									$2,000	$2,000
66	FASB	Molten salt furnace for PCG - (Program Funded)	Development									$500	$500
67	ZPPR	U processing and synthesis glovebox in ZPPR Workroom	Development								$500	$3,500	$4,000
68	FMF	PU Stabilization Glovebox	Development								$500	$4,500	$5,000
69	FASB	Multi-Purpose U Glovebox	Development									$4,500	$4,500
70	NRAD	NRAD fuel for 1 MW upgrade										$5,100	$5,100
71	FASB	Larinda furnace for PCG - (Program Funded)	Development									$200	$200
		Annual Totals		**$3,130**	**$20,480**	**$16,359**	**$11,482**	**$11,020**	**$11,450**	**$11,550**	**$11,000**	**$39,850**	**$136,321**
		Total FY IFM Funding Authorized		**$15,800**	**$12,500**	**$2,500**							
		IFM Spend Plan		**$3,130**	**$13,720**	**$9,935**	**$4,297**	**$1,920**	**$ –**	**$ –**	**$ –**	**$ –**	**$33,002**
		Laboratory Investment or Program Funding			**$6,760**	**$6,424**	**$7,185**	**$9,100**	**$11,450**	**$11,550**	**$9,500**	**$41,350**	**$103,319**

Potential to seek indirect lab investments, prior year carryover, **or other non-IFM program funding.** It is not certain that IFM will fund these items. **Extremely dependent upon IFM appropriation levels**.	Green shaded represent scope authorized to proceed
Note: Costs reflect estimates at completion for activities commenced in FY-20. Remaining costs are rough order of magnitude based upon current scope understanding and will be refined as detailed execution planning is completed.	The ranking priority of scope in the "Outyear" column is subjective and will certainly change as emergent scope is identified and priorities evolve

3.3.2 TREAT Experiment Infrastructure Strategy

INL-LTD-15-33324 provides an overview of the capabilities required for conducting experiments in TREAT. These capabilities (with some updates to the concepts shown in INL-LTD-15-33324) 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 (roughly) 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., the Accident Tolerant Fuels [ATF] 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-21 to FY-25 is needed to continue to meet nuclear fuel technology development objectives.

The TREAT Experiment Infrastructure Strategy addresses the following:

- 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 10. The descriptions of each instrument or support system are provided in Appendix C.

Table 10. Summary of FY-21 – FY-25 TREAT and Transient experiment infrastructure strategy and ROM cost estimates ($K).

	Transient Testing Experiment Scientific and Enabling Infrastructure	Funding source	FY-21	FY-22	FY-23	FY-24	FY-25	Totals	Comments
TREAT Multi-mission Experiment Support Infrastructure	**TREAT Experiment Support Building (TESB)**								
	TESB: Building Modifications for HC-3 experiment prep.	NE-3 (IFM)		$1,900	$2,500			**$4,400**	Reinforce concrete floor; modular containment and localized HVAC; building systems, HC-3 authorization
	TREAT Multi-mission Experiment Support Equipment								
	Multi-mission Experiment Assembly/Disassembly Equipment & Glovebox	INL Indirect	$600					**$600**	Generic Experiment Assembly/Disassembly Equipment (similar to TTAF at ATR)
	Multi-mission: large, fresh-fuel inert atmosphere experiment assembly	NE-42 (AFC)		$800				**$800**	Tall inert atmosphere enclosure, induction brazing setup
	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
	Big-BUSTER Design and Commissioning Test	Westinghouse FOA	$1,500					**$1,500**	Large outer container to support larger experiment vehicles. FY-21 includes design & commissioning test.
	Big-BUSTER-related TREAT & HFEF Modifications	NE-3 (IFM)		$300				**$300**	Prepare TREAT & HFEF for Big-BUSTER containers (fixtures and storage locations)
	Transport and Storage Casks								
	HFEF-15 Transfer Cask Preparation	NE-3 (IFM)	$750					**$750**	
	HFEF-15 Transfer Cask Modification for Big Buster	NE-3 (IFM)		$350				**$350**	Big-BUSTER is a TREAT experiment outer container that will accommodate large-dia. Experiments for multi missions
	International shipping container for small irradiated samples	NE-42 (AFC)		$500				**$500**	Qualification of HFEF to receive TN-LAB int'l cask (total cost of ~$550K shared with other programs) including certificate of compliance for shipments (Orano will generate and route to NRC for approval)
	Provide instrumentation to monitor core and fuel behavior during transients								
	Fuel Motion Monitoring								
	Hodoscope Operations and Maintenance	NE-42 (AFC)	$300	$300	$300	$300	$300	**$1,500**	
	Full View Hodoscope (Refurbish all 360 channel system)	NE-42 (AFC)		$300				**$300**	
	Develop Next-Generation Fuel Motion Monitoring System	NE-42 (AFC)	$200					**$200**	
	Develop Next-Generation Fuel Motion Monitoring System	NE-42 (AFC)		$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)	$1,500	$2,000	$2,000	$2,000	$2,000	**$9,500**	
LWR/ATF Fuel	**Experiment Vehicles**								
	Static Capsule Devices								
	Advanced Modules for MARCH System	NE-51 (NEUP) & NE-42 (AFC)	$1,000	$1,000	$1,000	$1,000	$1,000	**$5,000**	Upgrades to existing SETH, SIRIUS, SERTTA modules for visualization capability. Base technology under LDRD

	Transient Testing Experiment Scientific and Enabling Infrastructure	Funding source	FY-21	FY-22	FY-23	FY-24	FY-25	Totals	Comments
Testing	TWIST experiment vehicle (LOCA testing in capsules)	NE-42 (AFC)	$1,500	$1,000				**$2,500**	For time-at-temperature LOCA testing in water. Will replace SERTTA as RIA test vehicle for irradiated fuel.
	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								
	HENRI (He-3 injection system) final design and hardware procurement	NE-42 (AFC)		$1,200				**$1,200**	He-3 injection system necessary to narrow transient pulses to LWR RIA conditions (~40 msec FWHM)
	Capsule handling system in HFEF (TWIST)	NE-42 (AFC)	$750	$500				**$1,250**	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) - Conceptual Design	NE-42 (AFC)	$250					**$250**	Design based on copy of the IMCL TPC. May require slightly thicker shielding.
	Shielded Experiment Preparation and Inspection Cell (EPIC) - Procurement and installation into TESB	NE-3 (IFM)		$2,300	$4,000	$1,500		**$7,800**	For installing instrumentation on previously irradiated fuel rods for testing in ATR and TREAT
	Remanufacturing Bench for Irradiated Fuel Rods								
	Re-Fabrication Bench for Irradiated Fuel Rods at HFEF	NE-42 (AFC)	$1,400					**$1,400**	Welding, pressurization, and seal welding setup in Decon Cell in HFEF. Does not include instrumentation bench (next line)
	Advanced Fuel Rod Instrumentation Bench at TESB	NE-42 (AFC) & NE-5 (ASI)	$2,000	$1,500	$1,500			**$5,000**	Contract with Halden to implement and commission system in TESB shielded cell (ASI supporting out-of-pile testbed facility)
Fast Reactor Fuel Testing	**Experiment Vehicles**								
	Static Capsule Devices								
	THOR development and commissioning	NE-42 (AFC)	$1,000	$1,000				**$2,000**	For JAEA and DOE (AFC) joint test program and for other FR-type fuel testing
	Flowing Loops								
	Recirculating sodium loop system	NE-3 (IFM)	$2,350	$2,300	$1,500			**$6,150**	$5,520 spent in FY-19 and FY-20. Executed in collaboration with TerraPower. TP ADRP is first.
	Sodium loop nuclear equivalent hardware	NE-42 (AFC)		$500				**$500**	Needed for trial transients with the sodium loop prior to any fueled sodium loop test
	Sodium loop commissioning test	NE-42 (AFC)		$750	$250			**$1,000**	Preparation for first test using sodium loop to shake out all loop handling and operations through test lifecycle
	Experiment Support Systems and Equipment								
	Capsule handling system in HFEF (THOR)	NE-42 (AFC)	$600	$400				**$1,000**	HFEF fixtures & tooling design, assembly, and installation to support THOR experiment vehicles
	Sodium loop support infrastructure								

Transient Testing Experiment Scientific and Enabling Infrastructure			Funding source	FY-21	FY-22	FY-23	FY-24	FY-25	Totals	Comments
		HFEF sodium loop equipment and preparation	INL Indirect	$1,000	$2,000	$1,000			**$4,000**	HFEF fixtures & tooling design, assembly, and installation; SAR revision; procedure dev & mock-up
		Sodium loop out-of-pile prototype installation	NE-42 (AFC)			$750	$750		**$1,500**	Shipment of prototype test loop from TerraPower to INL, installation in IRC-IEDF
		Sodium loop sodium loading equipment	NE-42 (AFC)			$500			**$500**	Glovebox or inert enclosure and heaters with controllers
Other Program Investments	**Flowing Hydrogen Test Loop**									
		TREAT facility modifications for microreactor demonstrations	INL Indirect	$4,700					**$4,700**	
		Hydrogen Flowing Loop system	NASA	$4,000	$4,000	$4,000			**$12,000**	For NASA NTP fuel testing. Subsequent application of design and ancillary hardware to other users.
Scientific and Enabling Infrastructure ($K)				**$25,400**	**$27,150**	**$23,800**	**$9,550**	**$7,050**	**$92,950**	

Funding source	FY-21	FY-22	FY-23	FY-24	FY-25	Totals
NE-3 (IFM)	$3,100	$7,150	$8,000	$1,500	$0	**$19,750**
NE-3 (TREAT Plant Health)	$0	$0	$0	$0	$0	**$0**
NE-42 (AFC)	$6,000	$8,750	$4,550	$5,050	$4,050	**$28,400**
NE-51 (NEUP) & NE-42 (AFC)	$1,000	$1,000	$1,000	$1,000	$1,000	**$5,000**
NE-42 (AFC) & NE-5 (ASI)	$3,500	$3,500	$3,500	$2,000	$2,000	**$14,500**
Westinghouse FOA	$1,500	$0	$0	$0	$0	**$1,500**
INL Indirect	$6,300	$2,750	$2,750	$0	$0	**$11,800**
NASA	$4,000	$4,000	$4,000	$0	$0	**$12,000**
TBD	$0	$0	$0	$0	$0	**$0**
						$92,950

4. MFC CAMPUS VISION

MFC is a central part of the NE test bed and NRIC mission, and the future growth associated with these. 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 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. PIE RD&D facilities HFEF, IMCL, and SPL co-located in in the northwest quadrant of the MFC site. Current and future fuel fabrication RD&D facilities are primarily located 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 be leveraged to 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 areas 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 nuclear infrastructure 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, parking, sidewalks and pavement, and other sustainability efforts.

4.1 MFC Test Bed and Demonstration Platform Development

Two new capital asset construction projects are the MFC Research Collaboration Building GPP (completed in FY-19), administration building recently completed in FY-21, and the line-item Sample Preparation Laboratory under construction. Both are described in the following sections. Other facilities in much more conceptual phases are also generally described. None of the conceptual facilities have been estimated for cost and are all pre-mission need. These are identified below in Figure 3 and are described generally in the following subsections.

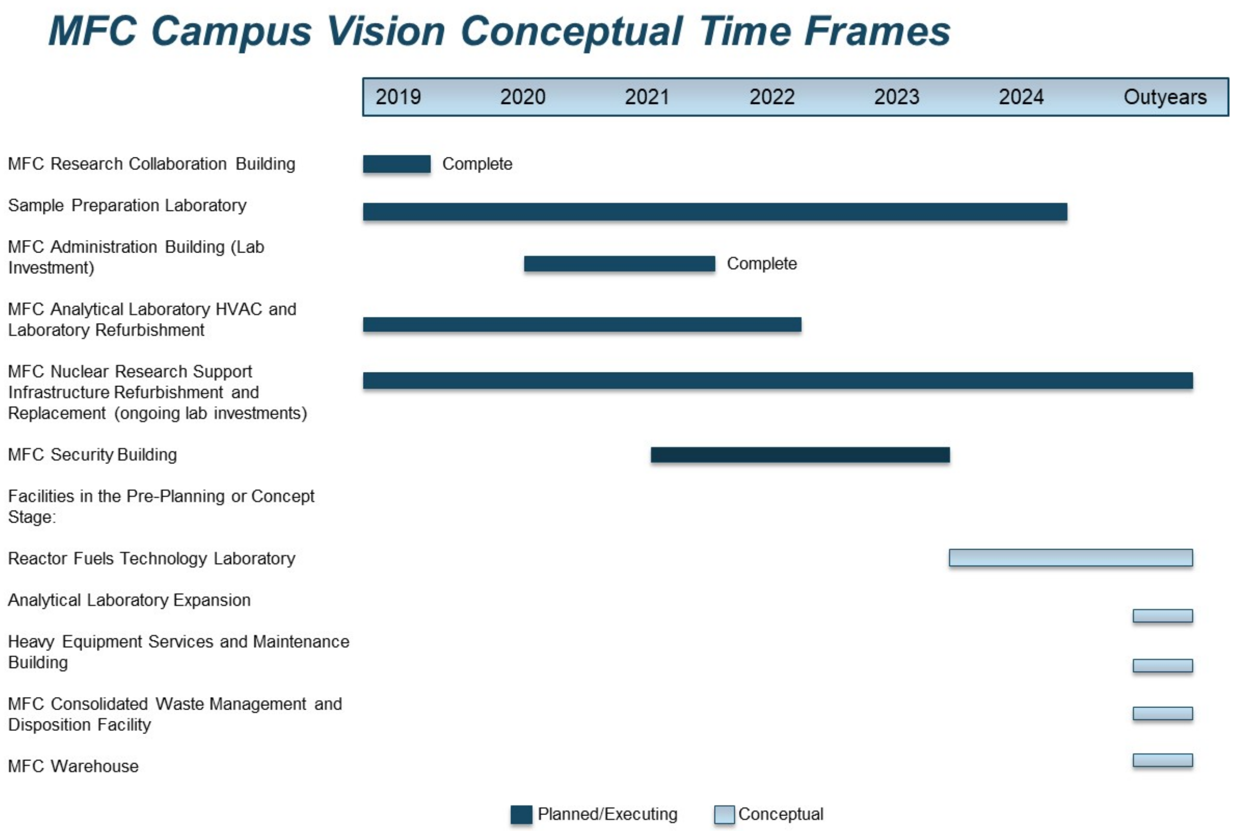


Figure 3. MFC Campus Vision Conceptual Time Frames for Test Bed and Demonstration Platform Development.

4.1.1 MFC Research Collaboration Building (RCB)

Description

A major role of DOE-NE in advancing nuclear technology is to bring the best and brightest scientists together in a cooperative manner to resolve technical challenges in nuclear energy. The interaction of scientists and engineers at the working level ensures that innovative ideas, supported by data, can be translated to workable technology solutions.

Benefits

This new facility provides much needed collaboration space that enables close interaction between INL researchers and technical staff with visiting users from outside INL and the United States. This allows technical staff to support key experiment discussions, design, and logistical activities at a location adjacent to the test bed without having to travel away from their work locations and provides visiting users close proximity to MFC.

Facility Risk

MFC office space is 100% occupied. As use of IMCL grows and SPL achieves operational status and the number of outside researchers using MFC is projected to grow beyond 200 per year by approximately 2022 with the growth of the test bed and demonstration platform. Additional collaborative research space is needed where research teams, consisting of INL researchers, visiting researchers and engineers, and other key technical support can collaborate and use advanced data analysis and visualization tools to resolve technical challenges.

Cost: $9.5M TPC.

Status: Facility construction was completed in FY-19 and RCB is in service supporting the RD&D Mission.

4.1.2 Sample Preparation Laboratory

Description

The Sample Preparation Laboratory (SPL) is focused on 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.

Benefits

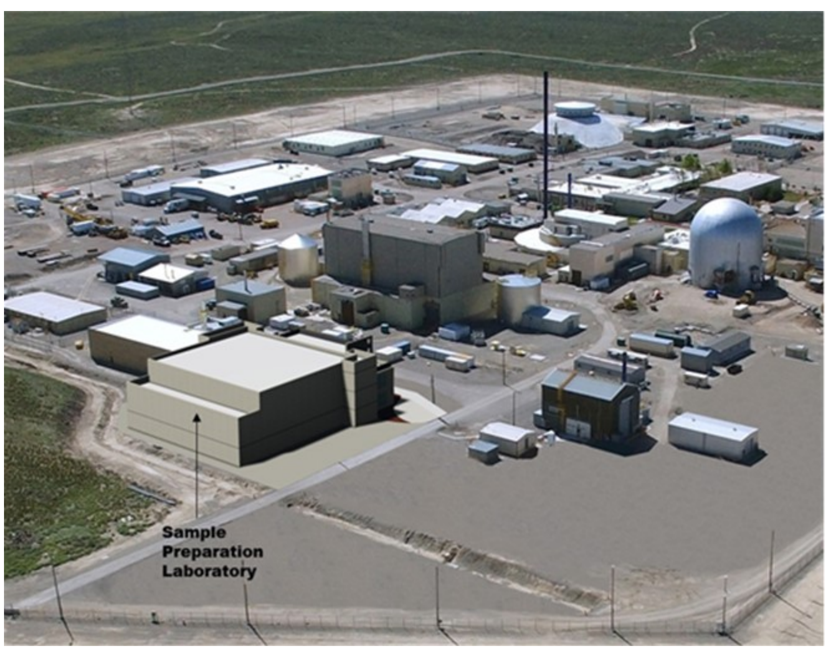
The proposed laboratory will include capabilities that will allow high-hazard materials to be routinely prepared and tested in a safe, secure, and environmentally controlled environment. SPL provides a key link between DOE-NE's core research functions at MFC and ATR and the broader nuclear energy research 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. 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: $166M.

Status: CD-2/3 approved 1/31/20; in construction



4.1.3 MFC Administration Building

Description

MFC is a central cog of the NRIC test bed concept. As such, there must be facilities available to support the anticipated growth of research and technical support staff. Modernizing aging capabilities such as cafeteria services and adequate office space also supports attracting and retaining personnel critical to support the growth of the test bed. A new administrative 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.

Benefit

The current MFC cafeteria infrastructure and equipment has been in service for decades and is antiquated. Considerable time is spent each year addressing facility reliability issues such as unclogging discharge piping. Code compliance is also at risk with this aging infrastructure. Completion of the proposed administrative building that includes a cafeteria will greatly enhance large capacity meeting capability and provide for more professional food service 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 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.

The current MFC food services cafeteria, large meeting support areas, training space, and administrative and support offices are inadequate to house a population that has increased to over 1,000 personnel. Expected project growth 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: The targeted cost range is $18.3M.

Status: Construction nearing completion

4.1.3.1 MFC Security Building

Description

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

Benefits

MFC-714 is the current MFC security building. It is a temporary modular office acquired in 1992 and generally considered to be in poor condition. A new MFC security building is a required priority 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. The new building will include both female and male sleeping quarters, showers and locker rooms, solving the existing condition wherein facilities of equal quality and access are 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: The current estimated TPC is $15.6M

Status: The new facility is currently in conceptual design and working towards CD-1 approval. Demolition of MFC-714 is tentatively planned to summer of FY-21 with construction planned to be awarded later is FY-21.

