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FY 2019 Annual Status Report for the

NUCLEAR FUELS AND MATERIALS LIBRARY

November 2019

Changing the World's Energy Future

Idaho National Laboratory

INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance, LLC

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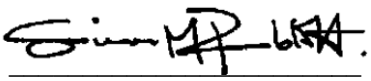

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FY 2019 STATUS REPOR FOR THE NUCLEAR FUELS AND MATERIALS LIBRARY

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 and donated materials from national labs and commercial reactors. The online library technology is always evolving to provide users a valuable, efficient, and user-friendly tool for nuclear research.

2. FY 2019 NFML UTILIZATION

NFML sample utilization remained consistent with past years. Twelve percent of submitted 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 is to 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.

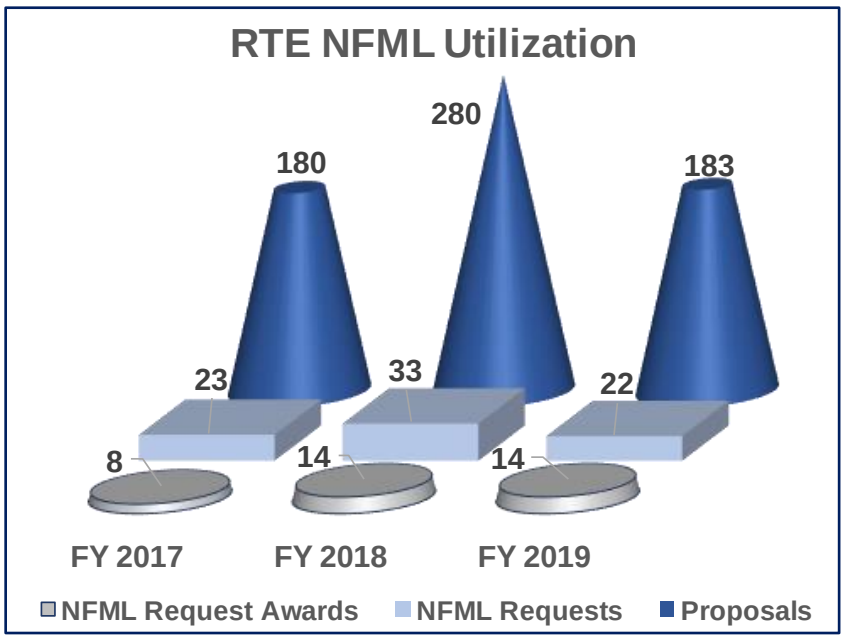


Figure 1. NFML utilization in RTE proposals and awards

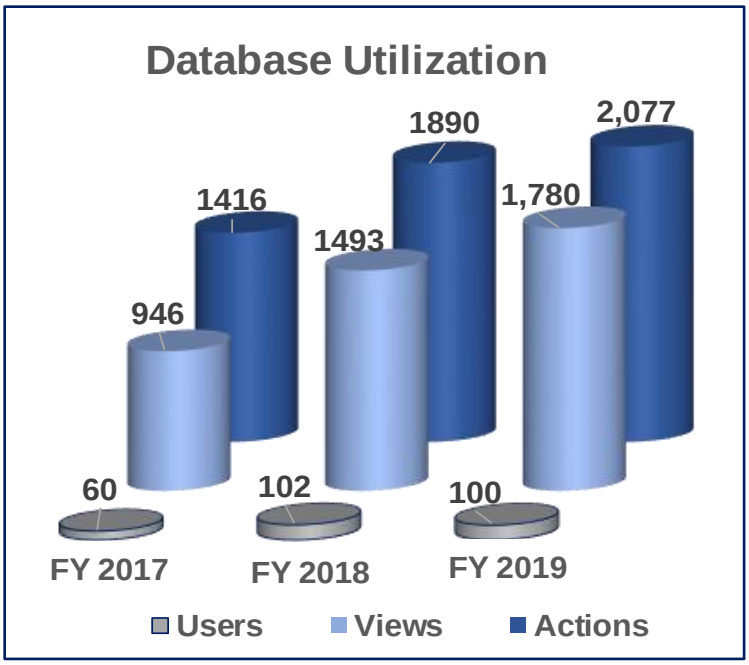


Figure 2. NFML database utilization

3. NFML FY 2019 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 6,300 samples. Several NSUF-funded project irradiations and/or Post Irradiation Experiments (PIE) were completed in FY2019. Samples from theses completed projects were added to the NFML or are in progress to be added soon. Additionally, repository donations increased the inventory of the NFML. The donations include material from commercial light water reactors (LWR), ex-reactor baffle bolts donated from the Electric Power Research Institute (EPRI), and samples irradiated in the Russian BOR 60 reactor.

3.1 NFML-Funded Project FY 2019 Addition – Metallic Fuels

