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FY 2018 Annual Status Report for the

NUCLEAR FUELS AND MATERIALS LIBRARY

October 2018

Nuclear Science User Facilities

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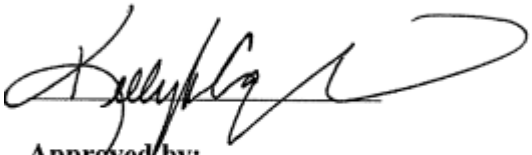

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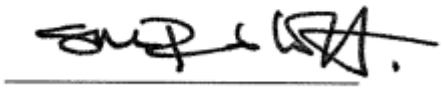

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FY 2018 Status Report for the Nuclear Fuels and Materials Library

1. INTRODUCTION

The Nuclear Fuels and Materials Library (NFML), which is owned by U.S. Department of Energy, Office of Nuclear Energy (DOE-NE) and curated by the Nuclear Science User Facilities (NSUF), is a collection of nuclear fuel and material samples, along with technical information, from past and ongoing irradiation test campaigns. The NFML also includes real-world components retrieved from decommissioned power reactors and donations from other sources. The NFML can be accessed through a web portal at the NSUF web page NSUF.INL.gov or directly at https://nsuf-infrastructure.inl.gov/.

The NFML was conceived shortly after the NSUF was established in 2007. The concept was to offer Advanced Test Reactor (ATR) irradiated materials and NSUF project samples that were stored in Idaho National Laboratory (INL) hot cells to researchers for use in NSUF-awarded research projects. The NFML catalogue began as a series of electronic spreadsheets gathered from principal investigators (PI) and INL programs. In the summer of 2016, the spreadsheets were migrated into an online database within the NSUF website. The NFML inventory has continued to grow with the addition of NSUF-funded project specimens, Experimental Breeder Reactor No. 2 (EBR-II) legacy samples, and donated material from Oak Ridge National Laboratory (ORNL). The online library technology further evolved with upgrades for users and administrators of the database.

NFML outreach in FY 2018 included NSUF representatives at conferences and workshops domestically and internationally. This document provides a status report on the NFML for FY 2018.

2. FY 2018 NFML UTILIZATION

Request for NFML samples in FY 2018 was consistent with FY 2017. Twelve percent of the RTE proposals requested samples from the library. However, the number of actions, unique users, and samples viewed in the NFML database increased. As the library is populated with additional samples from projects and donated materials, more utilization should be expected. NFML sample requests and awards for Rapid Turnaround Experiments (RTEs) are shown in Figure 1. The NFML database actions, users, and views are shown in Figure 2.

