Nuclear Science User Facilities

Nuclear Fuels and Materials Library

Kelly Cunningham
NFML Coordinator

NSUF Industry Advisory Meeting
October 8-9, 2018
Nuclear Fuels and Materials Library

• **Nuclear Science User Facilities**
  Established in 2007 by DOE-NE to support nuclear energy R&D by providing researchers with no-cost-to-the-user access to unique facilities and *materials* through competitive processes, Work-for-Others projects, etc. as agreed upon with NSUF Director.

• **The NSUF Nuclear Fuels and Materials Library**
  - Includes nuclear fuel and material samples from past and ongoing irradiation test campaigns, decommissioned power reactors, and donations from other sources.
  - Contains >6000 searchable samples and corresponding information
    - Irradiation Conditions
    - Experiment information
    - Project reports
Finding the Nuclear Fuels and Materials Library
Nuclear Fuels and Materials Library

Search

NFML Database

Search Materials Library

Keyword Search

Filter Options

Organizations

Dimensions

Material Names

Material Descriptions

Specimen Types

Data Ranges

As-Run Dose

As-Run Total Dose (DPA)

As-run Temperature (°C)

As-run Fluence (cm²)

Get Results
Material Type by Sample Count

- Ceramics (334) 5%
- Fiber (10) >1%
- Fuels (289) 5%
- Graphite (55) 1%

Steel/Alloys (5,523) 89%

Material Type by Project

- Steels/Alloys (9) 53%
- Fuels (3) 18%
- Ceramics (4) 23%
- Graphite (1) 6%
# Nuclear Fuels and Materials Library

**Online Inventory (~6,200 samples)**

<table>
<thead>
<tr>
<th>Original Project</th>
<th>Reactor</th>
<th>Irradiated Materials</th>
<th>Specimen Geometry</th>
<th>Material Type</th>
<th>Sample Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>08-75 UF Floryx</td>
<td>ATR</td>
<td>MgAl$_2$O$_4$, Nd$_2$Zr$_2$O$_7$, MgO, MgONdZr, Mg$_2$SnO$_4$</td>
<td>Diffusivity, TEM</td>
<td>Ceramics</td>
<td>120</td>
</tr>
<tr>
<td>08-92 ILLINOIS</td>
<td>ATR</td>
<td>Fe, Fe-Cr, HT9, MA-957 ODS, T91</td>
<td>TEM, Tensile</td>
<td>Steels, Alloys</td>
<td>768</td>
</tr>
<tr>
<td>08-96 NC STATE</td>
<td>ATR</td>
<td>Course &amp; nanograin Cu, Ni, carbon steel, ODS</td>
<td>TEM, Hardness, Tensile</td>
<td>Steels, Alloys</td>
<td>80</td>
</tr>
<tr>
<td>08-139 UC SANTA BARBARA</td>
<td>ATR</td>
<td>commercial F-M alloys, model RPV steels, ODS alloys, cast austenitic SS</td>
<td>Diffusivity, TEM</td>
<td>Metals, Alloys</td>
<td>1,561</td>
</tr>
<tr>
<td>08-331 WISCONSIN</td>
<td>ATR</td>
<td>F-M &amp; Austenitic SS, ODS alloys, refractory alloys, SiC, metallic glass</td>
<td>TEM, Tensile</td>
<td>Steels, Alloys, Metals, Ceramics</td>
<td>149</td>
</tr>
<tr>
<td>09-157 Utah State</td>
<td>ATR</td>
<td>Al$_3$Hf, Hf$_3$Al-Al composite</td>
<td>Density, Diffusivity, TEM</td>
<td>Metal Alloys</td>
<td>160</td>
</tr>
<tr>
<td>09-197 Idaho State University</td>
<td>ATR</td>
<td>Transuranic isotopes</td>
<td>Dissolved</td>
<td>Fuel</td>
<td>78</td>
</tr>
<tr>
<td>09-204 Drexel</td>
<td>ATR</td>
<td>Ti$_3$Si$_2$, Ti$_3$AlC$_2$, SiC</td>
<td>Resistivity, TEM, Tensile</td>
<td>Ceramics</td>
<td>153</td>
</tr>
<tr>
<td>10-242 UCF</td>
<td>ATR</td>
<td>DU, Mo, DU-7Mo, DU-10Mo, DU-10Mo w/Zr layer</td>
<td>TEM, Foils</td>
<td>Fuel</td>
<td>91</td>
</tr>
</tbody>
</table>
## Nuclear Fuels and Materials Library Inventory