NSUF-funded project #10-242 to the University of Central Florida (UCF) includes metallic fuels irradiated in the ATR. The project is made up of three phases. The first phase irradiation was completed in FY 2018. The second phase is on hold due to equipment issues. The third phase irradiation of Uranium-Zirconium and Uranium-Molybdenum based fuel samples was completed in FY 2019 with the samples cataloged, placed in storage and made available through the NFML. Figure 3 is a screenshot of the UCF project information and samples.

Project

Project Type	Irradiation/PIE
Institution	University of Central Florida
Facility	Materials Characterization Facility at the Advanced Materials Processing and Analysis Center
Fiscal Year	2010
Project Code	10-242
Proposal	Low Fluence Behavior of Metallic Fuels
Award Date	June 9, 2010
Organization	University of Central Florida
CINR Num	242
Irradiation Facility	ATR
PIE Facility 1	INL
Material Type	Oxide Fuel
Research Area	Advanced Fuels Campaign (AFC) and Accident Tolerant Fuels (ATF)

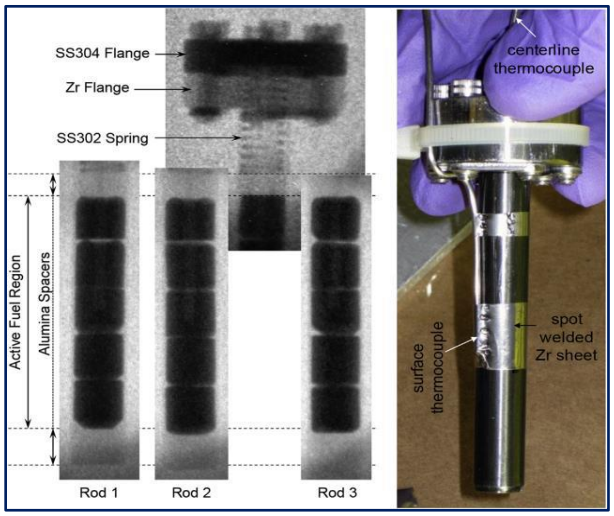
Samples | Resources | Publications | Presentations

	ID	KGT	Description	Material	Facility	Specimen
View	10-242-0001	1607	Disc	Uranium (U)		TEM
View	10-242-0002	1607	Disc	Molybdenum (Mo)		TEM
View	10-242-0003	1607	Disc	Uranium Alloys		TEM
View	10-242-0004	1607	Disc	Uranium Alloys		TEM
View	10-242-0005	1607	Disc	Uranium Alloys		TEM

Figure 3. NFML screenshot of Project #10-242 with sample information

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

NSUF-funded project #10-224 to University of California – Berkeley involved mini hydride fuel elements irradiated at the Massachusetts Institute of Technology Reactor (MITR). All PIE activities for this project were completed and the mini fuel rods sent to Pacific Northwest National Laboratory (PNNL) for a follow-on awarded RTE. The samples will be added to the NFML database when the pedigree has been processed.