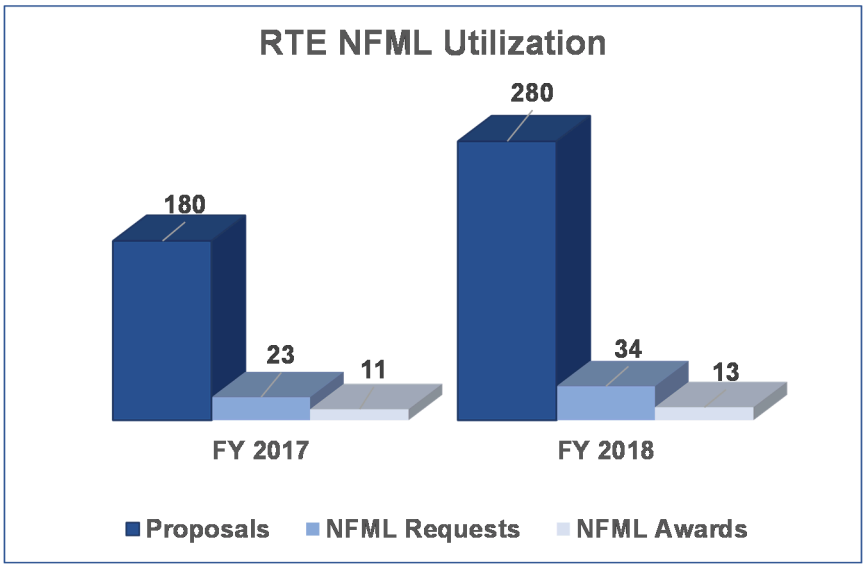

Figure 1. NFML Utilization in RTE proposals and awards

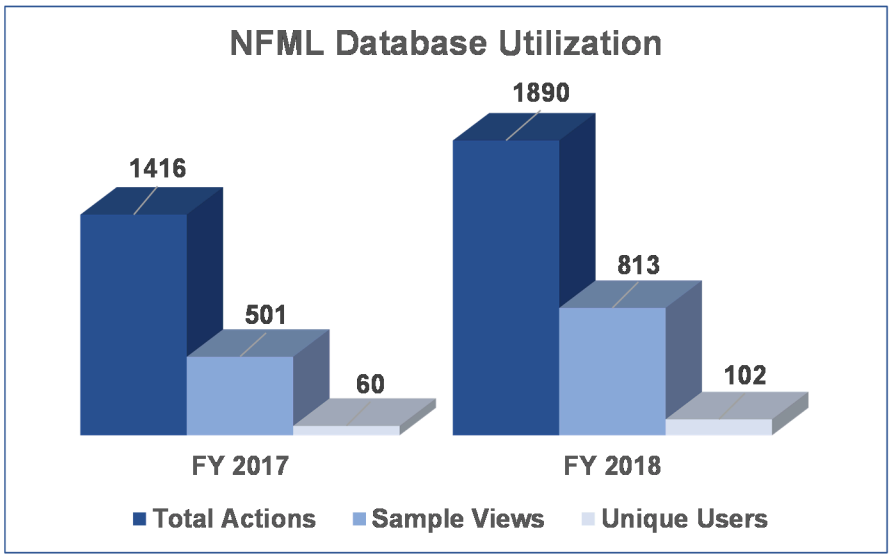

Figure 2. NFML Database Utilization

3. NFML FY 2018 Inventory Status

The original NFML catalogue comprised a series of spreadsheets from a variety of records. At the end of FY 2015, the inventory included approximately 3,500 samples. The NFML database now includes over 6,000 samples. Additional samples were added, or are in the process of being added, to the database in FY 2018 from EBR-II legacy material, previous NSUF-awarded projects, and samples donated from Oak Ridge National Laboratory.

3.1 EBR-II Legacy Material Addition

The NSUF has a cache of reflector assembly material from EBR-II. This legacy material consists of 304 and 316 stainless steel samples irradiated from August 1, 1964 through September 30, 1994. The reflector assemblies were fabricated with 12% cold-worked Type 316 or Type 304 steel cans and Type 304 steel hex blocks. The legacy inventory includes:

1. Hex blocks from EBR-II reflector assemblies
2. Portions (samples) of deconstructed hex blocks
3. Full assemblies with can and blocks
4. Hex cans and cans from other assemblies.

Historically these material and samples are owned by DOE-NE and curated by the NSUF, but were not listed in the online library as much of the information is tribal knowledge and the documentation (dating back to 1960) was not electronically available.

As a result of a FY 2017 contract, in-depth information such as irradiation conditions, sample geometry, identifiers, and locations were compiled and imported into the online library in FY 2018.