4.1.4 MFC Analytical Laboratory Refurbishment and Expansion

Description

The Analytical Laboratory (AL) 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, AL has been primarily focused on providing chemical and isotopic analyses in support of experimental programs. In addition, AL 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. AL has several single-point failures that could have a major negative impact to MFC's mission if they occurred. The current effort upgrades separate laboratories within the AL to include replacing aging or out-of-service fume hoods and refurbishing cabinets and floors. The major capital asset effort focuses on replacing the aging HVAC system and upgrading the system to support current and future research capabilities.

Benefits

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, AL 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 AL 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 Risks

A recapitalization program has been implemented to ensure the laboratory is able to meet its near-term mission by addressing critical infrastructure needs. This proposed 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. The AL footprint will need to grow to support expanded NRIC capabilities.

Estimated Cost/Status: AL HVAC upgrades are underway. Several separate efforts are being carefully integrated and coordinated to minimize RD&D mission support impacts. Current estimate for all the combined efforts is $15-18M with the GPP portion estimated at $12.6M TPC.

4.1.4.1 Expansion of Engineering Development Laboratory (MFC-789)

Description

MFC 789 is utilized by Nuclear Science and Technology (NS&T) staff to support research operations. This effort would increase the useable space inside the EDL building by use of the concrete pit, installation of an interior mezzanine, and construction of new bays to the east with interior mezzanines. The building additions would consist of two 20-foot bays to the east that would be the same width of the existing building. Construction would be similar to the existing structure with steel rigid frames, wall girts, and roof purlins. The wall material would be insulated metal panels. The floor would be concrete similar to the existing building.

Benefits

The building additions would add approximately 1300 square feet of useable floor space.

Facility Risks

The present occupancy in MFC-789 is not adequate for the operations and support staff needed to efficiently support NS&T RD&D. Additional floor space would increase research capacity and throughput for important NS&T initiatives.

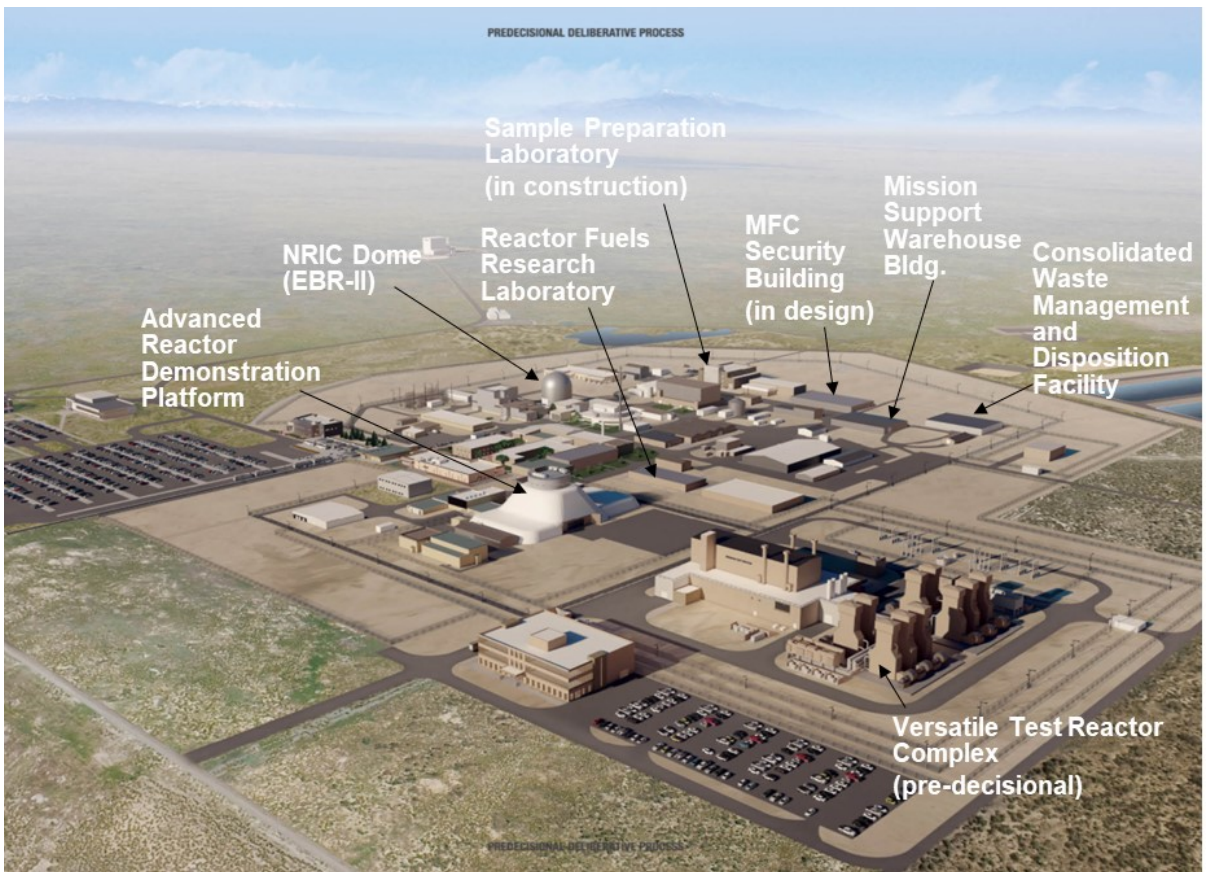
Estimated Costs: Rough order of magnitude costs are in the range of $750K to $1M

Status: An engineering evaluation and some limited conceptual work has been executed. Further efforts await identification of a funding source.

4.2 National Reactor Innovation Center Research Infrastructure

The Nuclear Energy Innovation Capabilities Act of 2017 (P.L. 115-248) (NEICA) amended the Energy Policy Act of 2005 to revise the objectives of the civilian nuclear energy research, development, demonstration, and commercial application programs of the Department of Energy (DOE).

Authorized by the NEICA, DOE chose INL as the home for the National Reactor Innovation Center (NRIC), which DOE commissioned in August 2019 to assist with the development of advanced nuclear energy technologies. NRIC is a national program led by Idaho National Laboratory (INL), allowing collaborators to harness the world-class capabilities of the U.S. National Laboratory System. NRIC is charged with demonstrating advanced reactors by the end of 2025. The NEICA requires NRIC to "minimize the time required to enable construction and operation of privately funded experimental reactors at national laboratories or other DOE-owned sites." Selection of INL as the NRIC lead national laboratory recognizes the unique, one-of-a-kind capabilities and legacy of the INL, where the United States built over 50 different reactors over 25 years. NRIC's mission is to bridge the gap between research and development and the commercial marketplace by enabling commercial developers to bring the Nation's most promising advanced nuclear reactors into commercial applications by 2030.



4.2.1 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 but is still 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 draft environmental impact statement identified the Idaho National Laboratory (INL) as the preferred site with Oak Ridge National Laboratory (ORNL) as a second choice. Fuel for the VTR would be constructed using capabilities at Savannah River National Laboratory (SRNL), or at the INL. For planning and cost estimating purposes, the VTR project has assumed the VTR would be located at the INL as the preferred alternative. Location and scope decisions will be finalized with the release of a record of decision (ROD) under NEPA. VTR's draft environmental impact statement (EIS) was released in December 2020 and public comments are being resolved. A ROD of decision is anticipated in October 2021.

VTR received capital funding in FY-21 and will begin expenditure of those funds in Summer 2021. VTR will also begin its siting investigation east of MFC in Summer 2021 (pending approval as a NEPA interim action, for which a determination is in process). The siting investigation will include boring, trenching, and seismology measurements. Preliminary design, final design, and construction timelines are dependent on appropriations.

4.2.2 Reactor Fuels Research Laboratory

Description

The Reactor Fuels Research Laboratory will provide a reconfigurable, long-term solution for meeting DOE, small business, and commercial needs for development of demonstration-scale quantities of fuel for licensing in current and advanced reactors. This supports the concept of working alongside industry as part of the NRIC test bed.

Benefits

A new demonstration-scale fuels research laboratory will be needed to support demonstration of advanced reactor technology. Demonstration articles must be fabricated using prototypic fabrication processes that produce fuel with reproducible characteristics. As the hub of NRIC, fuel demonstration capability is critical to support test bed demonstrations of advanced reactor designs. Significant investment is being made in advanced and rapid fabrication capabilities in industries with regulatory and risk profiles similar to the nuclear industry, including the aviation industry.

Currently the domestic NRC-licensed nuclear power industry is regulated to less than 5% enriched uranium and is only licensed for commercial reactor uranium oxide fuels (with only one exception). The advanced reactor design options that can capitalize on enrichment levels above 5% and below 20%, known as high assay low-enriched uranium (HALEU), are extensive and need to be exploited to develop advanced carbon free nuclear energy options. The existing facilities within the DOE complex are currently limited to research quantities of materials, generally less than one kilogram. There is a gap in capabilities for advanced fuel demonstration in the United States for fabrication of test-bed or engineering scale quantities of fuel focused on demonstration and process validation. To fill this gap requires a flexible and reconfigurable Nuclear Hazard Category-2 fuel development facility within the DOE complex that can handle large quantities of HALEU. This facility would allow the fabrication of lead test rods, lead test assemblies, microreactor cores, and the demonstration of new fabrication processes using many kilograms of material.

In addition to the direct fabrication capability, an important aspect of this study is to evaluate the extent of the quality assurance needed in the facility to foster reduced overall time required to produce a fully inspected fuel product. A critical quality component to nuclear fuel is elemental and isotopic analyses; as a result, this study needs to strongly evaluate the need for a fresh fuel analytical laboratory that may be included as a part of this facility.

Facility Risk

There is a gap in flexible capabilities for engineering scale fuel fabrication in the United States for advanced reactor fuel with enrichments higher than current commercial reactors incorporating potential advanced fuel fabrication and manufacturing technologies. Addressing this gap is critical to ensure that advanced reactor technology is able to move up the technology readiness scale from basic research through demonstration.

Estimated Cost: This facility is pre-conceptual design and no formal cost estimates are available at this stage, but the estimated range is $100 – $150M.

Status: This facility is in the pre-conceptual design stage.

4.2.3 NRIC Dome (EBR-II)

Description

A key component of the NRIC strategy is to provide by the end of 2024 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 EBR-II facility has been identified as a facility for testing of reactor concepts up to 10 MW thermal, using Safeguards Category-IV fuels. 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. Pre-conceptual design of the re-established EBR-II test bed was completed in FY-20 and is documented in the NRIC EBR-II Test Bed Pre-Conceptual Design Report (INL/EXT-20-59733). Initial design activities were conducted based on preliminary discussions with potential reactor demonstrators. Further specification of capabilities needed to support possible reactor demonstrations will occur throughout the design process.

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: This facility is pre-conceptual design, and no cost estimates are available at this stage.

4.2.4 Advanced Reactor Demonstration Platform (ZPPR Cell)

Description

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 useable 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.

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: This facility is pre-conceptual design, and no cost estimates are available at this stage.

Status: Aspirational pre-conceptual design.

4.2.5 MFC Support Infrastructure

4.2.5.1 Mission Support Warehouse Building

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.

Benefits

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. This facility creates significant operating efficiencies. 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.

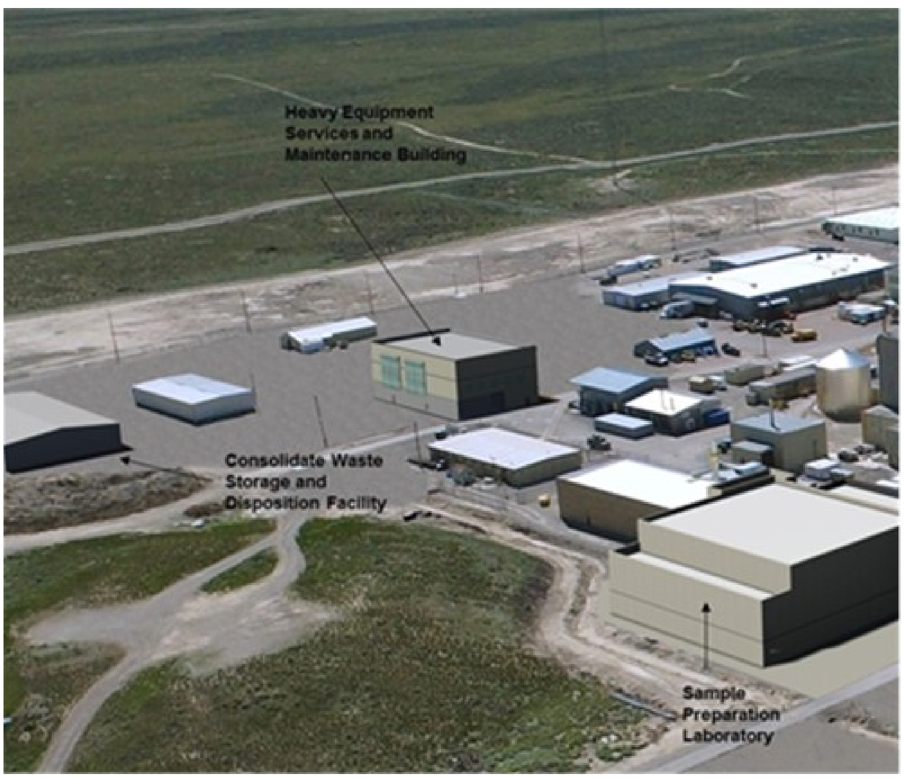
Facility Risks

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: This facility is pre-conceptual design, and no cost estimates are available at this stage.

Status: Aspirational pre-conceptual design.



4.2.5.2 MFC Cask Storage and Maintenance Building

Description

The MFC Cask Storage and Maintenance Building would provide a climate-controlled facility where casks and supporting equipment, instrumental in completing MFC's missions, can be stored and maintained in a controlled environment. This facility and those casks used for inter-facility and intra-INL transport activities would fall under the ownership of the Waste Management Integration and Transport Operations organization. This will provide clear roles and responsibilities, enable balancing of priorities, and enable hazard controls that can be tailored to the specific work being performed (storage and maintenance) and not subject to conflicting facility priorities and missions. MFC has identified the Sodium Components Maintenance Shop (SCMS) which could be repurposed to support MFC's cask management needs. This facility is currently a RCRA-permitted radiological facility; however, an upgrade to a HC-2 nuclear facility, along with installation of new support equipment, would further support staging and storage of loaded casks pending receipt to their respective facilities. This effort would D&D legacy equipment and systems, procure and install a new 25 ton single-trolley bridge crane and other support equipment, and construct a Butler building to consolidate and store cask support equipment.

Benefits

Casks and support equipment will be maintained mission-ready. Having single-ownership control in a central location for storing and maintaining the current fleet of casks and their equipment will enhance the availability of the casks and reduce impact on hot cell facility missions caused by storage and maintenance being performed in mission-designated facilities.

Providing single-point control of all casks and related support equipment, their use, storage, and maintenance follows the tenets of the ISMS process. This would also provide seismic stability for storage of casks. The work management and maintenance process will be enhanced when the currently dispersed cask and equipment storage and maintenance is under the ownership of a single organization.

Facility Risks

Casks and support equipment will continue to deteriorate and pose the risk of contamination to the environment. The casks are currently stored outside, and the required maintenance is performed in HFEF or FCF using valuable mission space and resources.

Estimated Cost: Pre-conceptual design.

Status: Pre-conceptual design.

4.2.5.3 MFC Consolidated Waste Management and Disposition Facility

Description

The current waste management capabilities of SCMS are limited and do not support an effective overall waste management and disposition capability. The MFC vision includes a new waste management and disposition facility in the northeast industrial area of MFC. MFC needs this capability to provide a foundation for an effective strategy to address legacy materials and the anticipated growth in newly generated waste streams resulting from increased and varied RD&D activities. This will provide a capability to more effectively consolidate, store, and stage waste and legacy materials and prepare this material for offsite disposition, reducing the environmental liability at MFC. This building will have limited treatment capabilities and be RCRA-permitted similar to SCMS.

Benefits

This facility reduces risk by reducing the footprint of outdoor storage of waste and material and optimizes waste- and material-management activities. This aligns with the vision of the research corridor expanding into the NW portion of the campus with industrial functions located in the northeast quadrant.

Facility Risks

MFC must meet the growing waste management demands that will be associated with the NE test bed. This facility is necessary to support consolidation of waste management activities from across the test bed, reduce internal waste container transportation distances, open more campus space at MFC from this consolidation as well as addressing legacy materials, and ensure that MFC has a consolidated capability to address current and future growth in waste management needs.

Estimated Cost: This facility is pre-conceptual, and no cost estimates are available at this stage.

Status: Pre-conceptual.

4.2.5.4 TREAT Control Room and Support Complex

Description

The transient testing facilities at MFC provide multi-programmatic support to an array of users from across the US and internationally. TREAT began operations in 1959 and some of the infrastructure is antiquated and does not effectively support modern-day operations at a world-class research facility, particularly the TREAT Office Building (MFC-721). Pre-conceptual and conceptual planning is ongoing to provide modern support facilities capable of housing staff and hosting visitors in an environment that supports world-class R&D collaboration and operations.

This effort has identified modifications and updates to the TREAT office building, including an additional support annex. The annex will include new offices, restrooms, and collaboration space. A new septic system and parking area are also included.

Benefits

MFC-721 was constructed in 1958 and added on to in a piecemeal fashion in subsequent (with the latest addition in the late 1970s or early 1980s). The supporting infrastructure, including the septic system, has not been substantially updated. TREAT provides a unique and growing transient testing capability in the U.S. and plays a pivotal role in the NE test bed and demonstration platform. Since restart, the role of TREAT and the burgeoning interest in fuels testing has led to an increasing scope of experiments and customers. This growth has raised challenges for providing adequate workspace for TREAT staff, as well as experiment personnel. This modification and upgrade provides needed expansion for direct support of daily operations and experiments, as well as a more appropriate esthetic for a world-class modern office building and entry point to the TREAT complex.

Facility Risks

The present occupancy in MFC-721 is not adequate for the operations and support staff needed to efficiently enable RD&D at TREAT. Based on the most recent tally of personnel assigned to the TREAT Office Building, 27 of the office spaces do not meet the INL office space standard (STD-140) and the usable space available per occupant is short of the DOE standard by 20 to 25%. Despite efforts to maximize efficient use of the present footprint, staff is currently overcrowded and doubled or sometimes tripled up in offices. There is no room to host users or to effectively manage, support, and collocate experiment teams with operations and technical staff. The septic system is approximately ½ the capacity needed to support the assigned building occupants, which increases risk of system failure. With the increasing experiment workload and requisite additional need, the present situation will only worsen in the future.

Estimated Cost: This facility is pre-conceptual and no current cost estimates are available at this stage.

Status: Pre-conceptual, no current time frame for construction.