Photos courtesy of Kurt Terrani (ORNL)

Figure 4. Fuel rodlets as fabricated

Photos courtesy of David Carpenter (MIT)

Figure 5. Hydride fuel element and capsule stack

3.3 NFML-Funded Project Addition – UCSB-2 RPV steel/alloy samples (in progress)

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 was completed in FY 2019. The sample information is currently being compiled and the samples will be added to the library when storage locations are verified and pedigree information has been processed.

3.4 NFML-Funded Project Additions – CSM and BSU additively manufactured steels and alloy samples (in progress)

Two NSUF-funded project irradiations were completed in FY 2019. Project #15-8242 awarded to Boise State university (BSU) includes alloy samples additively manufactured by powder metallurgy and hot isostatic pressing. Project #16-10584 awarded to Colorado School of Mines (CSM) includes stainless steel samples manufactured using various forms of additive manufacturing techniques. Following irradiation, both sets of samples were sent to INL's Materials and Fuels Complex (MFC) to be disassembled and cataloged. After three years of exclusive access granted to the project teams for PIE, the remaining samples will be made available in the NFML.

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

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 INL staff have completed their evaluations and a complete pedigree has been processed.

3.6 SAM-2 (in progress)

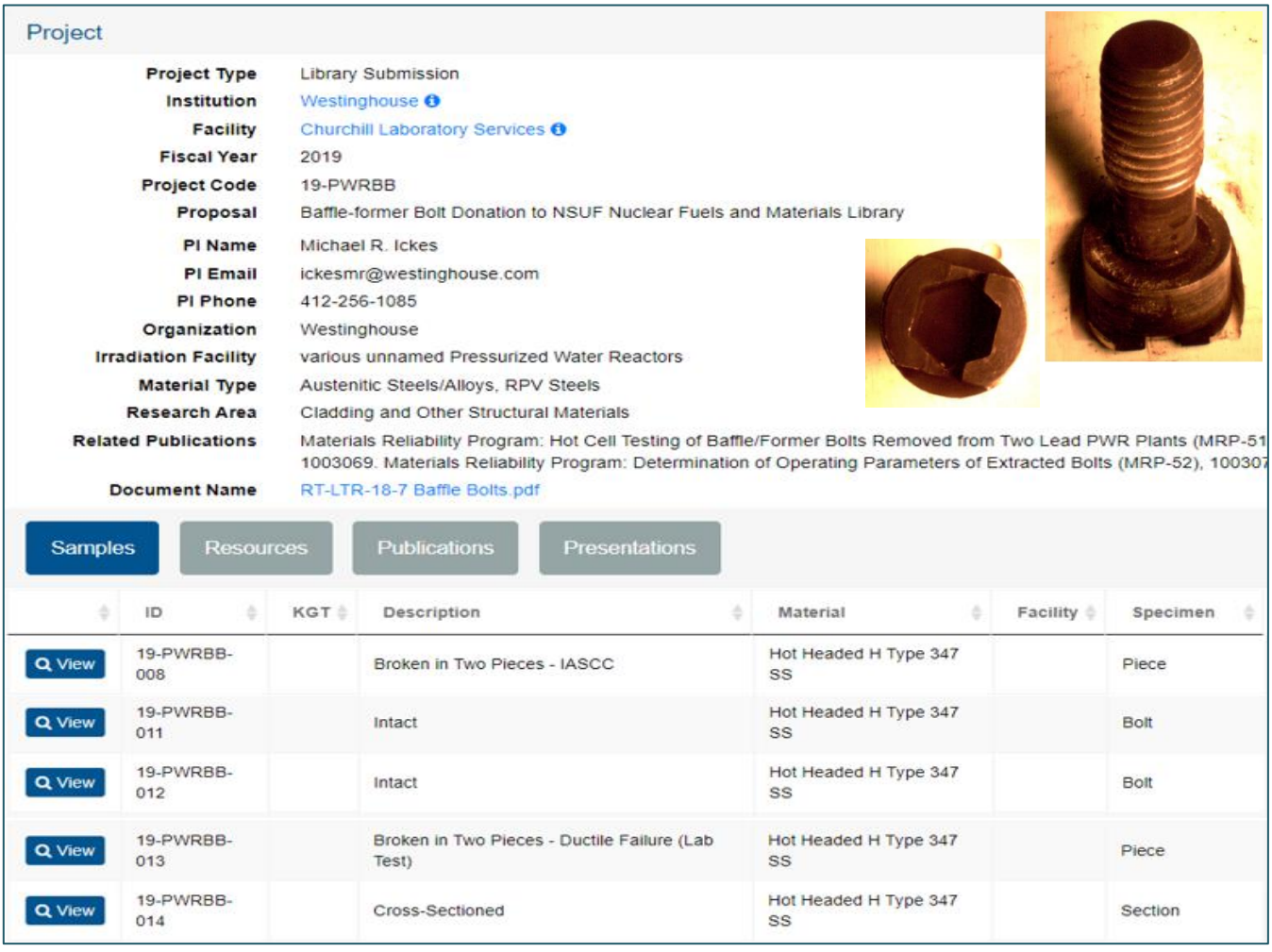
The NSUF performs periodic irradiation campaigns to populate the NFML with specimens for future investigations and to fill gaps in the current NFML inventory. Samples from the first NSUF irradiation campaign (SAM-1) added to the library in FY 2016. Requirements and scoping were completed in FY 2019 for the next NSUF irradiation, SAM-2. The SAM-2 irradiation will add high purity silicon-carbide (SiC) samples that will undergo PIE to help understand the complex inter-relationship between the electronic structure and the thermal and mechanical properties of high purity SiC. Sample insertion into the ATR is scheduled for December 2020 with irradiation completion in 2024.