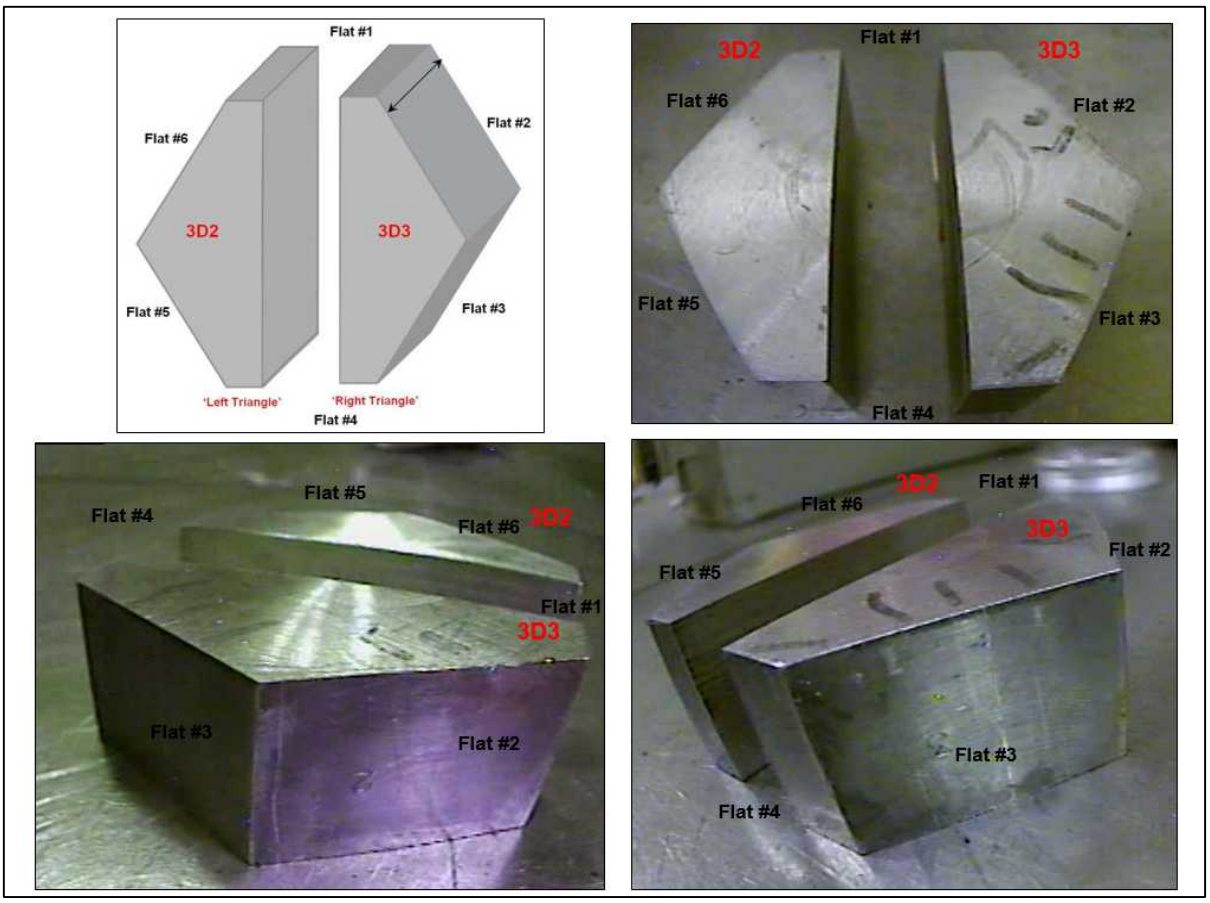

Figure 3. In-cell photos of hex block triangles.

3.2 NFML-Funded Project Addition – Ultrasonic Sensors

An NSUF-funded project #12-357 to Pennsylvania State University involved ultrasonic transducer sensors that were irradiated at the Massachusetts Institute of Technology Reactor (MITR). All activities for this project have been completed and the material samples, Remedor, Galfenol, Arnokrome, Zinc Oxide, and Bismuth Titanate, have been added to the NFML database.

3.3 NFML-Funded Project Addition – Metallic Fuels

An NSUF-funded project #10-242 to the University of Central Florida includes metallic fuels irradiated in the ATR. The project includes three phases. The first phase has been completed and the samples of Uranium-Zirconium and Uranium-Molybdenum based fuel material have been added to the NFML database. The second phase is on hold due to equipment issues and the third phase samples are scheduled to be added to the NFML in FY 2019.

3.4 NFML-Funded Project Addition (in progress) – Hydride Fuel Samples

An NSUF-funded project #10-224 to University of California – Berkeley involved mini hydride fuel elements irradiated at the MITR. All activities for this project have been completed. All irradiated and unirradiated samples at MIT were returned to INL in FY 2017. The samples will be added to the NFML database when the pedigree has been processed.

3.5 NFML-Funded Project Addition (in progress) - UCSB RPV steel/alloy samples

An NSUF-funded project #09-153 to University of California – Santa Barbara irradiated hundreds of samples of Reactor Pressure Vessel (RPV) steels in the Advanced Test Reactor (ATR). PIE began in FY 2015 and is ongoing. The samples will be added to the library when the pedigree information has been processed.

3.6 INL/SCK•CEN CRADA Addition (in progress) – Silicone Carbide Temperature Sensors

A Cooperative Research and Development Agreement (CRADA) between INL (NSUF) and SCK•CEN has completed PIE on a set of samples irradiated in the Belgian Reactor 2 (BR2). The samples have been returned to INL and will be added to the library when the pedigree information has been processed.

3.7 ORNL Library Donation – Ceramics

A small set of titanium carbide samples from ORNL was added to the library. The samples are from a larger set of advanced high temperature ceramics that were neutron irradiated in the High Flux Isotope Reactor (HFIR).