4.3 Repurposing Existing MFC Facilities to Support Growth of the Test Bed and Demonstration Platform

MFC is evaluating facilities within the existing campus footprint and determining if they can be repurposed. Repurposing existing MFC space can be a viable alternative to investing in new infrastructure if a new mission for these facilities can be economically established within existing footprint. Several candidate facilities are currently in execution and others are being investigated for repurposing. Actual execution of activities to repurpose these are dependent upon available funding and emergent mission need. Examples of existing footprint that might be converted to support new mission areas include:

- Selected areas within nuclear facilities. The DOE-EM contractor is supporting the laboratory by removing large out-of-service and sometimes contaminated equipment and systems within existing nuclear and radiological facilities. This creates additional footprint to support research activities and enables judicious use of current assets. The following areas are currently funded and in progress:
  - Removal of out-of-service control consoles and abandoned conductors within the ZPPR control room completed in FY-19
  - Removal of the Waste Characterization Glovebox and support equipment from FMF completed in FY-19
  - Removal of the Development Glovebox located in FASB completed in FY-19
  - Removal of the Argonne Fast Source Reactor Structure located within EML completed in FY-19
  - Removal of tanks and ancillary equipment from the Radioactive Liquid Waste Treatment Facility. A replacement system, being designed and installed elsewhere as part of overall plant health efforts is currently underway and planned to complete in FY-21
  - Removal of systems within FCF including the Inter-Building Cask and gloveboxes inside Room 20 is currently underway and planned to complete in FY-21.
- The EBR-II dome and ZPPR cell are discussed in Section 4.3.
- Repurposing MFC-768 Power Plant. This is the original power plant structure that supported the EBR-II reactor and is approximately 51,000 ft^2. This multi-story facility currently houses some of the electrical infrastructure for MFC and includes office and lab space. Some mock-up activities are also housed inside. This area is being evaluated for best use of the available office and lab space within the existing footprint.
- Relocation of the Mock-Up Shop now located in FCF is being considered. This would free up significant footprint in a HC-2 nuclear RD&D facility to support mission expansion of the test bed. No clear path forward has been determined but options range from using a portion of MFC-768 to construction of a new basic metal sided facility.
- Repurposing of parts of FCF areas in support of NRIC has been initiated. FCF is a HC-2 nuclear facility that has a high security posture. The building houses a large inert atmosphere hotcell and an air atmosphere hotcell. Part of the strategic focus for the facility is to move missions that do not require the facility's security or radiological capabilities to other locations. The goal is to maximize the space available for research missions.
- Work is currently underway to replace back-up generators near the North Radiography Station in HFEF, remove legacy equipment no longer used, and restore some of the original operability of the elevator and other control systems. This will provide critical additional footprint to expand neutron radiography capabilities such as digital radiography.
- The MFC-752 cafeteria will no longer be needed to support food services after the new multi-purpose office building is completed. This will provide additional footprint available for repurposing. Future use of this available space has not yet been determined but one candidate is utilizing the space to provide a larger area for occupational medicine personnel.

- The TREAT Warehouse (MFC-723) is currently underutilized, other than for storage of equipment and supplies. An effort is underway to repurpose the building to support demonstration platform expansion. The vision is repurposing this facility into the TREAT Experiment Support Building that will support experiment preparation and assembly.
- Expanding the fabrication footprint at MFC. MFC fabrication expansion can occur by repurposing the metal stock control building MFC-796 (4600 sq. ft.) and the no longer utilized vehicle inspection station building MFC-736 (4800 sq. ft.). The Space Nuclear Power and Isotopes technology division currently stores fixtures, casks, and other mission equipment in MFC-796. This material will be moved to the vehicle inspection station, which is being repurposed for general storage. This allows MFC-796 to be renovated for fabrication material receipt and quality storage, material sizing and preparation, and test train/other experiment fabrication.

4.4 Laboratory Investments in MFC General Use Infrastructure

4.4.1 MFC General Use Infrastructure

MFC Facility Operations are the hub of DOE-NE's test bed. The Utilities and Infrastructure Support (U&IS) Group (balance of plant), is the hub of MFC facility support operations. This group's operations, maintenance, and subcontractor-oversight activities are associated with:

- Direct- and indirect-funded infrastructure efforts such as updating or refurbishing existing support facilities and their associated structures, systems, and components (e.g., structural, electrical, or HVAC-related activities), and efforts such as legacy material disposition.
- Laboratory-funded investments in general-use buildings, structures, and supporting infrastructure systems. Examples include: administrative buildings/adequate space, building roofs & exterior upgrades, interiors refurbishment, electrical and HVAC upgrades, pavement and sidewalk replacement, landscaping, lighting replacement, and other sustainability efforts, as well as expansion activities.
- The operation and maintenance of MFC support facilities and balance-of-plant utilities.

The laboratory invests annually in maintaining the general-use infrastructure across INL. Additional laboratory investments in MFC general-use areas will ensure MFC has a reliable infrastructure to support the NE test bed and demonstration platform concepts incorporated in GAIN and NRIC. Much of the support infrastructure at MFC consists of original structures and systems installed many decades ago and well beyond their intended service lives. Additional support infrastructure will be needed to enable the increasing mission work being executed at MFC as well as the diverse new activities anticipated. These capabilities will extend the ability to support broader technology readiness levels.

4.4.2 General Infrastructure Examples

As stated above, more detailed planning is necessary to develop a comprehensive prioritized plan. Areas being evaluated include:

4.4.2.1 MFC Parking Lot Renovation and Service Entrance Relocation

Description

Increased mission scope and associated employee growth has increased the need for more parking access at MFC. The existing parking lot does not have the capacity for our current staffing levels. The parking lot paved area is many decades old, has degraded, and one half of the lot is on an adjacent unimproved gravel area that is muddy through the spring and fall. This area, and the transition area between poses a risk for slips, trips, and falls. The addition of the Research Collaboration Building has substantially increased foot traffic across traffic flow; a situation that will be remedied with a complete parking lot upgrade.

Benefits

This renovation will result in more than 600 parking spots (increasing capacity by about a third), safer traffic and pedestrian flow, enhanced lighting, and improved bus parking. It will also route all deliveries to the new MFC East Access Gate, which is expected be operational prior to the start of the parking lot project. The parking lot will also include multiple spots for government vehicles, visitors and people with disabilities, among other upgrades.

Risks

Roughly 30% of current parking occurs on gravel. These gravel surfaces are not marked, are lit with temporary lighting, and are challenging to adequately perform snow removal from in the winter. The uneven surfaces cause water pooling and muddy conditions, and when frozen this area is very slippery under the snow.

Estimated Cost: The parking lot and east gate installation will cost approximately $8M

Status: Renovation is scheduled to begin Spring FY-21 and complete late Fall FY-21.

4.4.2.2 MFC Front Entrance Improvements

Description

This effort 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.

Benefits

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.

Risks/Estimated Costs/Status

This effort is in the conceptual developmental stage and more details will be provided as planning proceeds.

4.4.2.3 Other General Areas Being Addressed

- Facility upgrades to enhance the appearance of MFC facilities such as adding façade exteriors to selected buildings and updated entrances.
- MFC has been systematically replacing HVAC unit on common support buildings, some of which were 45 years old. Replacement units are from the same manufacturer with common spare parts. The HVAC campaign is approximately 95% complete.
- Approximately 1500 linear feet of sidewalks and access pads have been replaced over the last several years. This included sidewalks and pads that posed increased risk for slips, trips, and falls as well as important access pads outside roll up doors. Work will continue to a specific annual replacement plan.
- Multiple upgrades to interior paving were completed in FY-20 removing broken areas, potholes, and trip hazards. A significant portion of the walking route from the main gate north to IMCL was replaced, as was approximately 1.5 acres of roadway north of building 713. Other areas will be targeted in subsequent FYs.
- Site electrical transmission upgrades and component refurbishment are needed for new capabilities and sustainment of the existing capabilities. This includes replacing aged substations with modern sectionalizer technology, replacing aging transformers, upgrading motor control centers in several facilities, replacing aged lighting panels and breakers, and other electrical upgrades. These upgrades are being scoped and added to the indirect priority list in FY-21.
- Phase one of the MFC Utility Corridor was completed routing utilities from the SW corner of MFC to the NE corner. Utilities include: power, service water, fire main, fiber optic lines, and sewer system.
- Routing fiber optic lines throughout MFC to increase high performance computing capabilities to support advanced modeling and analysis.
- Improving site-wide wireless internet and cellular capability.
- Completing conference room, office space, kitchenette, bathroom, locker room, and interior renovations to multiple administrative buildings.
- Roofs are being systematically repaired/replaced and facility exteriors painted or resided.
- Telecommunications modernization (e.g., high speed, broad-band communication between MFC and the outside world).

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Appendix A

Detailed Descriptions of Plant Health Activities

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1. Replace or Upgrade the AL HVAC System

Description

AL suspect exhaust fans and HEPA banks are operating at or near (within a few percent) maximum capacity at all times with the current configuration. Some existing equipment including HEPA banks are degraded and shut down or cannot be connected because the suspect exhaust system cannot support the ventilation requirements. The result is an inability to be efficient in our processes and creates delays in sample processing. General laboratory area airflow direction and pressure differentials are difficult to maintain as desired to limit migration from zones of higher to lower potential contamination (hot cell pressure differentials are maintained). AL's mission is continuing to grow and evolve with an anticipated increase in throughput and precision and sensitivity for radiochemical measurements. Reheat/Room heaters intended to maintain lab temperatures within a tighter band are currently steam heaters, which cannot provide the precision and control needed for current technology instrumentation.

The HFEF pressure and temperature (P/T) system is used to control main cell atmospheric conditions. A portion of the P/T system was replaced in the 2016 major maintenance outage. The next phase is updating the purification system which controls the cell oxygen and moisture content. Aging components in the system have begun to cause significant maintenance issues, requiring increased costs in personnel time and replacement parts.

Benefit

Control of differential pressure within the AL is currently extremely difficult with the analog equipment installed. Research activities are regularly suspended due to air flow concerns. This upgrade will provide digital pressure differential control technology for control of building ventilation, enhancing safety for personnel within the facility and improving efficiency of research activities.

As uncertainty of measurements gets reduced, the data produced gets more accurate. This also Increases availability of laboratory due to fewer ventilation-failure induced shutdowns. Improved flow and pressure control reduces the risk of contamination migration.

This effort increases reliability and operational safety of the HFEF argon cell purification system control which improves operational efficiency (reduced operational burden to maintain desired atmosphere and improved HFEF main cell atmosphere control to meet mission needs.

Facility Risk

Control of building air flow from areas of least contamination to areas of higher contamination is a fundamental principle for protecting workers in nuclear facilities. The current AL ventilation DP control is analog and segmented in approach. AL staff is required to regularly suspend research activities and adjust the ventilation system to achieve minimum air flows. The current system limits the addition of scientific capability within the AL as new instrumentation has a negative impact by exceeding the limits of the current HVAC system. This upgrade will provide enhanced air flows and minimize research interruptions. Failure of key blowers, dampers, or control system components would result in several weeks down time for key AL lab spaces.

ROM Cost Estimate: $10M.

2. AL Lab B-103 Refurbishment

Description

The scope of work includes the purchase and installation of replacement fume hoods and high efficiency particulate air (HEPA) filter housings with filters to allow for the return-to-service of two hoods located in Room B-103. The existing fume hoods have been out-of-service (OOS) for several years as a result of corrosion of the existing HEPA housings. Additionally, the steam heater will be replaced with an electric duct heater and new pressure and air flow controls will be installed.

Benefit

The MFC-752 Analytical Laboratory (AL) 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. Since that time, however, there has been no cohesive, concentrated effort to ensure the AL maintains its ability to support the nuclear mission of INL. With ever increasing programmatic demand, near-term investment is required to ensure programmatic commitments are met. This project will reestablish needed functionality in Room B-103 to support continued programmatic needs. This scope is part of the scope envisioned in Item No. 3 on the FY-18 MFC Five-Year Plan Investment - Facility Reliability Proposed Scope list, dated May 2018.

Facility Risk

Without the upgrades, the hoods will remain out of service. The work is part of the overall plan of the facility to support increasing programmatic needs.

ROM Cost Estimate: $1.2M

3. AFF HVAC Modifications

Description

Similar to the prior CESB-to-EFF HVAC modifications, this effort will design, procure, and install a HEPA-filtered building HVAC system in the Advanced Fuels Facility (MFC-784).

Benefit

The current facility has no air conditioning and gets extremely uncomfortable to work in during the afternoons in the three summer months. The HEPA-filtered building HVAC system will permit installation of radiological hoods and large radiological equipment with hooded enclosures (e.g., mill, lathe, grinder, arc melter) within a Contamination Area, significantly increasing the nuclear fuel manufacturing equipment that can be installed in the available facility footprint.

Facility Risk

If INL does not install a HEPA-filtered building HVAC system in MFC-784, then radiological hoods and large radiological equipment with hooded enclosures cannot be installed in the available facility footprint. The INL will miss or delay opportunities to meet RD&D test bed and demonstration platform objectives, for external lab impact, and for funded RD&D scope. The facility will also continue to have a very hot working environment for three months of the year limiting the amount of time personnel can reasonably perform continuous work.

ROM Cost Estimate: $3M.

4. Manipulator Replacement Campaign in HFEF, FCF, and AL

Description

This project procures a new manipulator system for replacement of the obsolete manipulators in HFEF, FCF and AL 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 'like for like replacement' of the aging manipulator fleet. 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: $17.9M.

5. Window Replacement Campaign in HFEF, FCF, and AL

Description

Main hot cell windows at HFEF, FCF, and AL 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 a total of 3 leaking windows in HFEF, 2 in FCF, and 2 in AL that require replacement.

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.

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: $25.5M.

6. HFEF Argon Cell Temperature and Pressure Controls

Description

The HFEF pressure and temperature (P/T) system is used to control main cell atmospheric conditions. A portion of the P/T system was replaced in the 2016 major maintenance outage. The next phase is updating the purification system which controls the cell oxygen and moisture content.

Benefit

Increased reliability and operational safety of the HFEF argon cell purification system control. Improved operational efficiency (reduced operational burden to maintain desired atmosphere. Improved HFEF main cell atmosphere control to meet mission needs.

Facility Risk

Aging components in the system have begun to cause significant maintenance issues, requiring increased costs in personnel time and replacement parts. The major risk to the facility involves a component failure that requires feed and bleed as the only method to control oxygen and moisture levels in the cell. This may not meet operational specifications or mission needs for the cell atmosphere and would result in delays while design and repair efforts are pursued. This may affect operational milestones and mission commitments.

ROM Cost Estimate: $1.5M

7. Replace the Criticality Alarm System (CAS) in FMF and ZPPR

Description

Replace the existing Criticality Alarm System (CAS) with a new and equivalent system. CAS components are many years past their intended design life and spares are no longer available. These facilities have each experienced one to two week outages due to failed detectors. Repair was accomplished by scavenging detectors from other out of service alarm systems.

Benefit

Installation of a state-of-the-art system will ensure maximum facility availability for mission work and readily available spare parts. Purchasing both systems together resulted in a net cost savings of over $1M.

Facility Risk

Failure to upgrade the CAS will result in the eventual failure of detectors or other irreplaceable components resulting in unacceptable facility downtime of up to 6-9 months as a replacement system is fabricated and installed.

ROM Cost Estimate: $2M.

8. HFEF Facility Out-Of-Cell 40-Ton High Bay Crane

Description

The 40-ton high bay crane is a traveling bridge crane that traverses the full length and width of the high bay. The crane is used to load and offload the majority of casks used to transport research specimens to and from the facility. Prior to installation in the HFEF, the 40-ton high-bay crane was in service at other INL locations since 1955. The crane was installed in HFEF during initial construction and has now been in service for over 60 years. The crane exhibits a variety of issues related to age that now requires upgrading. These issues include rails and trucks wearing out, trucks climbing up on rails due to crabbing of the trolley, and an obsolete control system failing frequently.

Benefit

The benefits related to repair of the 40-ton crane is significantly increased reliability as well as proper operation and operating efficiency.

Facility Risk

The facility risk (if this repair is not completed expeditiously) is the complete halt to HFEF operations and any HFEF related program work since the crane is vital in processing casks and waste containers in and out of the facility. It is estimated that a work cessation due to crane failure could span greater than a year as a replacement is obtained and installed.

ROM Cost Estimate: $3.1M.

9. HFEF/IMCL Supplied Argon System Replacement

Description

The existing HFEF argon compressors are obsolete. The existing compressors are old (1950s vintage) and obsolete; direct replacements are not available. HFEF is operating on compressor #2, compressor #1 is out of service. It is estimated that compressor replacement with a comparable system would take approximately 12-18 months and would require extensive modification to HFEF. Compressor #1failed in 2017 due to an internal water leak. The water damaged the connecting rod seals, efforts to repair the compressor failed. Now when running it raises the oxygen levels significantly in the HFEF main cell. Do to the lack of available spare parts, this compressor cannot be put back into operation. The solution to the failed/failing compressors is to replace this system with a large liquid argon storage tank. The tank will be located north or HFEF. The tank will supply all the loads that is currently carried by the compressor and will also remove portable gas bottles utilized to support various programs that require pure argon blankets, like JFCS. In addition to supplying the compressed argon system the argon tank will replace the current “emergency” argon supply system with one that can actually support the HFEF main cell for an extended period of time. The current system can supply 2000 SCFM to a cell that is 60,000 SCFM.

The system is large enough and will be located in an area that can also be utilized by IMCL to support programmatic work. IMCL has several gloveboxes that would benefit from have an argon atmosphere. Currently IMCL must use portable AR bottles to supply any programmatic need.

Benefit

The argon tank is a passive system that has no moving components. The removal of moving components greatly reduces failure mechanisms. This reduces the risk to programs in HFEF. Currently if the compressed argon system fails it will stop program work in the containment box, which also effects the METBOX. The failure of the compressors will also make the large equipment lock inoperable, if the large lock is inoperable the HFEF main cell must be placed in the standby mode. Again the lack of moving components will greatly improve reliability of HFEF. The ability to place the “emergency” argon system on the tank eliminates a potential vulnerability and provides a more extensive defense-in-depth system.

Facility Risk

This reduces the risk to programs in HFEF. Currently if the compressed argon system fails it will stop program work in the containment box, which also effects the METBOX. The failure of the compressors will also make the large equipment lock inoperable, if the large lock is inoperable the HFEF main cell must be placed in the standby mode. Currently if the compressors fail HFEF could be in the standby mode for 3 to 6 months while this modification is made. The operating compressor is due for an extensive rebuild based on hours of operation, if performed there is a potential that the compressor will not be capable of being resealed due to lack a materials or degradation of components. By not performing this maintenance there is an increased risk of compressor failure.

ROM Cost Estimate: $2M.

10. FCF Multi-Function Furnace

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: $6M.

11. Radioactive Liquid Waste Treatment Facility Process/Storage Tanks Alternatives Analysis and Replacement

Description

RLWTF has four 1000-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: $3M.

12. HFEF Small and Large Transfer Lock Drive Control System Replacement

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: $800K.

13. 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.