(~6,200 samples)

<table>
<thead>
<tr>
<th>Original Project</th>
<th>Reactor</th>
<th>Irradiated Materials</th>
<th>Specimen Geometry</th>
<th>Material Type</th>
<th>Sample Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-357 MITR</td>
<td></td>
<td>Magnorestrictive, Piezoelectric sensors FeCoV, IrGa, Fe-Cr, Fe-Mn, Arnokrome, ZnO, BiTiO</td>
<td>Wire strip, Wafer</td>
<td>Ceramic, alloy</td>
<td>7</td>
</tr>
<tr>
<td>Hexblock EBR-II</td>
<td></td>
<td>Legacy Hardware 304 SS</td>
<td>Hex Ducts, Reflector Blocks</td>
<td>Steels</td>
<td>226</td>
</tr>
<tr>
<td>SURV EBR-II</td>
<td></td>
<td>Surveillance Capsules Austenitic SS, Inconel X-750, Ferritic SS, Ber;ylum, Aluminum, Bronze, Stellite</td>
<td>Tensile, Hardness, Bend, Impact, Spring</td>
<td>SS, Alloys</td>
<td>~482</td>
</tr>
<tr>
<td>Creep EBR-II</td>
<td></td>
<td>AISI 316</td>
<td>capsules</td>
<td>SS</td>
<td>49</td>
</tr>
<tr>
<td>SAM-1 ATR</td>
<td></td>
<td>Nuclear grade graphite, SiO₂</td>
<td>Fiber optic sensors, disks</td>
<td>Graphite, fiber optics</td>
<td>66</td>
</tr>
<tr>
<td>LANSCE (donatated)</td>
<td>LANSCE</td>
<td>alloy 718, Type 316L, and Type 304L stainless steel, Fe9Cr-1Mo(T91), Al-6061-T6, and Al-5052-O)</td>
<td>TEM, Tensile, CT, Plate, Bend</td>
<td>SS, Alloys</td>
<td>2200</td>
</tr>
<tr>
<td>CNL (donated)</td>
<td></td>
<td>Inconel X-750</td>
<td>Spring spacers</td>
<td>Alloys</td>
<td>19</td>
</tr>
<tr>
<td>LIBSUB (donated)</td>
<td></td>
<td>TiC</td>
<td>Disks</td>
<td>Ceramics</td>
<td>3</td>
</tr>
</tbody>
</table>
## Nuclear Fuels and Materials Library

Coming Soon!!!

Many projects from previous years’ awards and recently awarded CINRs will become available in the next five to seven years (one year in dog years).

<table>
<thead>
<tr>
<th>Project</th>
<th>Material Type</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-153</td>
<td>RPV steel/alloys</td>
<td>Available, NOT ONLINE YET pedigree info not processed</td>
</tr>
<tr>
<td>10-224</td>
<td>Hydride Fuel</td>
<td>Available, NOT ONLINE YET pedigree info not processed</td>
</tr>
<tr>
<td>10-269</td>
<td>U$_3$Si$_2$ fuel</td>
<td>Available 2025, irradiation complete 2022</td>
</tr>
<tr>
<td>15-8242</td>
<td>PM-HIP alloys*</td>
<td>Available 2025, irradiation complete 2022</td>
</tr>
<tr>
<td>16-10537</td>
<td>Nanostructured A/F/M steels, HEA alloys</td>
<td>NFML material available 2020</td>
</tr>
<tr>
<td>16-10584</td>
<td>CAM 316 SS, Inconel**</td>
<td>Available 2021, irradiation complete 2018</td>
</tr>
<tr>
<td>16-10393</td>
<td>DMLM 316L, Alloy 718***</td>
<td>Available 2023, irradiation complete 2020</td>
</tr>
<tr>
<td>16-CR-17</td>
<td>SiC temperature sensors</td>
<td>Samples to be added online early FY 2019</td>
</tr>
<tr>
<td>18-14730</td>
<td>Thermoelectric materials &amp; generators</td>
<td>Fabrication Phase, availability ~2025</td>
</tr>
<tr>
<td>18-14741</td>
<td>U-10Zr</td>
<td>Design Phase, availability ~2025</td>
</tr>
<tr>
<td>18-14749</td>
<td>Piezoelectric Materials for sensors</td>
<td>Design Phase, availability ~2025</td>
</tr>
<tr>
<td>18-14788</td>
<td>Additive Friction Stir Manufactured 316L</td>
<td>Design Phase, availability ~2025</td>
</tr>
</tbody>
</table>
Nuclear Fuels and Materials Library

