INL Demonstration Reactor Infrastructure

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National Reactor Innovation Center (NRIC) authorized by Nuclear Energy Innovation Capabilities Act (NEICA)

- DOE Launched NRIC on August 15, 2019

- The National Reactor Innovation Center is intended to:
  - Enable testing and demonstration of reactor concepts
  - Access to infrastructure
  - Led by INL, coordinating with other national labs
**Nuclear Reactor**
Computational Capabilities
Experimental and Analysis Capabilities

- Decommissioning
- Operations Procedures
- Regulatory Support
- Staffed Site Services
- Utilities

- Nuclear Reactor
- Technical Expertise from National Laboratory Complex
- Fuel
- Computational Capabilities
- Experimental and Analysis Capabilities

- Glove boxes and hot cells
- Irradiation experiments
- Material testing
- Advanced imaging techniques
- Elemental analysis and quantification
- Advanced instrumentation

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Staffed Site Services

- Decommissioning
- Operations Procedures
- Regulatory Support

Demonstration Reactor Infrastructure

- Nuclear Reactor
- Technical Expertise from National Laboratory Complex
- Fuel
- Computational Capabilities
- Experimental and Analysis Capabilities
- Physical Demonstration Site
- Utilities

Staffed Site Services

Facility Services
Security Force
Fire Department
Emergency Services
Logistics
Construction
Field Engineering
Reactor Operations
Maintenance and Fabrication

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Regulatory Support

Adherence to NEPA and development of Environmental Assessment (EA) or Environmental Impact Statement (EIS)

Adherence to 10 CFR Part 830 Nuclear Safety Management (DOE Reactor Authorization)

Adherence to all applicable Public Law, Executive Orders, Federal Policies and Code of Federal Regulations

Adherence to all applicable DOE Directives, DOE Technical Standards, DOE Handbooks, Consensus Standards

Coordinate DOE and NRC technical readiness, sharing of technical expertise, and knowledge on advanced nuclear reactor technologies and nuclear energy innovation.
Operations Procedures

Demonstration Reactor Infrastructure

- Decommissioning
- Regulatory Support
- Operations Procedures
- Startup
- Initial Operation
- Performance Testing
- Shutdown
- Commissioning
- Pre-Commissioning
- Mechanical Completion
- R&D Check/System Check/Walkdown
- Flushing, cleaning, drying, leak testing
- Design fluids introduced, pumps and valves operated
- Pre Start-Up Safety Review / Operational Readiness Review

- Nuclear Reactor
- Technical Expertise from National Laboratory Complex
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Decommissioning

Remote Handling Systems
Fuel Removal
Fuel Storage and Disposition

Component/System Sections for Analysis
Post Irradiation Examination
Activated Material Disposition
Project Closeout

Decommissioning

Demonstration Reactor Infrastructure

Nuclear Reactor
Technical Expertise from National Laboratory Complex
Fuel
Computational Capabilities
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Physical Demonstration Site
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Operations Procedures
Regulatory Support
Staffed Site Services

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The EBR-II Dome has great potential as a demonstration reactor site

- Experimental Breeder Reactor-II Dome (EBR-II) MFC-767
- 78ft internal diameter, 87ft tall from ground level at highest point, walls are 1ft thick rebar reinforced concrete with 1inch of steel plating on outer side. Leak tight to 24psi.
- Safeguards category 2, hazard category 2
- Floor loading capacity of 3,750 pounds per square foot
- Two lightly loaded 2MVA transformers. 13.8kV or 480V service could be supplied
- 75ton overhead crane was damaged during decommissioning, could be repaired (est. cost ~$3M)
- Has been seismically qualified in the past, (est. cost ~$300k to recertify)
- Upgrades needed:
  - Larger containment penetration needed for equipment (currently only 6ft x 6ft door)
  - Installation of cooling capacity needed
  - Electrical power, instrument air, argon, and nitrogen not currently installed
  - Repairs to overhead crane
- Excellent radiation protection, very large space, co-located with MFC for access to infrastructure
INL’s Materials and Fuels Complex (MFC) offers world class infrastructure to support demonstration reactors

- IMCL - Irradiated Materials Characterization Laboratory
- HFEF - Hot Fuels Examination Facility
- EML - Electron Microscopy Laboratory
- FASB - Fuel and Applied Science Building
- AL - Analytical Laboratory
- EFF - Experimental Fuels Facility
- FCF - Fuel Conditioning Facility
- RCL - Radiochemistry Laboratory
- MFC-767 (EBR-II) Experimental Breeder Reactor-II Dome
Irradiated Materials Characterization Laboratory (IMCL) MFC-1729