Refurbish FCF Air Cell Ram – A large floor hatch located in the northeast corner of the air cell is used to transfer equipment and materials to and from the transfer tunnel, decontamination spray chamber (DSC), argon cell, and SERA in the basement. The transfer hatch is served by the Air Cell Ram a 5-ton capacity hydraulic lift located in the basement for material movement between the air cell and the basement facilities. The Air Cell Ram is original to the facility. The Argon Cell Ram, with the same history, had seals fail in 2020 requiring over a month outage to repair.

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 exist cell and old Decontamination Spray Chamber (DSC) roof to allow access for inspection.

Replace FCF SERA/DSC Crane and Control Equipment – The Suited Entry Repair Area (SERA) and Decontamination Spray Chamber (DSC) allows maintenance of large equipment items that require hands-on servicing. 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 EBRII 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.

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.

ROM Cost Estimate: Multiple annual funding increments of $3-4 M

14. MFC Legacy Materials Disposition

Description

Typically, disposition of waste is accomplished as waste is generated; however, past practices in performing mission work historically did not require disposition of waste as it was generated resulting in a buildup of waste in the FCF and HFEF main hot cells. This is considered legacy in that no current programs generated the material. This waste accumulation has reduced the programmatic workspace. To support GAIN, NRIC, and other missions, this legacy waste must be removed to provide adequate space for required facility and programmatic upgrades, and new mission-required equipment.

Benefit

Reduction in the existing quantity of legacy waste currently residing in the HFEF argon cell will increase the amount of useable floor space for installation of new programmatic equipment as well as facilitate transfer of equipment and materials within the cell.

Facility Risk

Failure to reduce the existing legacy waste backlog will inhibit new equipment installation as well as potentially delay programmatic work due to cell congestion and delays in equipment installation. Operations become severely limited and remote handling mishaps more frequent when waste items are allowed to build up in-cell.

ROM Cost Estimate: $3.8M in FY-18 through FY-20 and $1M per year through approximately FY-22 to support a multi-year campaign.

15. 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: $2.5M.

16. FCF Integration of Bottle Inspection with Wire Removal

Description

Currently inspection of EBR-II fuel bottles for the presence of moisture is conducted at window 10 in the FCF argon cell. This is several workstations away from the chopping function which occurs at window 2. Movement of uninspected bottles from the air cell to window 10, and the return of inspected elements back to window 2 for chopping introduces a number of handling steps which contribute to treatment process inefficiency. Additionally, removal of wires at the same workstation where chopping occurs accounts for a significant amount of the time that the fuel spends at that workstation. If wire removal and cassette loading occurred in conjunction with bottle/element inspection additional handling could be eliminated.

Benefit

Elimination of lengthy in-cell transfers through multiple workstations, coupled with consolidation of the element/bottle inspection and spacing wire removal functions will increase overall treatment system reliability and process rate efficiency.

Facility Risk

Requiring elements and bottles to travel through the primary treatment workstations (MK-IV ER, CP, & CF) creates challenges in making sure the transfer paths are clear and introduces the potential for delays in the treatment process while waiting for the pathway to clear. Additionally, consolidation of multiple fuel subassemblies at window 2 challenges zone inventory limitations. Thus, reducing the amount of time fuel assemblies spend in this zone due to wire removal will help mitigate this challenge.

ROM Cost Estimate: $1.7M

17. 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.

Benefits

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 Estimated Cost: $4.8M.

18. FMF/ZPPR Roof – Replacement

Description

The FMF is covered by an earthen berm that provides shielding for the nuclear material located in the building. The berm is classified as a safety system. A cellular confinement stabilization fabric is placed over this berm and serves as the roof for the building. The existing FMF roof exhibits numerous areas where the fabric anchors have backed out and the rock has fallen below the fabric. The ZPPR fabric roof is at end-of-life and requires replacement. This project will repair the entire berm area and replace the FMF roofing material with a new roofing system. Critical repairs to the ZPPR roof will be completed. This is needed due to the general amount of deterioration between 2011 and 2013, and the accelerated deterioration in areas where water is able to penetrate (TEV-1979). Drainage issues around the FMF/ZPPR facilities will also be addressed.

Benefit

The FMF berm serves a safety function as radiological shielding; the depth and material composition are important factors in the shielding calculations. Subsidence that significantly decreases the depth of the berm material will increase the resulting radiation dose. The ZPPR fabric and earthen covering serves a safety function as radiological shielding; the depth and material composition are important factors in the shielding calculations. Subsidence that significantly decreases the depth of the berm material will increase the resulting radiation dose.

Facility Risk

Roof degradation is significant in places. Infiltration of precipitation during rain events and snow melt are beginning to occur frequently. Infiltrations of water into the facilities can create hazardous conditions and halt operation until it is addressed. This impacts facility availability and requires significant labor resources to mitigate.

ROM Cost Estimate: $4.9M.

19. Analytical Laboratory Lab Room Renovations

Description

The Materials and Fuels Complex Analytical Laboratory (AL) provides high-quality processing, analysis and characterization of radiological materials. The AL 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 AL. 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-pane with aluminum framing which provide 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

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

Facility Risk

The conditions can be less than ideal for operating equipment. 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 AL.

ROM Cost Estimate: $750K/lab room.

20. – 25. IMCL Efficiencies

Description

The Irradiated Materials Characterization Laboratory (IMCL) is the newest nuclear energy research facility at the Idaho National Laboratory's (INL) Materials and Fuels Complex (MFC). This unique 12,000 square foot facility incorporates many features designed to allow researchers to safely and efficiently prepare and conduct microstructural level investigations on materials of construction and nuclear fuels.

Numerous smaller areas for improvement have been identified as work with the ultra-sensitive instruments has begun in earnest. These areas include:

- Optimizing sample transfer capabilities for more effective operations
- Installing a manipulator repair station to avoid having to ship manipulators to other facilities for repair
- Enhancing the communications infrastructure
- Further refinement of the ventilation system to reduce interference with instruments
- Refining the fixed air sampling system to support more effective operations

Benefit

The benefits of the noise reduction within IMCL will allow for the utilization of the state-of-the-art equipment at their optimum level, increased satisfaction for researchers and visitors to IMCL and increased knowledge for future state of the art building projects at MFC.

Facility Risk

Continued suboptimal utilization of instrument capabilities and uncomfortable noise level to researchers and visitors to IMCL.

ROM Cost Estimate: $2.4M.

26. Radiation Control Instrumentation and Monitoring Upgrades

Description

Additional radiological control equipment is needed to support facility operations and to complete the replacement and standardization of obsolete instrumentation and the procurement of new technologies designed to increase organizational capabilities and efficiencies. Multiple facility CAMS and RAMS are obsolete and have reached their EOL. Beta and Alpha CAMS are required to be replaced because the in-service instruments are no longer supported by the manufacturer. The old units are failing at an ever-increasing rate and spares are not available. The three main components of this plan are instrumentation standardization and modernization, software modernization and capabilities enhancement. Significant progress has been made over the past 7 years towards this goal. Other equipment consists of friskers, hand monitors, portable smear counters, and gamma spectroscopy equipment.

Benefit

The additional equipment will increase efficiencies associated with reliable new technology equipment that has lower fail rates and lower false alarms. New capabilities are being evaluated for portable alpha and gamma spectroscopy units to enhance our ability for characterization of radioactive material in the field without delay. Count room isotopic characterization equipment is also needed to quickly analyze survey media to reduce delays and increase work efficiencies. New software applications to allow remote readout of radiological instrumentation will reduce response time to alarms and enhance the facility monitoring capabilities. Gamma spectroscopy equipment is needed to perform Tier II and Tier III release on activated materials and volume contaminated materials.

Facility Risk

Continued inefficiencies in response to radiological instrumentation alarms. NORM determination will continue to be a lengthy process which creates down-time. Instrumentation failures due to outdated equipment results in facility down time while waiting for repairs or replacements. Continued lack of ability to release activated and volume contaminated material.

ROM Cost Estimate: $4M.

27. Replace Elementary Neutralization Units (ENU) Drain Piping

Description

The ENU piping of the Materials and Fuels Complex Analytical Laboratory (MFC-752AL) shows signs of leakage and corrosion. Therefore, the ENU collection system is currently out-of-service (OOS) requiring sample solutions be collected in a tote prior to disposition. The tote is located in the A-wing of the AL, a significant distance from the general chemistry lab rooms where sample preparation and analysis is conducted. The primary cause of this damage has been attributed to an incompatibility of existing piping material (stainless steel) and the concentration of waste chemicals and waste constituents being generated by the AL and discharged through the ENU drain piping network. As a result, all piping upstream and downstream of the ENU is to be replaced with a more suitable piping material.

Benefit

Placing the ENU drain piping system back into service will result in a significant efficiency gain for lab personnel. Working lab room sink drains will allow direct disposal of sample solutions following analyses into the lab room sink with drain piping tied to the ENUs. Additionally, having working sinks will allow the AL to install water purification systems local to each room rather than utilizing one purification system in room B-141, improving lab personnel efficiency for sample preparation.

Facility Risk

Not having a working ENU collection system severely impacts lab personnel efficiency for both sample preparation and sample solution disposal post analyses.

ROM Cost Estimate: $2.3M.

28. HFEF Exterior Roof/Stack Access Stairs

Description

Current HFEF emergency stack ladder has been condemned as unsafe and removed form service. Installation of a stair tower to replace the condemned ladder will provide the same function as the ladder it replaces by providing a safe access to the stack and access for security for equipment installed on roof.

The work scope of this project is to design a stair tower that meets the OSHA requirements and to supply HFEF with the seismic reaction to verify that the building seismic rating is not compromised. The project will build the stair tower either off or on-site, the preferred is off-site. The stair tower will be installed, this will require excavation and structural steel work. The tower is to be self-supporting but will require lateral support from the building. There is no electrical work associated with the project.

Benefit

The addition of compliant access at HFEF will provide a safer way to access the roof as well as providing a more efficient way to move equipment to the roof.

Facility Risk

The existing ladder has been condemned unsafe and does not meet OSHA requirements. This impacts access to the stack and security equipment located on the roof.

ROM Cost Estimate: $250K.

29. HFEF Argon Compressor Removal

Description

The HFEF argon compressors are being replaced by a bulk argon system. Once the bulk system is operating the compressors must be removed to provide additional space for other uses. The main scope of work for this project is the removal of the argon compressors and associated equipment in the HFEF basement. Specifically, this project will:

1. Review drawings and identify system components for removal
2. Remove compressor piping
3. Remove the two argon compressors
4. Remove the two compressor receiver tanks
5. Remove the compressor electrical and controls components
6. Remove the associated concrete equipment pedestals
7. Disposal of removed components and waste generated from equipment removal.

Benefit

Removal of the Argon compressors in HFEF will free up valuable real estate for other uses such as a transfer station to support NRAD and IMCL operations.

Facility Risk

The risk to the facility if the compressors are not removed is that equipment is abandoned in and occupies space that can be used for other functions including the support of program work.

ROM Cost Estimate: $500K.

30. HFEF Argon Regeneration Valves

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: $500K.

31. Convert RCL from Steam Heat to Electrical Heat

Description

The objective of this work is to replace the existing inline duct steam heater with an electrical coil for the Radio Analytical Chemistry Laboratory (RCL) at the Materials and Fuels Complex (MFC) located at Idaho National Laboratory (INL). Included in this work is a using subcontracting to replace the steam unit with an electrical heat coil, including the following demolition of steam piping and capping of lines, temporary removal of electrical and piping to facilitate the removal of the steam unit, removal of a large section of duct to allow removal of the steam unit, construction of new duct section to allow proper fit up of the new electrical unit, and tie in to the existing system, installation of a new 1200 amp electrical panel, and running conduit and wire to feed the new panel from the substation in room.

Benefit

The main benefit is to have better control of the heating within the RCL. Some of the instrumentation within the RCL requires the temperature fluctuation to be small. This would enable the ability to better control the heat to within the required temperatures. It would also correct an issue that would have to be fixed with a maintenance request; that being a hole in the steam coils. The costs benefit of upgrading at this time instead of replacement is increased as a result.

Facility Risk

Currently, we have a hole in the steam coil that requires maintenance to be performed. The system is being used, but there is an increasing risk of failure the longer we go without correction. Failure of the system would result in no heat to the building. There have already been several repairs made to the system and the costs of the repairs continues to increase and each repair increases the risk further.

ROM Cost Estimate: $750K.

32. Design, Fabricate, and install New FCF Feedthrough to Support CO_2 Cold Jet Decontamination System

Description

The SDI Select 60 Cold Jet CO_2 Blast Unit (Cold-jet) has been tested for contamination removal of materials (e.g. manipulators & EMMs) in the FCF Decon Spray Chamber (DSC). The use of the Cold-jet was demonstrated to significantly reduce surface contamination in some conditions and thereby further achieve ALARA objectives. To support the permanent installation and effective use of the new cold-jet decon system at FCF, a new feedthrough needs to be designed, fabricated, and installed in the DSC. We will modify an existing feedthrough to fit the needs of the cold-jet system.

Benefit

The use of the Cold-jet was demonstrated to significantly reduce surface contamination in some conditions and thereby further achieve ALARA objectives. The feedthrough will facilitate more efficient and effective use the cold-jet system.

Facility Risk

Without this new feedthrough the use of the Cold-jet system in the temporary non-routine procedure process requires multiple Suited Entry Repair Area and DSC entries which is not in alignment with ALARA objectives and causes measurable delays in the decontamination process.

ROM Cost Estimate: $350K.

33. HFEF MetBox Refurbishment

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: $500K.

34. HFEF Containment Box Lid Seal and Hoist

Description

The HFEF Containment Box, along with its associated support equipment, is located in the HFEF main hot-cell. The containment box is an enclosure that isolates the station from the main cell atmosphere. The purpose of the containment box is to isolate an area for use in preparation of metallographic specimens for optical microscopy and hardness testing. This enclosure is necessary because metallographic operations require the use of liquids that could be harmful to the system used to purify the main cell argon. Additionally, head-end operations prior to sample preparation (grinding and polishing) require sawing operations that produce fines that also need to be isolated from the main cell environment for contamination purposes. Issues related to the containment box that require attention include a lid and doors that no longer seal properly, aging controls and cooling systems that require upgrade, and aging hoist capabilities within the enclosure.

Benefit

Correcting the previously mentioned issues will improve isolation of the containment box interior from the main argon cell as well as improve reliability of the containment box functions.

Facility Risk

The risk to the facility is delay of program work should the door and lid seals completely fail or should the box controls or cooling system fail. It is estimated that containment box down time would exceed 9-12 months should complete failure occur.

ROM Cost Estimate: $500K.

35. Continued EBR-II Dome Test Bed Platform Refurbishment

Description

This effort reestablishes functionality of utilities, access, lighting, and maintenance of the EBR-II dome. This will provide a more functional structure that can be modified to support demonstration platform test bed activities inside the dome at much less cost than constructing new nuclear energy research test bed platforms.

Benefit

New HC-2 research footprint is extremely expensive for new construction. Optimizing this valuable asset to support NRIC is being evaluated to determine the best use of current nuclear research footprint. Repurposing the dome to serve as part of an expanding nuclear energy research test bed supports the NRIC mission and the GAIN vision at a fraction of the cost of constructing a similar new facility.

Facility Risk

The EBR-II Dome presents an opportunity to expand the nuclear energy research test bed to support more advanced technology readiness levels moving into demonstration of advanced nuclear technology such as microreactors and advanced fuels fabrication. This can be achieved by modifying and repurposing the dome at significantly less cost than new builds. Not optimizing existing infrastructure to support NRIC will slow or limit the ability to provide test bed platforms that enable partnerships with private industry or other governmental agencies.

ROM Cost Estimate: $500K of FY-20 funding (in addition to previous funding of ~$2.5M) to paint and repair the dome, provide a new vestibule access point, painting of the interior of the dome, and reestablishing utilities on a limited basis. Additional activities are being evaluated as mission needs emerge.

36. HFEF Standby Diesel Generator Removal & Replacement

Description

This capital asset project removes aging backup diesel generators from the HFEF basement. It provides a pre-engineered electrical building outside of HFEF and co-located pads with upgraded backup diesel powered generators.

Benefit

The current diesel generators, while providing essential levels of backup power for all safety related systems, do not provide adequate power to help ensure that vital research systems are not damaged in the event of a loss of power. Removing the current diesels from the basement of HFEF also provides additional footprint inside this nuclear research facility to accommodate expanding test bed capabilities.

Facility Risk

The current diesels provide adequate power to support all primary safety systems in the event of a loss of power. However, there are numerous new research capabilities and support systems within HFEF that would not be supported in the event of a loss of power. The new backup power capabilities provide adequate power to support most HFEF power need to allow for safe and timely shutdown of sensitive research capabilities in the event that it is necessary to do so. This minimizes damage to the HFEF research infrastructure housed inside this vital nuclear research facility.

ROM Cost Estimate: $3.3M.

37. Install Equipment Enclosure and North Side Upgrades at FASB

Description

Floor space within MFC-787 (FASB) is insufficient for the temporary and permanent receipt of equipment, materials, and supplies to support the facility mission. The standby diesel generator for FASB is currently mounted on a trailer and needs to be placed on a permanent support.

Benefit

This project will dramatically improve the look of the north side of FASB and support more effective facility operations.

Facility Risks

Without the FASB Equipment Enclosure MFC-787 will not be able to adequately support mission needs. The mission needs within MFC-787 are continuing to grow and with upcoming missions this enclosure will be very valuable space. This project is initiated and on-going.

ROM Estimated Cost: $500K

38. HFEF Cell Chiller Replacement

Description

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 2014, but the underlying problem remains, requiring increased cell chiller maintenance due to failures. 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.

Benefits

The benefit to the facility is increased chiller reliability resulting in reduced maintenance as well as less potential for cell down time and impact to programmatic work.

Facility Risk

When the chillers fail and/or require maintenance, HFEF has to shut down cell purification which precludes small and large lock transfers, restricts research activities with materials that are sensitive to cell atmosphere, and limits in-cell lighting which shuts down most programmatic research.

The facility risk if this project is not completed is the potential for increasing frequency in corrective maintenance and the potential for chiller failure that could impact programmatic work due to cell conditions.

ROM Estimated Cost: $1.9M

39. Refurbish FCF Air Cell Transfer Hatch RAM

Description

A large floor hatch located in the northeast corner of the air cell is used to transfer equipment and materials to and from the transfer tunnel, decontamination spray chamber (DSC), argon cell, and SERA in the basement. The transfer hatch is served by the Air Cell Ram a 5-ton capacity hydraulic lift located in the basement for material movement between the air cell and the basement facilities.

The Air Cell Ram operates with no known issues but has not been inspected since the early 90’s. The equipment is original to the facility. The Argon Cell Ram, with the same history, had seals fail in 2020 requiring over a month outage to repair.

Benefit

Reliable capacity to perform needed maintenance on Air Cell EMMs, Manipulators, and Cranes to ensure availability for program mission.

Facility Risk

Without additional funds mission commitments are at-risk of completing as scheduled.

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

ROM Cost Estimate: $800K.