4. NFML AS A REPOSITORY

The NFML acts as a repository for a diverse selection of nuclear fuels and materials that are a valuable resource to the nuclear research community. Adding material assets to the NFML safeguards them from disposal as waste or being lost in long-term storage. As the curator of valuable unused or residual fuels and materials, the NSUF maintains the physical inventory and material provenance ensuring that the samples and associated information will not be lost to future researchers. Additions to the library donated by external sources, coupled with new research samples, offer nuclear researchers further opportunities to continue to advance the nuclear mission. A number of continued activities, as well as new opportunities, were pursued in an effort to add repository samples to the NFML.

4.1 Naval Reactors Materials – Ongoing

NSUF management was contacted in 2010 by Bechtel Marine Propulsion Corporation (BMPC) with a list of identified materials from the Naval Reactors Program that are available for transfer to the NFML. The list included irradiated and unirradiated silicon carbide (SiC), conventional and nano-ferritic steel samples, and various other materials. The unirradiated portion of the list has been transferred to the NSUF and is stored at an INL storage warehouse. The irradiated materials are stored in the ATR canal.

Contact with BMPC staff in FY 2016 continued the effort to transfer the irradiated samples and materials. BMPC has received a formal letter stating that the NSUF will accept the transfer and management of the materials with the understanding that any data generated using these materials will be made available to the Naval Reactors Program. After transfer, the NSUF will assume responsibility for all materials and hardware associated with the transfer. BMPC (now Fluor) staff are in the process of cataloging the inventory in the ATR Canal that will be transferred to NSUF.

4.2 Fuel Cycle Research and Development Program Samples – On Hold

The U.S. Fuel Cycle Research and Development (FCR&D) program conducted experiments using DU-Zr alloys irradiated in HFIR to low doses. The ORNL Advanced Fuels Campaign will disassemble the capsules at ORNL and perform preliminary PIE. When the capsules are disassembled, ORNL will compile a list of the samples that Advanced Fuels Campaign is planning to donate to the NFML.

4.3 LAMDA Samples – Ongoing

A list of samples currently held at the Low Activation Materials Development and Analysis Laboratory (LAMDA) was provided to NSUF for inclusion in the NFML. The samples are from various programs, including LWRS, FCRD, and Fusion. ORNL staff are in the process of compiling pedigree information for all the samples.

4.4 Westinghouse Baffle Bolts - Potential Addition to NFML - Ongoing

Westinghouse Electric Company, LLC has offered two sets of stainless steel Type 347 reactor baffle bolts to the NFML. The baffle bolts were removed from two different nuclear power plants and used in EPRI-funded testing at Westinghouse. Westinghouse has agreed to provide documentation that identifies the bolt materials in their possession and to identify what specific information can be provided for these bolt materials in the future – based either upon available Westinghouse records/EPRI permission to release information, or by NSUF-funded analysis and testing to reaffirm material characterizations. Information associated with the samples will not be tied to any particular plant identification when it passes into the public domain. DOE-ID is currently addressing Westinghouse questions and will continue moving forward with the title transfer.

5. NFML OUTREACH

Outreach included staffed booths at technical and university conferences, NFML introduction and explanation within presentations, speeches, and forums attended by NSUF staff, and NFML sample mention and description from PIs during NSUF-awarded presentations.

NFML outreach was also provided when NSUF staff attended the Nuclear Science User Facilities Industry Advisory Meeting with attendees from EPRI, Southern Co., G.E. Hitachi, and many national laboratories. An overview of the NFML was given followed by discussion with attendees. A portion of the discussion included the Ex-Plant Harvesting Workshop (held in FY 2017) that focused on the valuable opportunities of harvesting real-world material from decommissioned power plants. NSUF staff stressed that NFML should be the repository for harvested materials.

6. NFML DATABASE APPLICATION STATUS

The NFML database went online in 2016. Prior to the online database, the library index consisted of a series of spreadsheets with samples listed from various NSUF-awarded projects, EBR-II legacy samples, and donated samples. The online database provides an organized list of projects with accompanying samples. In 2017, the NSUF retained a full-time Information Management employee who works with NFML staff to continually upgrade the NFML database to make improvements to the database that benefit researchers and NSUF staff by providing a database that is user-friendly and efficient.

6.1 NSUF Integrated Database

The NFML has been integrated with all databases housed within the NSUF website. The integrated database gives the user the ability to access any of the subjects from anywhere in the database (Figure 5). For example, a user can access PI contact information (in the SME database) from the NFML database, or a user can access an institution's information (in the NEID database) from the project database as well as any publications resulting from the project or the PI, etc.