**Irradiated Materials Characterization Laboratory (IMCL) MFC-1729**

- Recently installed thermophysical glovebox/hot cell
- Abundant microscopy resources
- Differential Scanning Calorimetry (DSC) Specific Heat
- Thermogravimetric Analyzer (TGA) *When combined with DSC*
- Laser Flash Analysis (LFA) Thermal Conductivity, Thermal Diffusivity
- Gas Chromatograph
- Surface Morphology, Elemental Analysis, Grain Structure, Corrosion Rates, Lattice Defects
- Electron Probe Microanalyzer (EPMA) Elemental Mapping
- Optical Microscopy Surface and Cross Section Imaging
- Microindentation, Microhardness Testing System Material Hardness and Ductility
- X-ray Diffraction (XRD) Crystal Structure, Phase Analysis, Interplanar Spacing
- Sample Prep Equipment Polishing, Cross Sectioning
- Metrology Equipment Analytical Balances, Micrometers, etc.

**Thermophysical characterization of metallic and oxide nuclear fuels.**

**Allows for remote manipulation of highly radioactive samples via master/slave manipulators on the hot cell side of box.**

**Part of National Science User Facility (NSUF).**

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Hot Fuels Examination Facility (HFEF) MFC-785
Fuel and Applied Science Building (FASB) MFC-787

Large number of experiments ongoing, variable atmospheres quality

- Electrochemistry
  - Electrochemical cell
  - Potentials, chemical activity

- Bubble
  - Surface Tension, Contact Angle, Interfacial Behavior
  - Kinking, Wettability of Surfaces

- Tensile Strength
  - Creep Strength

- Fatigue
  - Fracture Toughness

- Bending Strength

- Microstructural, Microhardness Testing System

Sample Prep Equipment: Polishing, Cross Sectioning

- Metallurgy Equipment: Analytical Balances, Micrometers, etc.

- Neutron Radiography: NTRAG

Differential Scanning Calorimetry (DSC)
Thermogravimetric Analyzer (TGA)

- Electrochemistry
  - Energies of formation, redox potentials, chemical activity

- X-ray Diffraction (XRD)
  - Crystal Structure, Phase Analysis, Interplanar Spacing

- X-ray Fluorescence (XRF)
  - Elemental, Chemical Analysis

Sample Prep Equipment: Polishing, Cross Sectioning

- Metrology Equipment: Analytical Balances, Micrometers, etc.

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Electron Microscopy Laboratory (EML) MFC-774
Analytical Laboratory (AL) MFC-752

- Abundant microscopy resources
- Scanning Electron Microscopy (SEM)
- Surface Morphology, Elemental Analysis, Grain Structure, Corrosion Rates, Lattice Defects
- Sample Prep Equipment
- Polishing, Cross Sectioning
- Metrology Equipment
- Analytical Balances, Micrometers, etc.

Focused Ion Beam (FIB)
- Energy Dispersive X-Ray Spectroscopy (EDS)
- Electron Backscatter Diffraction (EBSD)
- Transmission Electron Microscopy (TEM)

Analytical Laboratory (AL) MFC-752

- Differential Scanning Calorimetry (DSC)
- Specific Heat
- Thermogravimetric Analysis (TGA)
  - melting temperature, crystallization temperature, phase changes, enthalpy, volatility
- Laser Flash Analysis (LFA)
  - Thermal Conductivity, Thermal Diffusivity
- X-ray Fluorescence (XRF)
  - Elemental, Chemical Analysis
- Alpha Spectroscopy
  - Identification and quantification of alpha-emitting isotopes
- Gamma Spectroscopy with high-purity germanium detector
  - Identification and quantification of gamma emitting isotopes
- Gas Pressurized Extraction Chromatography
  - Used pressurized nitrogen to push solutions through media instead of liquid or gravity
- Fourier Transform infrared Spectroscopy (FTIR)
  - Vibrational spectroscopy
- Laser Ablation Laser Induced Breakdown Spectroscopy (LIBS)
  - Elemental analysis (ppt)
- Inductively Coupled Plasma (ICP) Mass Spectrometry (MS) and Optical Emission Spectroscopy (OES)
  - Elemental analysis (sub-ppm)
- Thermal Ionization Mass Spectrometry (TIMS)
  - Elemental Analysis (sub-ppt)
- Liquid Scintillation Counting
  - Quantify the radioactivity of low energy radionuclides, mostly beta-emitting and alpha-emitting
- Ultraviolet/Visible Spectroscopy
  - Spectroscopy, Emission States

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