40. FCF MTG Revision and User Interface Update

Description

The FCF Material Tracking System (MTG) 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 MTG 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 out-dated 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 EBRII Fuel Processing and HALEU Production activities relying on MTG will be challenged to demonstrated compliance with NQA-1 standards and effective and efficient process activities.

ROM Cost Estimate: $5.7M.

41. 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 AL'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 AL, 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 AL'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 AL's results and jeopardizes the AL'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 AL.

ROM Cost Estimate: $300K.

42. TREAT Loop Handling Cask – New 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.

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: $0.075M.

43. AL Hot Cells 1 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 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.

Benefits

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 support multiple programs simultaneously, increase throughput, and reduce maintenance efforts. Improvements will also provide greater ergonomic benefits and reduce the strain on the manipulators.

Risks

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 Estimated Cost: Year 1: $1500K, Year 2: $1500K, Year 3: $500K

44. Contamination Control Upgrades

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 costs 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 costs of operations.

ROM Cost Estimate: $800K.

45. HFEF Pneumatic Sample Transfer System and Control Systems Overhaul

Description

The two pneumatic sample transfer system lines between the HFEF main cell and metallography hot cell (Met Box) are key for transferring samples to the optical microscopes for post-irradiation examination. The primary line has experienced multiple failures in recent years and the back-up line has been out of service for multiple years due to failures as well. This project will overhaul the transfer systems, including mechanical system and controls, to restore full functionality. This will be a minimum 2-year effort (1 year of design including issue of procurement, and 1 year for implementation and close-out).

Benefits

The benefit to HFEF and all post-irradiation examination programs is increased efficiency and increased reliability of sample transfers to perform mission research. The system overhaul will also provide system redundancy, currently lacking due to an out-of-service line, allowing for uninterrupted research during future maintenance and repair.

Facility Risk

When the pneumatic sample transfer system is inoperable, HFEF cannot complete programmatic work. The previous system outage resulted in a 3-month interruption of programmatic work at the HFEF Containment Box (where sample preparation is performed) and the HFEF Met Box (where optical microscopy is performed) while troubleshooting and repairs were completed. Delays such as these jeopardize programmatic work and mission milestones. Without a system overhaul, similar failures are expected to increase, resulting in loss of mission research.

ROM Estimated Cost: $2.75M

46. NRAD TRIGA Fuel Purchase for Continued Operations and Mission Enablement

Description

NRAD reactor in the 64-element configuration has $0.96 of excess reactivity at full power. The banked critical rod heights at full power are at 80% of core height. $0.54 is required to reach equilibrium xenon conditions, leaving $0.42 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 ≥$0.50 depending on core position. Regardless of the future vision of NRAD, NRAD will need additional fuel to compensate for burnup.

Makeup fuel: ROM Estimated cost $3.6M

- 2022 - 4 sticks 30/20 + 8 graphite
- 2023 - 4 sticks 30/20 + 4 graphite
- 2024 - 4 sticks 30/20 + 4 graphite

Experiment enabling Fuel: ROM Estimated cost $1.7M

- 2025 - 6 sticks 30/20 + 2 instrumented elements

Benefits

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.

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, αU 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 Estimated Cost: $5.3M spanning 4 years.

47. Flex Test 40 Controllers

Description

The Transient Rods Control system in TREAT uses MTS-450 analog controllers, which were installed in 1988. These controllers are essential to TREAT operations but present a risk because their spare parts are now obsolete and unavailable through suppliers. This project will replace the old controllers with Flex Test 40 controllers.

Benefit

The replacement controllers will remove a failure vulnerability and offer expanded control capability for supporting future TREAT experiments.

Facility Risk

Facility risk (schedule interruption due to component failure) will be reduced because the replacement controllers will be modern and better maintained with parts available through suppliers.

ROM Cost Estimate: $0.35M.

48. Roof Repairs for Nuke/Rad Facilities (HFEF, FASB, EML)

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: $4.5M.

49. 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.

Benefits

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 Estimated Cost: $2M

50. HFEF Decon Cell Fire Suppression System

Description

Current fire suppression in the HFEF Decon Cell (air atmosphere) consists of external CO_2 fire extinguishers plumbed through the wall and relies on operators to manually activate the fire extinguishers while using manipulator arms to hold and point the nozzles at a fire. Given historical manipulator availability and challenges with holding erratically moving hoses with a manipulator, this system does not provide the reliability needed for future mission work.

MFC Fire Protection recommends clean agent systems because they are designed for flooding applications and leave no residue after discharge. HFEF facility engineering has concerns with total flooding fire protection systems as total flooding systems require ventilation to be secured; if ventilation is secured in the Decon Cell, then the negative differential pressure is lost on an unsealed hot cell. This project needs a feasibility study prior to design to ensure that nuclear and radiological concerns are balanced with fire protection concerns.

Benefits

Installing an automatic fire suppression system in the HFEF Decon Cell would provide reliable fire suppression to support new mission activities, including fuel pin re-fabrication with welding, and assembly and disassembly of TREAT sodium loops. This project will assess feasibility, installation, acceptance testing, operation, as well as inspection, testing, and maintenance requirements.

Facility Risk

Existing fire suppression may not be adequate for new mission activities planned for the HFEF Decon Cell such as fuel pin re-fabrication with welding and TREAT sodium loop assembly and disassembly. If adequate fire suppression is not available, these mission activities may not be approved.

ROM Estimated Cost: $4.5M

51. Analytical Lab Process Management System Upgrade

Description

Updating the lab management system to support the AL 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.

52. Cask Integration, Management, and Capability Sustainment

Description and Benefit

A number of casks are utilized to support movement of nuclear materials between facilities and to support disposition of wastes generated as part of R&D activities at MFC. Operability of these casks is critical to the safe, compliant operation of MFC's nuclear facilities. Focused integration and management of the casks is integral to efficient and effective nuclear operations. Inoperability of the casks can result in substantial programmatic impacts across multiple facilities and programs, representing a single point failure mechanism. This investment includes establishing a coordinated cask integration and management capability, cask sustainability actions, and development of a new cask/container for transport of legacy wastes from MFC to the new RHLLW Disposal Facility.

Integration and management of casks ($300K) is critical to efficient facility operations. Coordination of use, preventative maintenance, and sustainment/refurbishment activities will help ensure that the casks are available to support program needs, when needed.

Legacy casks owned by INL which are in active use include the HFEF-5, HFEF-6, HFEF-14, HFEF-15, and NRAD casks. These casks do not have complete or as-built drawings. In addition, most of the analyses to support these casks are not current or have known deficiencies which need to be corrected. Procurement and fabrication of spare items to support both legacy casks and recently procured casks (such as the Outpack, GE-100, and BRR) are needed to ensure continuous operations or expedite needed preventative or corrective maintenance. This plant health investment ($1M) will support a methodical evaluation of the casks and implementation of necessary corrective actions, including modern analyses and modifications, if necessary, to support safe operations.

Existing casks represent a single-point failure. Investment to procure additional casks (i.e., HFEF-5 cask) is warranted to ensure that R&D outcomes are not impacted due to operability issues and conflicting demands with existing casks. ($1.5M–$3M)

Facility Risks

Failure to fund and implement a focused cask management and sustainment capability increases the risk that inoperability of a given cask will negatively impact MFC R&D outcomes and the potential for non-compliances due to an inability to properly maintain the physical and analytical bases for the casks.

ROM Cost Estimate: $3.5M–$9.5M.

53. TESB: Building Prep (HVAC, sealing doors)

Description

The TREAT Experiment Support Building (TESB, MFC-723) does not have a central HVAC system; it is equipped with ceiling mounted resistance heaters, which are undersized for the building, and it does not have air conditioning. Experiment assembly operations will be moved into TESB, to relieve pressure on fuel fabrication space within MFC, but year-round occupancy of the building requires heating and cooling (whether central or distributed). This project will determine and install the best occupancy HVAC solution for TESB. In addition, the roll-up doors are no longer sealed to keep wind and dust out of the building; so this project will also ensure all doors are adequately sealed to maintain a suitable experiment assembly environment inside the building.

Benefit

A TESB HVAC solution and sealing of doors will make TESB habitable year-round for experiment assembly.

Facility Risk

Without additional space for TREAT experiment assembly, the load on MFC fuel fabrication facilities (where most TREAT experiment assembly now take place) will be difficult to support. Assembly personnel are using ad hoc accommodation in MFC facilities, which is said to have required personnel to do some assembly operations while standing on one foot inside a safety shower.

ROM Cost Estimate: $0.65M.

54. 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 are 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 rick 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: $0.15M.

55. FMF Ventilation System –HVAC/Suspect Exhaust

Description

FMF Ventilation system- HVAC/ Suspect exhaust 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.

56. Radiochemistry Laboratory Back Up 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 Estimated Cost: $1.5M.

57. 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 Risks

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

ROM Cost Estimate: $4.5M - 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.

58. Fire Barrier Refurbishment in Nuke and Rad Facilities Across MFC

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 Risks

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: $2M

59. TREAT Crane Rail Alignment

Description

"J" bolts on the TREAT 15-ton crane rail are loose in some locations, which allows the crane rails to move. Repair to tighten the J bolts requires rail re-alignment to ensure proper rail position to 1/8" tolerance.

Benefit

Repair and realignment of the 15-ton crane rails will reduce wear on the crane rails and wheels.

Facility Risk

Without repair, the crane rails and wheels will continue to wear and will present increasing risk of breaking or crippling misalignment at some inopportune time, with impact on the TREAT operating schedule. The need for repair and realignment is such that the project can wait until FY-22.

ROM Cost Estimate: $0.09M.

60. Filtration/Cooling System (FCS) Variable Fan Drive (VFD) Upgrade

Description

The TREAT Filtration / Cooling System is used to reduce the amount of time needed to cool the fuel assemblies after transient (power-burst) operation or steady-state operation. Forced cooling also provides cooling for test loops or experiments installed in the reactor core. Many of the components that adjust the blower motor speed and system flowrate are old and difficult to maintain due to limited availability of parts. The VFD upgrade will eliminate these parts and create a more reliable system.

Benefit

This project eliminates potential points-of-failure in the Filtration/Cooling System, improves efficiency, and reduces time-to-troubleshoot/time-to-repair.

Facility Risk

Improving the maintainability and duration of the maintenance cycle will reduce risk of operating schedule impact due to a F/CS failure.

ROM Cost Estimate: $0.3M.

61. 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 items 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.

Benefits

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 a 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 Estimated Cost: $2M

62. TREAT Diesel Generator Replacement

Description

The TREAT Reactor Building electrical systems are backed up by two diesel generators, each of which is old and difficult to maintain due to limited availability of parts. The Standby generator provides 30kW of power and the Redundant generator provides 130kW of power. Theses generators and associated equipment are obsolete. Third-party parts are being used in order to maintain the units. This proposed project will procure and install a single diesel generator to replace the functions of the two older generators. The intention is to replace the generators with a brand and model that is used elsewhere on the INL.

Benefit

Replacement with a single diesel generator will reduce the maintenance effort currently needed for two generators. Replacing with a unit model that is used elsewhere on site will allow synergies for stocking spare parts and developing in-house expertise, each of which will reduce turnaround time and cost for responding to maintenance issues.

Facility Risk

The two existing generators continue to work and can be maintained, providing no key parts are needed. However, a prolonged shutdown of either unit could impact the TREAT operating schedule.

ROM Cost Estimate: $0.175M.

63. 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.

Benefits

Replacing HFEF MCCs with modern equipment will reduce maintenance activities on the 45-year-old system and reduce maintenance efforts to rebuild and salvage old parts.

Facility Risk

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.

ROM Estimated Cost: $2.5M**.**

64. 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 to better exhaust system to hook up additional equipment currently none of the characterization equipment is going 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 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 Estimated Cost: TBD pending authorizing advanced planning.

65. AL 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 AL 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: $4M.

66. HFEF Main Cell HEPA Filter 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.

Benefits

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 Estimated Cost: $3M.

67. Replace FCF Argon Cell North Recirc Blower and Purification Monitoring

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 lower bearing temperature 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.

A redundant Purification Analytical Instrument is needed to monitor atmosphere from the North Recirculation Loop to provide capability of continuous atmosphere monitoring if the South Recirculation Blower or Loop require maintenance.

The project will include complete design modification to install a redundant Purification Analytical Instrument with connection to the North Recirculation Loop, Purchase of replacement blower, and development of strategies to plan and execute the blower replacement.

Benefit

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

Facility Risk

The South Loop Recirculation Blower and Purification Analytical Instrument are evaluated as a single point failure piece of equipment. Its failure would significantly adversely impact EBRII Fuel Processing and HALEU Production program commitments.

ROM Cost Estimate: Year 1 $100K, Year 2$100K. Based on Installation of existing Purification Analytical Instrument and Work Planning for replacement of North Recirculation Blower.

68. Replace FCF Process Control Equipment

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 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.

Benefits

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: $4.5M.

69. HFEF Truck Lock Floor Repair

Description

Water continues to be an issue where the electrical feeders enter the HFEF basement. Water flow suspected along the electrical duct bank would mean voids as well. It is possible the soil became saturated in less than optimum compaction and the voids left behind after water moved away, could have allowed soil consolidation. The soil consolidation is the probable cause for the settling of the truck lock floor. Sonic subsurface results were inconclusive in determining if voiding under the slab has occurred.

There 2 possible solutions:

The project will core the floor in several location to verify voiding, if voiding is found hydraulic grout/sand could be pumped under the truck lock slab. This will raise the settled areas and could stop the flow of water along the electrical duct bank by forcing material in the channeled areas.

The other solution is found in TEV-3373, it recommends pouring a stem wall inside the foundation of the truck lock to stop the water flow along the electrical feeders. To accomplish this the floor must be removed and repoured. The estimated project cost is based on this option.

Benefits

The water intrusion into HFEF via the conduit duct is the greatest benefit, water and electricity do not mix well. The other benefits relate to cask handling. A level floor aids in aligning cask components by ensuring the part on the floor is parallel to the item suspended from the crane.

Facility Risk

Hard wheel vehicles sometimes create a hollow sound when rolling across the truck lock floor. It is unclear if this is due to voiding under the floor. Sonic subsurface results were inconclusive in determining if voiding under the slab has occurred. If the floor were to crack or fail, cask operations along with other large loads could become restricted.

ROM Estimated Cost: $3.5M

70. Critical Spares for ARCS, 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 on-and 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 operation of a system key to completing scheduled TREAT experiments.

ROM Cost Estimate: $0.4M.

71. NRAD Elevator and Cask Interface

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.

Benefits

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: $900K.

72. 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: $1M.

73. In-cell FCF Periscope and Camera System

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.

Benefits

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: $1.7M

74. HFEF In-Cell Compressed Argon Manifold Supply and 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 located 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.

Benefits

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 Estimated Cost: $500K.

75. HFEF Decontamination Spray System

Description

Adding a CO_2 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 CO_2 spray system into the existing HFEF decontamination spray chamber and associated containers for storing dry ice pellets.

Benefits

Adding a CO_2 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 CO_2 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 Estimated Cost: $1.2M**.**

76. 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 in key to moving hot samples between HFEF, FCF, and the Analytical Laboratory. Samples are prepared in HFEF and moved to FCF and AL for further analysis. This is a key transport capability between HFEF and AL. 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 AL will be significantly impacted if this capability is not available.

ROM Estimated Cost: TBD until further evaluation and advance planning is completed**.**

77. ZPPR Vault Cooling System Upgrade

Description

The new AC units that will be installed in the ZPPR vault are a split system type, with two separate condensers and evaporators. They will be mounted to the ceiling structure inside the vault.

These units will be provide required cooling to the vault space in MFC-775. Currently the vault is cooled by 1 evaporator and condenser that is tied to the existing main cooling unit for the facility. This unit frequently has issues with not running continuously (compressor replaced summer of 2020), which is needed for the vault due to extreme temperatures that are present in the vault

Benefit

Replacing the cooling system will reduce the need to perform maintenance and troubleshoot the existing system. This will also support personnel entries and reduce heat stress which increases productivity.

Facility Risk

The heat load in the vault will continue to rise if not adequately cooled, which presents issues. Personnel may not be able to enter vault to perform work if temperature becomes too extreme. Risk of materials in the vault degrading due to extreme temperatures may increase. Continuous issues with maintenance to troubleshoot and repair activities, temporary modifications to provide cooling.

ROM Estimated Cost: TBD.

78. AL Hot Cells 4, 5, and 6 Update and Refurbishment

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 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.

Benefits

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 support multiple programs simultaneously, increase throughput, and reduce maintenance efforts. Improvements will also provide greater ergonomic benefits and reduce the strain on the manipulators.

Risks

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 Estimated Cost: $5.4M

79. Replacement of the AL 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 AL, conversion from steam to electric heat and numerous new research capabilities and support systems within the AL, 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 AL's existing 250KW backup diesel generator with an upgraded 350KW diesel generator. The scope includes connecting all the AL's primary safety systems and vital research systems to the backup power source. It provides a pre-engineered electrical building outside of AL 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 AL'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 AL research infrastructure housed inside this vital nuclear research facility.

ROM Cost Estimate: $2.5M

80. Removal of Abandoned Lines and Associated Equipment

Description

Over the years, modifications in the Analytical 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 what is existing. 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 removed.

Benefit

The removal of the legacy equipment and abandoned piping will allow for future growth under the existing footprint of the Analytical Laboratory to meet the INL's mission. We consistently have 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.

ROM Cost Estimate: $1000

81. FCF In-Cell Lighting Upgrade

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 may need to be replaced on as-needed basis.

Benefit

In-cell lighting directly impacts the ability of operations 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 all 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: $750K

82. 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 s reduces the variation during specific material evolutions.

Facility Risk

This issue increases the risk of human performance errors.

ROM Estimated Cost: TBD until advanced planning is authorized

83. New Decon Fume Hood for Container Examination

Description

The FMF facility does not have a dedicated decontamination hood for use in decon of items when transferred from a glovebox.

Benefit

Adding this support capability will increase operational efficiency and capacity. This will also reduce risk of spread of contamination

Facility Risk

The risks are essentially the opposite of benefits. This reduces the risk of personnel exposure and increases efficiency.

ROM Estimated Cost: $100K

84. FMF/ZPPR/SSPSF Compressed Air Supply System

Description

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. These include building ventilation controls in conjunction with pressure monitoring, glovebox system and instrument controls, door operations, and radiological monitoring to include continuous and fixed air monitoring/sampling and stack effluent discharge monitoring. Funding is necessary to eliminate deficiencies and to improve the reliability of the systems in a timely, cost effective strategy based upon the recommendations documented in TEV-1804.

Benefits

Increased reliability. Decreased maintenance costs. Increased facility availability to support mission milestones.

Facility Risk

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: $2.75M.

85. Glovebox Removal from FASB

Description

This glovebox is a multi-purpose, multi-program glovebox installed under ANL-W. The Glove box is no longer connected to any program.

The pressure control systems for the glovebox has been in limp mode for years. The A/B and C/D side are identical yet separate pressure control systems very similar to the VAC and Wilkins gloveboxes in FMF. Our I&C technicians do what they can to keep it alive, but parts are becoming harder and harder to find and, in some cases, obsolete. This request is to remove this glovebox and replace with a new glovebox.