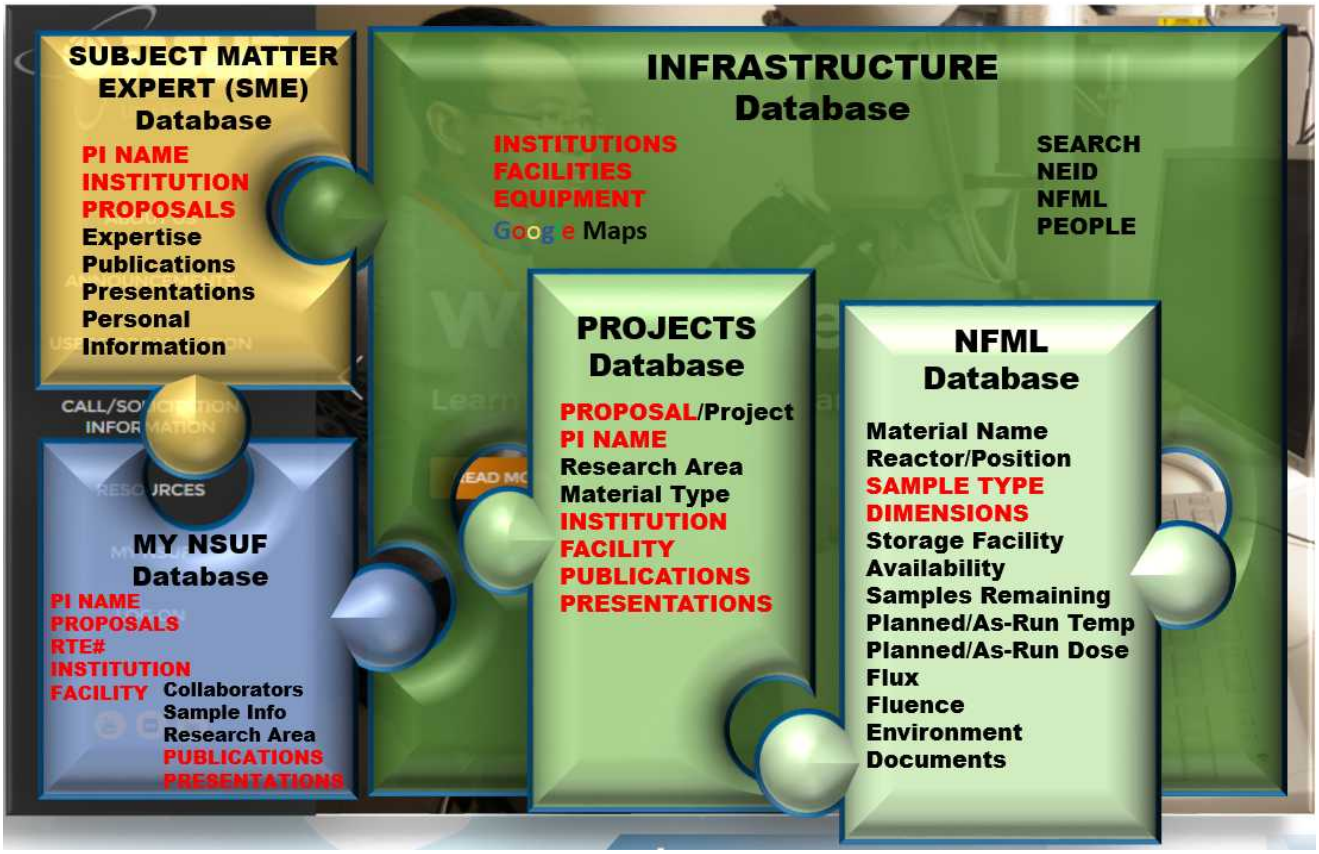

Figure 4. A diagrammatic representation of the NSUF integrated database

6.2 Search and Sample Improvements

Search functionality within the NFML database has been improved with the creation of keywords that allow a user to search for specific materials and corresponding compositions.