Library donations (completion TBD)

- **BOR 60 P038 & P043 TEM samples**
- **Irradiated & Unirradiated SiC, conventional, and nano-ferritic steels**
- **Ex-plant 347 SS baffle bolts**
- **Zombie Raccoons & Killer Bunnies**
- **Samples from various programs including LWRS, Fusion, FCRD**
Fuels and materials added to the NFML are subject to the following stipulations and criteria:

- DOE owns all material in the NFML. Acquisitions may require a transfer of ownership agreement between the donor and DOE. In general, the NSUF would take physical possession of the specimens, although other arrangements are possible.
- NSUF is the caretaker of the samples, holds them within the NFML, manages their utilization, and maintains sample pedigree documentation.
- The materials have demonstrated relevance to the nuclear energy research community.
- The materials complement the content of the NFML in uniqueness or need.
- There is strong supporting pedigree information in the form of available data, reports or peer reviewed journal publications.

Proprietary materials may be accepted without sensitive information such as owner of materials, irradiation facility, etc. However, a pedigree including processing history, mechanical history, irradiation conditions, etc. must be included.
Pedigree information should include:

- **General Information**
  - Material or sample type
  - Institution
  - Point of contact
  - Material Type

- **Irradiation Conditions (pre-irradiation and post-irradiation)**
  - Dates of irradiation
  - Reactor position
  - Environment
  - Temperature
  - Dose or burn-up
  - Flux
  - Fluence

- **Sample Information**
  - Irradiation Facility
  - Material Name
  - Sample Type
  - Number of Samples
Nuclear Fuels and Materials Library
Current Operating Policy

1. Unless otherwise agreed to, the Department of Energy (DOE) owns sample specimens that are irradiated using NSUF support.

2. Unless otherwise agreed to, DOE owns the sample specimens offered to and accepted into the NSUF Sample Library by a third party. This will be effected through a transfer of ownership agreement between the donor and DOE.

3. NSUF is the caretaker of the sample specimens, holds them within its Sample Library, manages their utilization, and maintains specimen pedigree documentation.

4. Agreement to the policies of the NSUF Sample Library is required. If not agreed to, either the proposed sample specimens offered from a third party will not be accepted into the Sample Library or the project supporting the production of the sample specimens will not be awarded or supported by the NSUF.

5. Exclusive rights to samples for a 3-year period of PIE following the completion of the irradiation portion of an awarded experiment will be given to the project lead unless other conditions are agreed to, such as earlier open availability. After the 3-year period, samples will be made available to the general research community for subsequent proposals.

6. As a courtesy, subsequent proposers can be put in contact with the original project lead for collaboration. Original project leads may collaborate or not but may not deny access to library samples requested in an awarded proposal.

7. NSUF reserves the right to fabricate, irradiate and add sample specimens to the NFML as part of any NSUF-supported irradiation.

8. In the case of dispute over the admittance of sample specimens to the Sample Library, for which DOE-NE has supported or enabled in their production, the final arbiter of decision will reside with the DOE-NE Selection Officer.
Decommissioned power plants provide a valuable opportunity to harvest real-world material. Challenges include:

- **Proactive vs. reactive harvesting:**
  - Harvesting is not part of a decommissioning plans
    - Harvesting should be part of the critical path of decommissioning plans
  - Harvesting isn’t currently a compliance or licensing activity for nuclear power plants
  - No financial incentive for nuclear power plants to harvest material
  - Research agencies must have funds available as opportunities present themselves

- **Decisions and plans need to be made within the research community:**
  - What materials are most valuable
  - Harvesting decisions must balance knowledge gain vs. costs (monetary and physiological (dose to workers))
  - What kind of international participation is available and what hurdles will be encountered

NFML should/could be the repository for harvested material
NSUF Sample (SAM) irradiations are done specifically to populate NFML with relevant samples

Request for Information (RFI) is always available for possible donations and suggested material irradiations (https://nsuf.inl.gov/Page/rfi_nfml_callsolicitation)

Comments and suggestions on the website and library are encouraged and welcome.