Benefit

Removing this glovebox will increase capacity for future fuel fabrication work. This also decreases risk of facility down time due to minor and major repair. This will enable repurposing of this area with a new glovebox in the future.

Provide a more reliable glovebox and operating system with spare parts available as needed.

Facility Risk

This capability is experiencing increased maintenance costs. Parts are increasingly difficult to procure. Facility availability can be impacted by increased frequency of short duration facility down time during failures, major facility downtime in the case of major component failures, and decreased capacity for existing equipment and new components and/or processes. This can result in loss of capabilities such as arc melting, hydride/dihydride, powder work, welding, etc.

ROM Estimated Cost: TBD until additional advanced planning is authorized.

86. Install Perma-Con containment to Replace Aging Waste Management Tent Workrooms

Description

The containment tents in MFC-793 and MFC-793C are aging and in need of replacement with more permanent containment structures that are better suited to long-term use and have little to no risk of degradation or failure. The current tents have been in place for multiple years and are designed to be a temporary containment. The current containment tents require repairs routinely and are becoming very difficult to pass certification. The tent in MFC-793 is connected into the building ventilation system which helps reduce cost for a permanent work space and the tent in MFC-793C has ventilation provided through a portable air handling unit. Work in both MFC-793 and MFC-793C is ongoing and consistent; however, there may be a desire to modify the dimensions of each work space based upon upcoming D&D work in both buildings which will free up floor space and add potential new work scope as well. Perma-Con structures offer the ability to easily modify the dimensions of the structure if needed and do not degrade as they are a metal structure.

Benefit

Replacement of the temporary

87. Replacement 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: $0.9M over FY-22 and FY-23 (rough estimate; to be improved in FY-21)

Appendix B

Detailed Descriptions of Instrument Capability Activities

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Appendix B

Detailed Descriptions of Instrument Capability Activities

1. Completion of the Thermal Properties Cell and Glovebox in IMCL

Description

This effort includes completion of the installation of the thermal properties cell and glovebox, an effort that began in FY-18. Completion of this will provide the support infrastructure required to house thermal properties instruments discussed further.

This project installs and qualifies thermal property measurement instruments in the IMCL thermal property shielded cell.

Benefit

Thermal properties define the performance limits of nuclear fuel under irradiation. In most fuels, information on thermal conductivity as a function of burnup and temperature do not exist. This results in conservative assumptions about thermal conductivity that increase the required safety margin and decreases the reactor operating envelope. These instruments include LFTD (Laser Flash Thermal Diffusivity), DSC (Differential Scanning Calorimetry), a thermal expansion measurement system, and a thermal conductivity microscopy. Ancillary equipment for sample coating and microscopy will also be provided.

The current state-of-the art method for measurement of thermal conductivity involves three measurements; a thermal diffusivity measurement using LFTD, a heat capacity measurement using DSC, and a measurement of density as a function of temperature by one of several methods. This system provides excellent capabilities for measurements of fuels and materials that can be fashioned into regular disc shapes for the LFTD measurement. This suite of instruments provides data on thermal conductivity to temperatures of approximately1500°C.

The thermal conductivity of irradiated fuel can be very difficult to measure using the standard laser-flash thermal- diffusivity method, because it requires a well-defined sample with specific dimensions. Irradiated fuel is often either fragmented, has the wrong diameter, or contains a center void that prevents the straightforward use of the LFTD method. In order to address these issues, INL has developed the TCM (Thermal Conductivity Microscope). Unlike the standard LFTD method, TCM allows thermal conductivity measurements to be made on fragments of irradiated fuel below 500°C. The existing TCM will be installed in the IMCL Thermal Properties Cell.

The TCM method, together with LFTD must be used together to cross calibrate measurements and obtain a complete picture of thermal conductivity as a function of temperature for irradiated fuel.

Status: The TPC installation completed in November 2018. The LFTD, DSC, and thermal expansion system will be procured, installed, and qualified. The TCM has been developed and tested on the bench scale with radiological materials; remotization and qualification are required. Several other small pieces of equipment are required for sample handling, coating, inspection, and measurement.

ROM Cost Estimate: $3.4M.

2. Expanded Fuel Fabrication Capability

Description

This strategy addresses multiple facility and process equipment upgrades to MFC fuel fabrication capabilities in several facilities in an attempt to meet continually increasing demand. The capability expansion under this strategy is intended to address our short term (5 year) RD&D Test Bed needs within existing MFC facilities and planning for possible future expansion.

1) There is a need to improve our basic science capability by providing high purity actinide materials and single crystal samples for characterization and evaluation. 2) Current applied science fuel fabrication research areas include plate fuel development, fast reactor fuels, transmutations fuels, advanced reactor fuels, and performance enhanced LWR and PWR fuels (accident tolerant fuels), all of which need to continuously improve processing techniques, including the use of advanced manufacturing techniques. 3) INL fields numerous requests to fabricate multi-kilogram quantities (engineering scale quantities) of experimental fuels including accident tolerant fuels for existing LWRs, as well as, develop fabrication processes for and build fuel in quantities sufficient for licensing of sodium-cooled fast reactors for industry, demonstrate fabrication of recycled fuel (Joint Fuel Cycle Study with KAERI), and conduct a special one-of-a-kind projects for advanced and unique reactor concepts. These requests have highlighted the need for expanded fuel fabrication capabilities.

Benefit

Expanding our basic science capabilities will allow the study of the fundamental properties of actinide materials that could provide valuable data for fuel performance modeling. Producing single crystals of uranium alloys and uranium doped materials will open up numerous fundamental property evaluations (including semiconductor characteristics) as well as provide unique irradiation opportunities to see how single crystals perform under irradiation and respond to irradiation damage. These capabilities will also help drive fuel development from an empirical art to a science.

In conjunction with the Lab initiative in advanced design and manufacturing, maintaining our leadership in applied fuel fabrication science requires keeping up with ever improving fabrication and manufacturing techniques. Many of these new fabrication techniques will open up fuel and cladding design options that where not possible with traditional fabrication techniques. Examples of advanced manufacturing techniques that are funded and require laboratory space to deploy are Spark Plasma Sintering (SPS), additive manufacturing, continuous metal fuel casting, metal fuel co-extrusion, and laser welding of cladding. Numerous other options are available that should be considered for applied science evaluation for use with nuclear fuel.

Many of the requests received by INL require large-scale fabrication campaigns under an NQA-1 program (Nuclear Quality Assurance) to increase the Technological Readiness Level through demonstration of fabrication and irradiation performance. These larger-sale campaigns, which cannot be conducted elsewhere, push the licensing constraints of our existing facilities and in some cases may make these activities impossible to execute in current facilities. Evaluating all of our current facilities to house engineering scale demonstrations such as these will be an on-going effort depending on the fuel fabrication process equipment needs and the quantities of finished fuel that is required.

Status: Project is in full execution and is expected to complete in FY-20.

ROM Cost Estimate: $4M.

3. Mass Spectrometers for AL (Quad/ToF-MS/LA-LIBS)

Description

Currently, AL owns one quadrupole ICP-MS (Elan DRC) purchased in 2005. This is essential to the support of programmatic, compliance, and waste characterization work, but its age and workload increase the probability of failure. There is an Increasing backlog of samples as more customers come to AL for analyses.

Benefit

Loss of the aging Elan would delay indefinitely the majority of programmatic support. Dated hardware and software of the current instrument result in suboptimal analyses. Replacement parts are becoming more difficult to find

Limited current AL sample throughput can be significantly enhanced with a Time-of-Flight mass spectrometer (ToF-MS). Current AL mass spectrometers must calibrate in different mass ranges, increasing analysis times and producing more waste.

The AL's sample throughput is impacting the ability to meet demands as programs and programmatic scope increases. The ToF-MS also increases the ability to keep up with advancements in measurement science as technological advancements in other facilities grow. This allows AL to expand to multi-faceted capabilities as the ToF-MS can be easily coupled with other techniques.

Current AL methods for isotopic analysis lack the capability of surface profiling: only bulk material composition is measured. Surface profiling can give information on homogeneity or how the composition of a substance varies by depth. Laser Ablation-Laser Induced Breakdown Spectrometry (LA-LIBS) allows AL to take advantage of national and international collaboration opportunities, such as expanded partnerships with the Korean Atomic Energy Research Institute (KAERI), the Lawrence Berkeley National Laboratory (LBNL), and the Department of Homeland Security.

A new Quadrupole, ToF-MS, and LIBS along with replacement counting equipment was procured in FY-18 with installation planned for FY-19.

ROM Cost Estimate: $3.5M.

4. Complete HFEF GASR and Polisher/Grinder Refurbishment

Description

The GASR (Gas Assay Sample and Recharge) system provides the ability to laser puncture irradiated fuel rods, measure fission gas pressure and fuel rod internal void volume, and if needed, refill/repressurize the rod with gas and weld the puncture hole closed. The GASR system also collects fission gas samples for composition and isotopic analyses.

Benefit

GASR data is critical for understanding the performance of all rod or pin-type fuels and contributes heavily to the licensing bases for these fuels. The GASR system has been maintained over its 30-year life, but never significantly upgraded. Many system components have become unreliable and component failure rates have increased dramatically over the last 2 years. The GASR system was inoperable for 4 months in FY-14, 1 month in 2015, and 1.5 months in FY-16. GASR failures have impacted PIE schedules for several programs. Replacement components are obsolete, and recent repairs were completed using parts purchased from eBay. Repairs have not restored 100% system capability. The GASR is scheduled for more than 1500 hours of operation in FY-17. Replacement of the system is necessary to ensure system reliability for future PIE campaigns.

GASR failure rates are increasing. Upgrade and replacement of mechanical and electrical components, the GASR laser, electrical feedthroughs in the hot cell confinement boundary, and electrical control cabinets are necessary to ensure the reliability of these systems.

ROM Cost Estimate: $4.6M.

5. TREAT Experiment Handling Support at HFEF

HFEF capability to support TREAT test programs is addressed in Sections 2 and 3 of Appendix C.

ROM Cost Estimate: $1M.

6. HFEF East Radiography Station Elevator Repair

Description

Virtually all programmatic work that comes through HFEF starts with neutron radiography (nondestructive PIE). Critical decisions for destructive PIE are based on results from neutron radiography.

The ERS elevator mechanical and electrical control systems are original equipment, circa 1980. Components and spare parts are obsolete and no longer commercially available. Current controls do not allow for rotation of samples in the elevator. Tomography can only be supported with sample rotation "by hand," adding significant time and cost to research efforts.

Benefit

Several functions of the elevator are out of service and can only be fixed with a complete upgrade (full up and down positioning detection, determining cable reel slack). A lack of position detection causes some images to be misaligned and requires rework, adding significant time and cost to research efforts.

Utility feed-through has failed circuits that have been bypassed with a temporary jumper.

Failure of obsolete components would result in long lead times to regain operational status, jeopardizing HFEF's ability to meet mission outcomes (if the elevator is not working, then programmatic work cannot move on from nondestructive to destructive PIE).

An up-graded elevator and control system would allow neutron radiography to become more efficient, less expensive, and provide greater reliability and repeatability to programmatic campaigns. The addition of rotational sample control will allow for Neutron Tomography to become a more cost effective nondestructive PIE capability.

ROM Cost Estimate: $800K.

7. North Radiography Station Footprint Repurpose

Description

This effort will repurpose footprint and restore support capabilities for the north beam line area in HFEF to support digital neutron imaging advancement, neutron diffraction, and new neutron science for irradiated fuels and materials in the North Radiography Station in HFEF. Existing backup generators and out-of-service equipment occupies space that is needed to support new programmatic research on advanced neutron imaging techniques and neutron science for irradiated fuels and materials. New research equipment cannot be installed until new backup generators are installed elsewhere and obsolete equipment is removed. Beam line modifications are required for development of new techniques to be effective.

Benefit

NRAD north beam line and elevator controls are original 1980 equipment with degraded operation and no spare part availability. When the elevator controls do not function, irradiated experiments requiring remote handling cannot be examined in the NRS.

This enables facility mission expansion by creating space for additional beam lines and instrumentation with ties to IMCL/SPL/TREAT research based on beam layout and capability. Elevator and beam controls support TREAT loop experiment and industry partner experiment examination.

This also enhances spatial examination of irradiated fuels by nondestructive means, and improved understanding of behaviors in realistic conditions such as neutron tomography, neutron powder diffraction, kinetic testing with combined techniques, time-of-flight studies, X-ray scattering, X-ray μCT.

Removal of legacy equipment eliminates existing liability (hazardous materials) and reduces future liability.

ROM Cost Estimate: $1M.

8. Purchase/Installation of New MC-ICP-MS in the Analytical Laboratory

Description

The Analytical Laboratory is planning to purchase and install the next generation Plasma 3 multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) to ultimately replace the existing instrument placed into service in 2010. The existing MC-ICP-MS has a life expectancy of approximately 10 years. The new Plasma 3 instrument has a lead time for manufacture of 10-12 months. Upon delivery, installation, acceptance testing and turnover will take approximately 3 months to complete. The plasma 3 is needed to meet increasing programmatic needs and maintain a leading role in nuclear research capability.

Benefit

Purchase and installation of a new multi-collector will allow us to have the latest technology on the instrument and ensure there is no interruption in being able to process samples through the existing instrument. The hope is that we will be able to use both instruments for a short period of time and to have a backup instrument in case one goes down. As the current multi-collector reaches the end of its life, we can expect to see an increase in downtime for repairs to the instrument. Due to the lead time for purchase and install of a new multi-collector, the further we delay the purchase, the more risk we are taking on. The negative impact to programs using the instrument will continue to increase.

ROM Cost Estimate: $2.1M.

9. Reestablish TREAT Na Loop Capability

The TREAT Sodium Loop effort is addressed in Section 7 of Appendix C.

ROM Cost Estimate: $10M.

10. Establish Nondestructive Assay (NDA) Capabilities in FCF

Description

Radiological characterization of waste and other materials is an essential step for removing items from the FCF hot cell. Technicians use process knowledge and characterization data to select the type of waste packaging best suited to remove waste from the facility. Current and past practice of acquiring accurate radiological characterization data has required a transfer of the items from the hot cell to an area with a lower radiological background dose rate. Frequently, multiple transfers are required introducing ALARA concerns to the radiological workers and inefficiencies to the overall process. Installation of Non Destructive Evaluation instrumentation which utilizes existing Non-Destructive Assay ports located between the hot cell and the sub-cell basement area provide an opportunity to reduce the ALARA risks and minimize the impact on the treatment process.

Benefit

Improving initial radiological characterization methods by installing an in-cell characterization system (NDA) would improve initial characterization efforts and confidence in package selection while reducing ALARA concerns, as well as rework (cost and schedule impacts) associated with repackaging the waste. Use of the existing NDA port(s) will require awareness of the potential for inadvertent spread of contamination between the hot cell and sub-cell basement area. The current manual approach with material transfers impacts operational efficiency and increases the opportunity for error.

ROM Cost Estimate: $625K.

11. AL 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 AL. 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 AL 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 AL 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 AL, to molecules heavier than 300 daltons, which are able to be characterized by the AL's high performance liquid chromatograph (HPLC).

The AL has already been forced to turn down requests for analysis of certain gaseous mixtures or volatile liquids, such as moisture content analyses, because of the lack of GC instrumentation. Additionally, some analyses that are currently carried out on the GMS could more rapidly and affordably be performed on a GC, thereby also reducing the time required to provide results from the GMS. As mentioned above, GC instrumentation opens new fields of collaboration in nuclear research. Without GC capabilities, the AL would be at risk of stagnation in its gas analyses, forcing potential customers and collaborators to pursue partnerships with other laboratories in areas in which the AL holds extensive expertise.

ROM Cost Estimate: $300K.

12. Time of Flight Secondary Ion Mass Spectrometer (TOF SIMS) for Plasma Focused Ion Beam (P- FIB) in the IMCL

Description

The TOF SIMS (time of flight secondary ion mass spectrometer) will be implemented as a detector on a Plasma Focused Ion Beam (P-FIB) instrument in IMCL. The TOF SIMS provides a means of characterizing both the near surface chemistry and the isotopic composition of a material as a function of depth. The P-FIB has a multi ion source that provides a primary focused ion source that projects onto the surface of a material samples, causing secondary ions to be emitted from the sample surface. The atomic mass of the secondary ions is analyzed by the TOF SIMS. When combined with information from other P-FIB detectors that provide information on microstructure, grain orientation, mechanical properties, chemistry, and isotopic (burnup or transmutation), the TOF SIMS detector provides a complete picture of the response of a material system to irradiation. The TOF SIMS is a multi-programmatic instrument for which work will be prioritized based on program mission priorities and milestones and impact of applied and basic science.

Benefit

The instrument will allow for state of the art characterization of nuclear fuels and materials; very few of these instruments exist in the world in this configuration, and to our knowledge, none for use on nuclear fuels. Incorporating the TOF SIMS as a detector into a FIB instrument allows operational parameters (burnup, exposure) to be directly measured and related to behavior on the microstructural scale. The TOF-SIMS enables faster, more efficient, multimodal characterization of samples. Secondary benefits include reduced personnel exposure and reduced transfer of samples. Not acquiring a TOF-SIMS impedes continued development of advanced characterization methods for nuclear fuels and materials. These same methods are used universally in other industries (semiconductor, transportation, aerospace) to continually advance the state of technology.

ROM Cost Estimate: $600K. Laboratory investment.

13. Atom Probe Tomography Instrument in IMCL

Description

Because irradiation damage occurs beginning on the atomic scale, atom probe tomography is ideal for the study of irradiation damage in materials. Atom Probe Tomography (APT) is the only material analysis technique offering extensive capabilities for both 3D imaging and chemical composition measurements at the atomic scale (around 0.1-0.3nm resolution in depth and 0.3-0.5nm laterally). We have recently pioneered the use of APT on irradiated fuels, which exhibit extremely complex behavior caused by fission; electronic energy transfer, compositional changes, and fission gas. The complexity associated with nuclear fuels, however, offers the opportunity for tailoring of fuel properties and performance, once understood. For example, the use of focused ion beam analysis has identified an association between solid fission products and fission gas that could be used beneficially to provide some control over gas-driven swelling.

Benefit

Current APT technology applied to the analysis of the complex multi element structure of irradiated fuel is limited by collection efficiency. The latest generation of atom probe exhibits a 20% increase in signal, resulting in greatly enhanced counting statistics and analysis. Analysis using a newer, advanced atom probe will greatly increase our ability to understand the underlying processes associated with microstructure development in nuclear fuel and therefore apply principles of materials design where it has never before been possible.

Use of instruments not collocated with the FIB instruments in IMCL (used to prepare APT samples) results in oxidation of reactive metals and unsatisfactory analysis. This request is for an instrument in IMCL.

ROM Cost Estimate: $4.5M. Laboratory investment.

14. Process Development for Large-Scale Fuel Castings

Description

This effort involves establishing an induction heated melting and casting system for large-scale casting. The location has yet to be determined but could exist at ZPPR, FMF, or repurposed space such as RLWTF.