25 ceramic

Material Name	Composition by Weight (%)
0.7MgO-0.3Nd2Zr2O7	Mg-34O-15Nd-9Zr
Al2O3	Al-47O
Mg2SnO4	Sn-28O-21Mg
MgAl2O4	Al-29O-22Mg
MgO	Mg-40O
MgO-ZrO2	Zr-29O-15Mg
MgO1.5Al2O3	Al-47O-4Mg
MgTiO3	O-40Ti-20Mg
Nd2Zr2O7	Nd-31Zr-19O
SiC	Si-36C
Ti3AlC2	Ti-14Al-12C
Ti3SiC2	Ti-14Si-12C
YSZ	Y-26Zr-23O

Figure 5. Screenshot of the NFML material search

Sample details with the NFML database have been extended to include composition graphs.

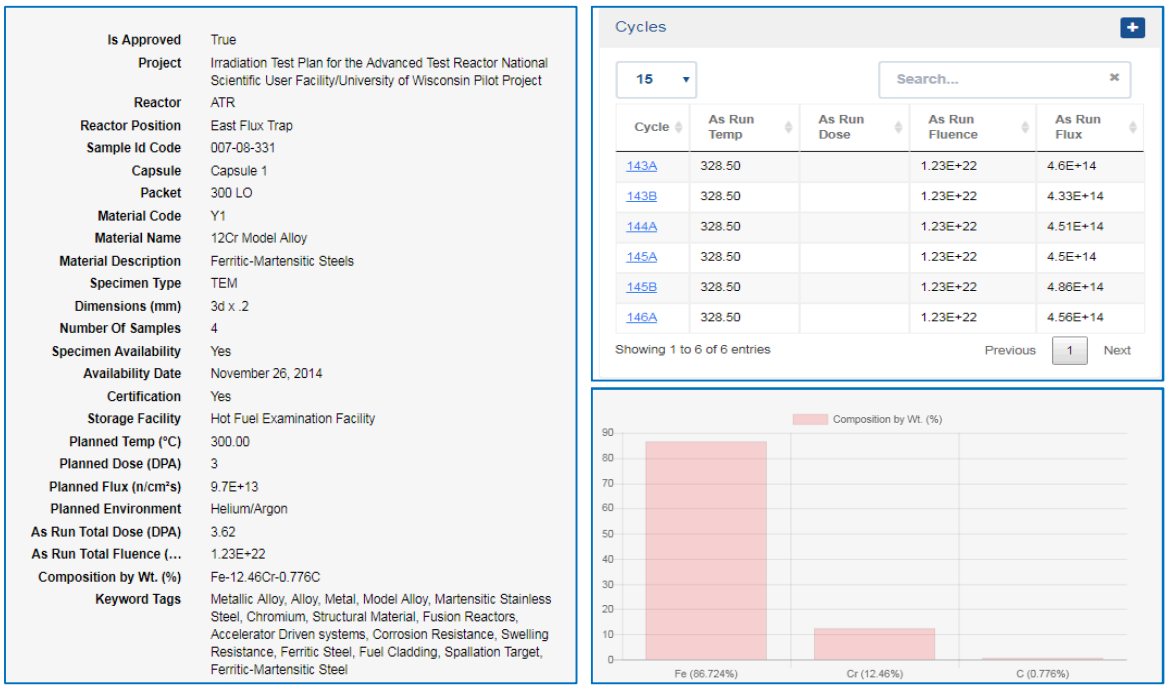

Figure 6. Screenshot of the NFML experiment details

6.3 Action Items

The following list of FY 2019 action items have been compiled from this document:

1. Section 3.4 – Add project #10-224 UCSB hydride fuel samples to the NFML when pedigree information is received from the PI
2. Section 3.5, Table 3 – Add project #09-153 UCSB RPV steel/alloy samples to the NFML when pedigree is received from PI.
3. Section 3.6 – Add the SiC samples from the INL/SCK•CEN CRADA when pedigree information is compiled.
4. .Section 4.1 – Continue pursuing the transfer of the Naval Reactors irradiated materials stored at ORNL and the ATR canal.
5. Section 4.2 and 4.3 - Follow-up with ORNL on the status of the FCRD DU-Zr alloys and LAMDA samples that are to be added to the NFML when PIE is complete and pedigrees have been compiled (respectively).

7. CONCLUSION

The NFML inventory should increase greatly in FY 2019 when samples from previously awarded projects become available after PIE and pedigree verifications are complete. Continued outreach will introduce the NFML to new researchers from academia, national labs, and industry providing more opportunities for sample creation and possible repository donations. The NFML database will continue to evolve as more researchers use the application and areas for improvement are discovered. Inventory additions and an evolving web application ensures that the Nuclear Fuels and Material Library will continue to be an invaluable asset to the nuclear research community.

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