Several fuel and reactor concepts are being evaluated that use larger fuel than traditional “slugs”. These concepts range from micro-reactors to first of a kind scientific instruments. Some of these concepts may need 20-40 kg single castings in order to efficiently produce the fuel in a cost efficient manner. This size of casting is larger than much of the previous fuel casting capabilities, such as the EBR-II fuel fabrication process, but smaller than casting systems used for strictly depleted uranium castings. Capability to perform this size of castings have been lost in the DOE-NE complex and will be unique particularly to HALEU and therefore is an impediment to development of new reactor and fuel fabrication concepts, civilian and otherwise. Because this capability has not existed outside of classified space for several decades, once a furnace is designed to handle large masses there will need to be work done to evaluate how the system functions and how the castings behave during solidification. Parameters such as super heat, crucible materials, mold design and cooling, etc. will need to be evaluated for each alloy of interest. Some alloys of interest include uranium, U-Mo and U-Zr with and without other minor alloying additions. This furnace will also be capable of developing casting techniques and parameters for other novel fuel alloys.

Benefit

Expand our understanding of uranium alloy metal casting. Support efficient and cost effective deployment of advanced reactor concepts. Work will also provide a test bed for fabrication concepts and casting simulation benchmarking. Increasing our understanding of the kind of casting will reduce risk for future programs such as VTR and other metallic HALEU fuel concepts. Without engineering scale development capabilities advanced reactor deployment will be negatively impacted.

ROM Cost Estimate: $1M.

15. Gas Mass Spectrometer Replacement in AL

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 AL, 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 AL. 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 AL to 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 AL will be able to accept work that has previously been performed at recently decommissioned laboratories within INL, such as the Analytical Laboratory at RWMC. The AL's GMS is aging and having significant problems due to equipment malfunctions. A replacement is needed to improve reliability and complement the expected workload of the lab. Much of this work is currently sent off-site to other laboratories with the capabilities, and an extended lapse in the capabilities at INL could result in a loss of customers and funding sources for future projects.

ROM Cost Estimate: $3M.

16. Replace Leica Metallograph in HFEF

Description

Replace the Leica microscope in the HFEF MetBox with a more robust unit, less susceptible to radiation levels found in the MetBox.

Benefit

The Leica microscope lost function of the 100X objective during the summer of 2018. Radiation levels in the MetBox are damaging to electronics and new instruments need to be re-engineered to be able to operate in that environment. A new state-of-the-art microscope would provide increased capacity for Met Box sample throughput and serve as a backup for the existing Leica. Alternatively, an entirely different system, Scanning Electron Microscope (SEM), would complement the Leica microscope and the LECO micro-hardness tester.

ROM Cost Estimate: $300K. Laboratory investment.

17. In-Situ Micromechanical Testing for Titan TEM (Picoindenter) in IMCL

Description

Install a TEM (Transmission Electron Microscope) Picoindenter in the IMCL.

Benefit

A TEM Picoindenter is uniquely suited for the investigation of nanoscale mechanical phenomena. Performing these types of studies while imaging at high resolution in the TEM provides unambiguous differentiation between the many possible causes of force or displacement transients which may include dislocation bursts, phase transformations, spalling, shear banding, or fracture onset. This information couples directly to deformation models that are important to understanding material behavior under irradiation. The picoindenter is a multi-programmatic instrument for which work will be prioritized based on program mission priorities and milestones and impact of applied and basic science.

The development of nuclear energy has suffered, over the last three decades, from a lack of understanding of the in-service behavior of materials. In all sectors of technology, including nuclear energy, the in-use degradation of materials is life limiting. The acquisition of picoindenter will allow for the continued development of the understanding of the complex evolution of the mechanical properties of materials under irradiation.

ROM Cost Estimate: $300K.

18. Digital Image Correlation for Mechanical Testing in FASB

Facility: Fuels and Applied Science Building/Hot Fuel Examination Facility

Description

Digital Image Correlation increases the amount of information gathered about the fine details of deformation and failure during mechanical testing several-fold when compared to currently used strain gauges and extensometers. DIC techniques are increasingly used in science and engineering, especially in micro- and nano-scale mechanical testing applications due to its relative ease of implementation and use. Advances in computer technology and digital cameras have enabled this method and while white-light optics has been the predominant approach, DIC can be and has been extended to almost any imaging technology. This technology will be developed for remote use in FASB and implemented in HFEF.

Benefit

Investing in DIC (Digital Image Correlation) technology brings INL a technique commonly available at other laboratories that perform displacement and strain measurements on materials. DIC provides detailed full-field strain measurements that allow detailed characterization of failure modes in nuclear structural materials. Idaho National Laboratory (INL) currently lacks the capability to perform full-field displacement and strain measurements using DIC techniques. INL currently uses directly contacting displacement and strain gauge transducers, which do not provide full field displacement and strain measurements. Further, these contact transducers are extremely difficult to use on radiological materials, especially in the remote environment of the HFEF hot cell. DIC because it is non-contacting, simplifies use in a remove environment such as the HFEF hot cell.

ROM Cost Estimate: $200K.

19. B-Wing ICP-MS in AL

Facility: Analytical Laboratory

Description

The ICP-OES located in B-148 still functions, but has required large amounts of maintenance and replacement parts. Since this instrument is no longer supported by manufacturer service agreements it has gone long periods of time awaiting repairs. Furthermore, this instrument is several generations behind the current models and requires special manufacturing of some consumable parts essential for its use. Current analysis provided by this instrumentation is limited to Si and B elementals in non-irradiated fuels. The instrument is not regularly in use, but is heavily used when analyses are required.

Benefit

It is recommended this instrumentation be upgraded to a current generation instrument with high resolution capabilities, inside of a walk in hood. Use of a HR-ICP-OES would allow for the analysis of halogens and improve the resolution and sensitivity to the elements generally analyzed. The addition of a hood to enclose the instrument would allow for higher activity samples to be analyzed and reduce the load on the A-wing OES, eliminating the tedious process of transferring samples, standards, and checks into Hot Cell #6 before being transferred into the ICP glovebox. A HR-ICP-OES could afford improved data and lower data analysis time as many of the interferences the plague the current instrument would be eliminated by the improved optics of a HR.

ROM Cost Estimate: $300K.

20. Tailored Enrichment Capability Demonstration – Aqueous Precursor in RCL

Description

Develop a research-scale, aqueous-based process to produce HALEU UO2 or precursor solutions for other uranium compounds.

Benefit

Most available HALEU feedstocks are metallic. This capability will expand the options for conversion to other fuel forms.

ROM Cost Estimate: $1.5M.

21. 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.

22. Replace Focused Ion Beam (FIB) instrument in the Electron Microscopy Laboratory (EML)

Description

Replacement of the EML FIB due to the age of the instrument.

Benefit

The EML FIB was the second FIB in the world to be used for characterization of irradiated fuels. The EML FIB is fully utilized, and key to the future operation of MFC as a user facility. The EML instrument is used primarily to prepare samples for other advanced characterization techniques such as transmission electron microscopy, scanning electron microscopy, and atom probe tomography, and micromechanical testing. The replacement SEM in EML will be used for multiprogram work, including classified work. These missions require a reliable SEM outfitted with a suite of analytical detectors. The EML FIB instrument is near end-of-life (>9 years old) and experiencing decreased availability because of more frequent maintenance issues. The FIB is >100% utilized, and increasing failure rates affect the ability to meet programmatic and milestone commitments.

ROM Cost Estimate: $1.3M.

23. Expanded CNO Capability in AL

Description

The LECO model RHEN602 is an inert fusion hydrogen analyzer that is capable of measuring hydrogen impurities in metals, refractories, and other materials common in the nuclear fuel cycle sample. This instrument will support material analysis in a laboratory bench top environment for NS&T/Naval Reactors (NR) work requiring material composition certification where low level hydrogen analysis is necessary or where small sample sizing becomes a concern.

The LECO model CS844 is a simultaneous carbon/sulfur combustion analyzer that is capable of measuring these impurities in metals, refractories, and other materials common in the nuclear fuel cycle. In particular, carbon is an element of high interest when casting new fuels due to its prevalence in the environment making it one of the major impurities in most materials.

The LECO model ONH836 is a simultaneous oxygen/nitrogen/hydrogen inert fusion analyzer that is capable of measuring these impurities in metals, refractories, and other materials common in the nuclear fuel cycle. The content of each of these elements can vary significantly depending on the material being analyzed and the processes they have been exposed to. This instrument will support material analysis in a laboratory bench top environment for NS&T/NR work requiring material composition certification.

Benefit

The hydrogen analyzer is unique in terms of hydrogen analyzers due to its large sample size analysis capabilities. The ability to run samples that are many times the mass of what other inert fusion instruments will provide lower detection levels, down to 0.05 ppm, and higher confidence in the sample composition being representative of a material. The carbon/sulfur analyzer will support material analysis in a laboratory bench top environment for NS&T/NR work requiring material composition certification. The ONH analyzer is unique when compared to other inert fusion analyzers because it can measure all three elements on one sample. This means less sample is required which helps facility material limits and programs that may be material limited.

ROM Cost Estimate: $600K. Laboratory investment.

24. 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.

25. Replacement of the AL 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 AL 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, more 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: $2M.

26. Multi-program U/Pu 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 across 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 for 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 demonstration for these critical experiments and reactor concepts.

ROM Cost Estimate: $5.2M.

27. In-situ Testing Stage for Titan and Talos Transmission Electron Microscopes

Description

Procurement of TEM (Transmission Electron Microscope) sample holder (stage) capable of exposing samples to operational environments in-situ during TEM observation. This in-situ capability is a significant in enabling rapid discovery of improved nuclear and battery materials through understanding of material behavior in environments relevant to operating conditions. In-situ testing provides information on the interaction of materials with environments as they are occurring, resulting in a much shorter time frame and higher probability of achieving mechanistic understanding of operational and failure processes. Acquisition of this capability is jointly supported by NS&T (NMDQi and NSUF programs) and MFC to help accelerate discovery of new materials and understanding and improvement of current materials. For battery development, in-situ TEM offers the opportunity for EES&T scientists to study phenomena including solid electrolyte interphase (SEI) formation and phase changes during battery operation.

Benefit

In-situ staging is necessary to strengthen INL's current and future lead role in nuclear (NS&T, MFC, NHS) and battery materials (EES&T). Not adopting this technology put INL at a competitive disadvantage. For example, many studies have been performed on irradiation assisted stress corrosion cracking (IASCC), and many theories exist to explain the phenomena, but a unified mechanistic understanding and designing alloys resistant to IASCC has never been achieved. Higher energy densities in batteries can be achieved by increasing battery cell capacity or cell voltage, however batteries are complex systems, subject to multiple processes during operation such as volume changes, solid electrolyte interphase layer formation, and phase transitions. Moving towards data-driven materials design and optimization, accelerated qualification of nuclear and battery materials would largely benefit from in-situ microscopy to accelerate our understanding on the role of irradiated defects, interfaces, surfaces, and phase transformations under relevant conditions. Adopting this in-situ capability at INL, with the ability to handle and study highly radioactive materials, would also be unique in the DOE complex.

ROM Cost Estimate: $800K.

28. Eddy Current Head for Oxide Determination in HFEF

Description

The HFEF oxide thickness measurement (eddy current) system requires procurement, installation, and qualification of a new probe head to conduct oxide thickness measurements on light water reactor fuels. The eddy current system provides a primary means to evaluate the potential of new industry-developed improved cladding (EPRI) for extended burnup service and the performance and safety benefits of new coated fuel designs being developed through the DOE accident tolerant fuel program. The data from the eddy current system provides a significant part of the technical basis through which improved fuel designs can be developed and is required for licensing new cladding alloys, higher burnups, and current alloys with new coatings designed to improved resistance to oxidation.

Benefit

This measurement currently cannot be completed on fuel rods of current interest. One of the primary concerns in the evaluation of the performance of light water reactor fuel is cladding corrosion/hydriding. Without the new eddy current head, the ability to support burnup extension by the nuclear industry, development of coated cladding by commercial fuel vendors, EPRI, NRC, or DOE-funded ATF (Accident Tolerant Fuel) programs will not be possible at INL. The DOE funding model is currently shifting to an industry-focused model, where national laboratories and foreign entities compete for project funding based on capabilities and expertise. Without this capability, commercial fuel examinations, DOE-funded ATF development, and NRC confirmatory examinations cannot be completed at INL, and will be funded at other national laboratories, in Canada, or overseas.

ROM Cost Estimate: $250K.

29. Ion Chromatography - prepFAST Attachments to AL ICP

Facility: Analytical Laboratory

Description

The prepFast ion chromatography (IC) is a syringe-driven liquid chromatography (LC) system with 4 syringes. The syringes are used for ICP tuning, eluents for separations, and post-column addition eluent. The column used for separations, for example UTEVA, is attached to a switchable valve that allows the column to be in-line or bypassed, with respect to the ICP-OES during analysis. The system is also equipped with a prepFAST M5, which is a syringe driven unit that allows for inline dilutions of standards or samples prior to introduction onto the chromatographic column.

Benefit

Currently, the AL does not have an IC attachment to an ICP, but a manually built auto-gas pressurized extraction chromatography (GPEC). The manually built GPEC is not attached to any instrumentation, requires a great deal of maintenance, and the elution times for samples are considerably long (~20 minutes).

A prepFast IC would provide additional capabilities beyond that of our current auto-GPEC. While the auto-GPEC can provide separations, it still requires a great deal of maintenance, the elution times for samples are considerably long, and it still requires preparation of dilutions. The prepFast IC requires minimal maintenance, the elution times for samples are 3x faster, and dilutions are automated. The preparation and analysis time could be completed in about half the time, plus eliminating more human error.

ROM Estimated Cost: $150K.

30. Automated Sample Prep/Dissolutions

Description

Update AL 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.

31. Update PGS in HFEF

Description

The PGS motor and control system was upgraded in 2009 in order to eliminate electronic noise interfering with the detector and to replace outdated components. Positioning motors, sensors, cables, control electronics, software, and some hardware were the obsolete components that were replaced. This effort was only partially completed. The Y-motor install was not finished and the magazine support was not upgraded and Y-drive motion has been out of service since 2008. It also included efforts to prepare the system for new detection equipment and Compton suppression needed for future programs that was installed in 2011. Following that, the detection equipment was upgraded again to a digital system in 2015. The stage experienced an accidental collision with the EMM bridge in early 2017 that resulted in an upgrade to the gripper box. The most recent upgrades were completed through Phase 1 and 2 in mockup late 2017 that included an all new control cabinet and accompanying OCS changes, magazine support and rotate, Y-motor and cabling. The hardware has all been stored waiting on funding to complete.

The current effort requires the following high-level activities for completion. Equipment should be brought back to mockup for a quick checkout. The old cabinet CP-110 on the second floor of HFEF needs removed, and the new cabinet installed and wired. The new magazine and motors need transferred in-cell and installed. The 6M table will need relocated to access the breakout box and y-motor mount. Once all the hardware is installed the software and operation can be qualified with a Phase 3 procedure.

Benefit

Precision Gamma Scanning is one of the most utilized non-destructive exams in HFEF. Gross and isotopic data provided from PGS analysis is most commonly used for determining burnup, and paired with neutron radiography, is used to collect dimensional information making decisions on destructive examinations. This system is typically scanning experiments nonstop. Upgrade of the PGS will restore capabilities that have been lost.

The PGS is currently meeting all of the program requirements but as components age they will need replacement. The y-motor has been inoperable for almost 10 years and should be replaced to offer more adjustment in scan parameters (reducing solid angle scatter). The X-motor was damaged during the VEM upgrades and is still functional but in a fragile state. The magazine rotate has also been inoperable for some time and that capability should be restored.

ROM Cost Estimate: $1.5M.

32. Replace Leitz Metallograph in HFEF MetBox

Description

The Leitz MM 5 RT metallograph is over 35 years old (the microscope design actually dates back to 1965) with the most recent upgrade to the step-motor stage control capability having been completed in 2009. At over 35 years of age, the microscope components are no longer replaceable and the metallograph is in need of replacement.

Benefit

Replacement of the metallograph will restore capabilities that have been lost as well as improve reliability to continue supporting program work. At over 35 years of age, the microscope components are no longer replaceable. Function of the step-motor stage position has degraded to the point that precise positioning of the stage to view certain regions of a given specimen is nearly impossible. This has made it very time consuming and difficult to collect micrographic tiles of a specimen to later construct into a montage of the entire specimen. The camera, upgraded several years ago is obsolete and the quality of the images relative to that generated by new state-of-the-art microscopes, are inferior. This is part due to facility translated vibrations, the inability of the stage to hold its position and the aging optics involved in the system.

ROM Cost Estimate: $1.5M.

33. 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.

34. Precision Ion Polishing System (PIPS II) for Sample Preparation for Microstructural Characterization in the IMCL

Description

One of the most important aspects of microstructural characterization is sample preparation. The PIPS II is a broad beam ion milling system that is a powerful tool for TEM (Transmission Electron Microscopy) specimen preparation. It uses a focused argon ion beam to precisely mill TEM samples until a small hole is created in their thinned area. The low voltage ion beam is used for the final stage of sample preparation to remove surface damage caused by high voltage ion beam. Although FIB (Focused Ion Beam) systems are provide revolutionary capability for site specific sample preparation, the PIPS is useful for milling larger samples and removing damage cause by higher energy ions beams.

Benefit

Without the PIPS II tool, neither TEM sample preparation and FIB instruments FIB instruments are optimally utilized. The PIPS II system provides an inexpensive alternative to the FIB systems for the preparation and finishing of some samples. It relieves some of the workload from the FIBs, reducing backlog and increasing access.

Although FIB (Focused Ion Beam) instruments have revolutionized TEM examinations by improving sample preparation capability, artifacts caused by FIB can mistakenly be attributed to reactor irradiation damage or mask other microstructural features. The PIPS II works with the FIB to ensure extremely high-quality sample preparation and analysis results. Use of the PIPS II speeds research in many cases by removing ambiguity about the source of irradiation defects, leading to better understanding of material irradiation behavior, contributing to higher quality research.

ROM Cost Estimate: $300K.

35. Shielded Experiment Preparation and Inspection Cell (EPIC) - Procurement and installation into TESB

Description

This hot cell will provide functionality to support LWR fuel testing, and perhaps fast reactor fuel testing. This will include 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.

Benefit

EPIC will form the foundation of a key capability for backfilling the loss of the Halden Test Reactor.

ROM Estimated Cost: $8M

36. Triple Quadrupole ICP-MS

Facility: Analytical Laboratory

Description

A triple quadrupole mass spectrometer (TQ-MS) is defined as a tandem mass spectrometer comprising two transmission quadrupole mass spectrometers in series, with a (non-selecting) RF-only quadrupole (or other multipole) between them to act as a collision cell. In the case of TQ-ICP-MS, the three quadrupoles are positioned between the ICP and the detector. The first and third quadrupole act as mass filters while the second quadrupole can act as either a collision or a reaction cell.

Benefit

Currently, the AL has a single Q-ICP-MS, meaning the first quadrupole mass filter is not there. In addition, the current Q-ICP-MS in operation has a reaction cell that cannot be used as a collision cell.

A TQ-ICP-MS would provide additional capabilities beyond that of our current Q-ICP-MS and HR-ICP-MS. While HR-ICP-MS can provide excellent resolution of many polyatomic interferences, it can fall short when it comes to isobaric interferences. Isobaric overlap resolution is important when analyzing low concentration isotopes of some naturally occurring or fission produced elements. Using the reaction/collision cell of the TQ-ICP-MS, many of these isobaric interferences can be resolved. The TQ-ICP-MS can also be used as a single Q-ICP-MS and can be used as a back-up for other Q-ICP-MS instruments.

ROM Estimated Cost: $1M.

37. AL HR ICP-MS

Description

Adding a new high resolution ICP-MS to the AL 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.

38. Comprehensive Mechanical Testing Capabilities for Light Water Reactor Fuel

Description

INL requires mechanical testing capability for testing to support extending fuel burnup license limits and qualifying new fuels with enhanced accident tolerance. The capabilities required include those for (1) defueling LWR rods, (2) in-cell sample machining of test specimens from cladding tubes, and (3) mechanical testing. (1) Defueling - Installation and qualification of a rotation stage in HFEF and demonstration of dissolution processes for high-burnup fuel. (2) Sample machining is required for tests with complex geometry requested by industry. Time and resources are required to develop and demonstrate necessary jigs and procedures. (3) Mechanical testing - The nuclear industry and NRC are requesting more complex tests to better understand the behavior of cladding. Ring hoop tension tests, ring compression tests, 3 and 4 point bent tests, tube axial tension tests, and expansion due to compression testing capability are requested. Fixtures for testing in HFEF and for in-situ x-ray tomography in IMCL are not commercially available, and must be designed, fabricated, and qualified.

Benefit

Without mechanical testing capability for cladding, INL faces significant challenges in capturing work scope that supports industry and DOE-NE goals for extending fuel burnup license limits and qualifying new fuels. Recent EPRI-funded work has been awarded to the Canadian Nuclear Laboratory and Studsvik (Sweden). Importantly, DOE funding is currently shifting to an industry-focused model, where U.S. national laboratories and international laboratories compete for industry-directed project funding based on capabilities and expertise. INL has recently invested in fuel cladding mechanical testing expertise, but still lacks adequate fuel testing infrastructure. Relatively small investments will remedy this situation and place INL in a competitive position. Not being able to perform these tests will put INL at a competitive disadvantage, and important commercial/EPRI fuel examinations and DOE-funded work will be awarded to ORNL, PNNL, or international laboratories.

ROM Cost Estimate: $850K.

39. Three-dimensional Strain Mapping for Improved Understanding of Material Behavior

Description

A 5 Kilonewton mechanical testing stage, digital volume correlation software, and Zeiss computer workstation upgrade will be used in conjunction with INL's Zeiss Versa x-ray microscope (installed in IMCL) to investigate the fundamental mechanical behavior and failure mechanisms of a wide range of materials such as zirconium alloys, steel cladding materials, structural materials, and nickel-based alloys. Imaging in three-dimensions (tomography) while subjecting an irradiated material specimen to mechanical loading provides time-resolved information on the failure initiation site and mode of failure propagation. In conventional testing, failure initiation sites and mode of failure propagation are most often hidden under the material surface. Understanding of failure mechanisms allow the performance of materials to be improved (through processing or compositional changes) much more efficiently than conventional trial and error-based experimentation. This instrument will be used in IMCL for all work on the XRM, including major DOE programs; FCRD (Fuel Cycle Research and Development), NSUF (Nuclear Science User Facility); NNSA's MMM (Material Management and Minimization program funded through National and Homeland Security; EES&T's advanced manufacturing program; LDRD projects, university collaborations, and work for others.

Benefit

This capability will be unique in providing the volumetric data needed to better understand the complex strain behavior of irradiated materials up to and including failure. To our knowledge, there is no comparable capability in the United States for use on high activity materials. Currently plastic deformation models cannot predict component failure under other than simple uniaxial tensile loading, which rarely occurs during in-service conditions. The complexity of this problem is such that it remains unresolved after many decades using conventional methodology. Not having this capability inhibits our ability to understand and improve nuclear materials.

ROM Cost Estimate: $150K.

40. Plasma Cleaner for IMCL

Description

Sample preparation is critical for accurate microstructural characterization of materials. Laboratory air can result in surface oxidation and contains organic impurities that collect relatively quickly on pristine sample surfaces. The plasma cleaner is used to clean and store sample holders and samples for the ultra-high vacuum TEM (Transmission Electron Microscope), Atom Probe Tomography (APT), and FIB (Focused Ion Beam) systems to remove surface impurities that interfere with analysis. This plasma cleaner system that will accept 5 sample holders to increase efficiency of examinations using multiple instruments. This instrument will be used in IMCL for all work on the TEM, including major DOE programs; FCRD (Fuel Cycle Research and Development), NSUF (Nuclear Science User Facility); the NNSA funded MMM (Material Management and Minimization program run by NHS; analysis of microstructure and failure modes of battery materials with EES&T (currently posted joint hire) with MFC, LDRD projects, university collaborations, and work for others.

Benefit

Currently sample holders are stored on a benchtop and are contaminated with moisture and organic materials. The contamination increases instrument pumping time, results in imaging artifacts, and can lead to additional maintenance of the sample transfer systems increasing time and costs. The plasma cleaner increases research productivity and quality and helps to prevent unplanned maintenance.

ROM Cost Estimate: $100K.

41. Benchtop Optical Microscope for IMCL

Description

A benchtop optical microscope is needed for basic characterization of low dose rate materials in IMCL. Uses include metallography and inspection of sample surface condition and mounting. Currently the only optical microscope in IMCL is located in a shielded cell, increasing cost of simple analysis by a factor of ~10. This instrument will be used in IMCL for all work on the TEM, including major DOE programs; FCRD (Fuel Cycle Research and Development), NSUF (Nuclear Science User Facility), and MMM (Material Management and Minimization; LDRD projects, university collaborations, and work for others.

Benefit

The lack of a benchtop microscope in IMCL increases the cost of simple analytical work and quality inspections by a factor of ~10. This simple instrument will substantially increase the productivity of sample preparation and analysis.

INL FIB systems will continue to be used extensively for sample preparation, limiting their use as powerful analytical tools.

ROM Cost Estimate: $130K.

42. 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.

43. Replace EML SEM

Description

High resolution analytical SEM (Scanning Electron Microscope) is essential to achieving MFC's mission. Current instrument is utilized > 150%. The replacement SEM in EML will be used for multiprogram work as well as for classified NR work. Both missions require a reliable SEM outfitted with a suite of analytical detectors.

Benefit

The current instrument is near end-of-life (10 years old) and experiencing a decrease in availability due to maintenance issues. The SEM is over100% utilized, and failure will affect program schedules.

ROM Cost Estimate: $900K.

44. Replace Dilatometer in FASB

Description

Current FASB dilatometer is near end-of-life. Measurement of the thermal expansion coefficient provided by this instrument are critical for the determination of thermal conductivity. Current measurements of the thermal conductivity of most nuclear fuels have an uncertainty of 25% or greater, leading to excessive conservatism in reactor design, increasing costs and lowering the probability of deployment. This instrument is used for major DOE programs; FCRD (Fuel Cycle Research and Development), NSUF (Nuclear Science User Facility), and MMM (Material Management and Minimization; LDRD projects, university collaborations, and work for others.

Benefit

The capability for accurate measurement of thermal conductivity will not be readily available for uranium-bearing fuels.

ROM Cost Estimate: $155K.

45. 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. 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.

46. Versatile Fuel Form Capability - Powder Handling

Description

Install a powder handling glove box in AFF (versatile fuel form capability – powder handing).

Benefit

Increased efficiency and capacity for working on powder based developmental fuels.

ROM Cost Estimate: $3M.

47. 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 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.

48. Powder Bed Additive Manufacturing

Description

Powder bed additive manufacturing.

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. Expanded fabrication options for advanced fuels. This expanded capability will allow us to be more competitive in attracting new fuels work.

ROM Cost Estimate: $2M.

49. 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. A new access to the NRS Highbay may also be included to allow quick access to imaging equipment in the basement and NRS Highbay workspaces.

Benefits

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.

50. Differential Scanning Calorimetry Instrument

Description

Replacement of the existing DSC (differential scanning calorimeter) in FASB. The current instrument is two generations old, near end-of-life and is experiencing issues with baseline drift. The instrument requires calibration weekly, which requires approximately 2 days to accomplish, reducing instrument availability to 50%.

Benefit

The calorimeter is at high risk for failure. FASB will not have the capability to measure the thermal conductivity of uranium-bearing fuel for program and NSUF users unless this instrument is replaced.

ROM Cost Estimate: $300K.

51. NRAD NRS Elevator Replacement and Upgrade

Description

The NRS elevator, originally designed to radiography 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.

Benefits

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.

52. 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 in room 029 (old argon compressor room) in the basement of HFEF.

Benefits

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 Laboratory (AL), 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.

53. Replace Scanning Electron Microscope in the EML

Description

Replacement of the SEM (Scanning Electron Microscope) in the EML (Electron Microscopy Laboratory) with a new SEM with equivalent resolution and analytical capability.

Benefit

The current SEM instrument in EML is near end-of-life (>10 years old) and heavily utilized (~ 60 hours per week), but is experiencing decreasing availability due to maintenance issues. Unplanned failure will affect program milestones.

SEMs are essential materials characterization tools, providing data for understanding irradiation behavior in nuclear materials and fuels. The EML SEM is used for multiprogram work, and will soon be capable of also conducting classified work. Both classified and unclassified missions require a reliable SEM outfitted with a suite of analytical detectors.

ROM Cost Estimate: $1.5M.

54. 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.

55. Irradiation Assisted Stress Corrosion Cracking Hot Cells

Description

Installation of additional capability for IASCC (Irradiation Assisted Stress Corrosion Cracking) capability in the Fuels and Applied Science Building, including a small shielded cell and 2 additional load frames and chemistry control systems.

Benefit

IASCC is one of the most important issues facing the further extension of reactor operating lifetimes and for the development of new nuclear structural materials, and one of the most difficult to understand. Not installing this capability leaves the many questions associated with IASCC of current materials unanswered, and does not allow for informed development of improved future nuclear structural alloys.

INL's current IASCC capability is unique in the United States for its ability to test highly activated materials. The current capability of 2 testing systems is in high demand; adding additional capability will lead to new business. IASCC is an important issue facing the development of new materials and extending reactor lifetimes, that after five decades of research is still not well understood. Understanding and mitigating the IASCC problem would ensure INL continued leadership as the national nuclear energy laboratory.

ROM Cost Estimate: $8.5M.

56. 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.

Benefits

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.

57. 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.

Benefits

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.

58. 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.

Benefits

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.

Advantages of laboratory robotics:

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 the variances in the reagent quantities and less likely to have the 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.

Risks

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 Estimated Cost: $4750K

59. AL Liquid Scintillation Capabilities

Description

The AL 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

60. Gas Mass Spectrometer Replacement in AL

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 AL, 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 AL. 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 AL to 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 AL will be able to accept work that has previously been performed at recently decommissioned laboratories within INL, such as the Analytical Laboratory at RWMC. The AL’s GMS is aging and having significant problems due to equipment malfunctions. A replacement is needed to improve reliability and complement the expected workload of the lab. Much of this work is currently sent off-site to other laboratories with the capabilities, and an extended lapse in the capabilities at INL could result in a loss of customers and funding sources for future projects.

ROM Cost Estimate: $3M.

61. – 66. Program Funded Capabilities for the FASB Pyrochemical Glovebox

Description

The multiple furnaces within the Pyrochemistry Glovebox (PCG) will serve as an integrated test bed for the major unit operations of pyrochemical processing. Full capabilities will include multiple furnaces including Fermi MEDE, oxidation-reduction, distillation, molten salt, multi-function, and Larinda type furnaces as well as electrorefining equipment will be installed within the PCG.

Benefit

There is currently no capability to do oxide reduction with uranium, which is the basis of current commercial fuel. The co-location of these capabilities will streamline research operations and allow for testing with uranium-based surrogates of used nuclear fuel. Additional capabilities to be installed in the glovebox will allow for additional proof-of-concept evaluations as well as production of the oxidant used in pyroprocessing and waste form development. These capabilities will further establish test bed research support for the back end of the fuel cycle and fuel recycling research.

This will establish capabilities within a new glovebox atmosphere that can more effectively control experimental conditions. This also establishes in-house capability for large scale production of oxidant to support electrorefining.

ROM Cost Estimate: $5.5M+. This estimate will be refined in the future when commitments to establish these capabilities are made and execution planning occurs. (Program funded)

67. U Processing and Synthesis Glovebox in ZPPR Workroom

Description

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

Since the majority of the remaining excess HEU is stored in ZPPR, directly processing in ZPPR would be more efficient and eliminate the future need for material transfers and processing in FMF, keeping that facility more available to support transuranic missions.

Facility Risk

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. If this occurs the current capability to disposition this type of material will no longer be available.

ROM Cost Estimate: $2M.

68. PU Stabilization Glovebox

Description

Enduring glovebox capability to process legacy and newly generated transuranic scrap materials into forms suitable for stable storage and ultimate WIPP disposal. This capability could also prove complementary to potential Pu fuel fabrication missions.

Benefit

In addition to the significant safety and responsible material management enhancements this capability will provide, processing of the associated transuranic material will also free up significant vault storage space that will be required to support future missions without having to build more expensive and space consuming storage racks.

Facility Risk

Significant quantities of excess Pu-bearing materials (casting scrap, MOX fuel elements, feedstock, etc.) have been stored in the FMF vault for more than 30 years. INL currently has no glovebox capability to process these various materials for stable storage and ultimate disposition. It is essential to develop this capability to ensure continued safe storage of high-risk transuranic materials, to deal with anticipated/known degraded forms (casting scrap and breached ZPPR plates in particular), and to convert the excess material into forms that can be safely shipped or disposed.

ROM Cost Estimate: $5M.

69. Multi-Purpose U Glovebox

Description

Enduring glovebox capability to process legacy and newly generated transuranic scrap materials into forms suitable for stable storage and ultimate WIPP disposal. This capability could also prove complementary to potential Pu fuel fabrication missions.

Benefit

In addition to the significant safety and responsible material management enhancements this capability will provide, processing of the associated transuranic material will also free up significant vault storage space that will be required to support future missions without having to build more expensive and space consuming storage racks.

Facility Risk

Significant quantities of excess Pu-bearing materials (casting scrap, MOX fuel elements, feedstock, etc.) have been stored in the FMF vault for more than 30 years. INL currently has no glovebox capability to process these various materials for stable storage and ultimate disposition. It is essential to develop this capability to ensure continued safe storage of high-risk transuranic materials, to deal with anticipated/known degraded forms (casting scrap and breached ZPPR plates in particular), and to convert the excess material into forms that can be safely shipped or disposed.

ROM Cost Estimate: $5M.

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Appendix C

Detailed Descriptions of TREAT Instrument Capability Activities

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Detailed Descriptions of TREAT Instrument Capability Activities

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 2 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.

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 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-21 to FY-25 (to be proposed from multiple funding sources)

- TESB Building Modifications $5,050
- Multi-mission experiment assembly/disassembly equipment $3,900
- EPIC procurement and installation $8,050K
- EPIC instrumentation equipment $5,000K.

ROM Cost Estimate (Next-Generation Hodoscope and In-Pile Instrumentation): $12,700K, for FY-21 to FY-25.

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 a 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. 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 use 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.

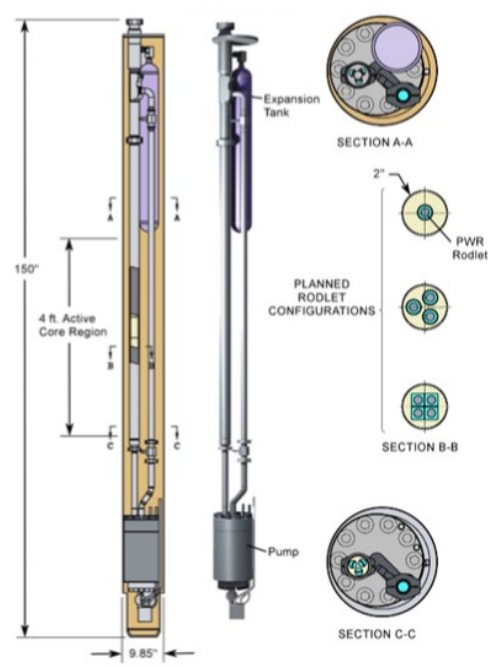
Another important experiment system needed to simulate LWR accident conditions is a ^{3}He injection system, used to clip TREAT transient pulses more quickly than possible with the TREAT Transient Rod Drives. The **Helium-3 Enhanced Negative Reactivity Insertion (HENRI)** system is being designed to 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).

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.

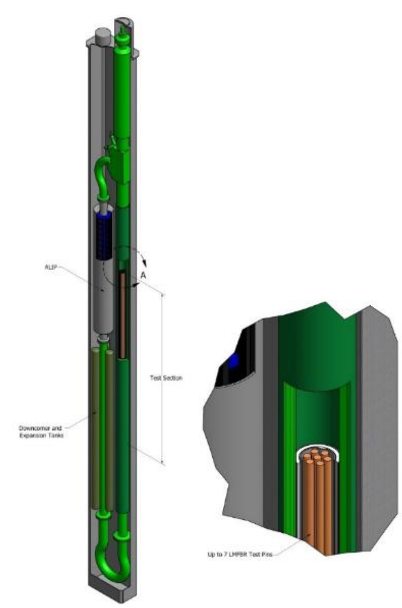
The experiment vehicles planned for testing of fast reactor fuel design include

- **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 another 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.



TREAT Mk-IIIR Sodium Loop

ROM Cost Estimate: Roughly $17M over FY-21 to FY-25.

4. 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.

The Sirius-4 test series calls for prototypic testing in a flowing hydrogen test loop, something new for TREAT. The test loop 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 gaseous hydrogen (H2) supply and exhaust system for experiments in TREAT, referred to here as the "Loop," is a flow-through system supplying H2 to experiments and releasing exhaust gases to atmosphere. The Loop will be separable into three major sections: H2 supply, inert gas supply, and experiment exhaust. Each experiment that uses the Loop and the connections that integrate the Loop with an experiment will be in the design of the experiment. The Loop system consists of hydrogen and inert gas storage, gas control panels for the hydrogen and inert gas, and the gas lines connecting supply to the panels, and the exhaust lines from the experiment. The Loop design and assembly is funded by NASA and is scheduled to be available in FY-23.

Other investment is needed to modify the TREAT Reactor Building to support micro-reactor demonstrations. 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 (kilowatt range) 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-23).

ROM Cost Estimate (Hydrogen Test Loop): Roughly $12M over FY-21 to FY-25 (complete in FY-23).