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.

4.1 Westinghouse Baffle Bolts – FY 2019 Addition to NFML

A title transfer was signed between DOE-Idaho Operations Office and Westinghouse Electric Company, LLC that resulted in two sets of stainless-steel type 347 reactor baffle bolts added to the NFML. The baffle bolts were removed from two different nuclear power plants and used in EPRI-funded testing at Westinghouse (Figure 6).



Project

Project Type	Library Submission
Institution	Westinghouse
Facility	Churchill Laboratory Services
Fiscal Year	2019
Project Code	19-PWRBB
Proposal	Baffle-former Bolt Donation to NSUF Nuclear Fuels and Materials Library
PI Name	Michael R. Ickes
PI Email	ickesmr@westinghouse.com
PI Phone	412-256-1085
Organization	Westinghouse
Irradiation Facility	various unnamed Pressurized Water Reactors
Material Type	Austenitic Steels/Alloys, RPV Steels
Research Area	Cladding and Other Structural Materials
Related Publications	Materials Reliability Program: Hot Cell Testing of Baffle/Former Bolts Removed from Two Lead PWR Plants (MRP-51 1003069. Materials Reliability Program: Determination of Operating Parameters of Extracted Bolts (MRP-52), 100307
Document Name	RT-LTR-18-7 Baffle Bolts.pdf

Samples | Resources | Publications | Presentations

	ID	KGT	Description	Material	Facility	Specimen
View	19-PWRBB-008		Broken in Two Pieces - IASCC	Hot Headed H Type 347 SS		Piece
View	19-PWRBB-011		Intact	Hot Headed H Type 347 SS		Bolt
View	19-PWRBB-012		Intact	Hot Headed H Type 347 SS		Bolt
View	19-PWRBB-013		Broken in Two Pieces - Ductile Failure (Lab Test)	Hot Headed H Type 347 SS		Piece
View	19-PWRBB-014		Cross-Sectioned	Hot Headed H Type 347 SS		Section

Figure 6. NFML screenshot of baffle bolt information and pictures

4.2 BOR-60 (in progress)

Contracts were signed in FY 2019 between INL and PNNL, Los Alamos National Laboratory (LANL), and Oak Ridge National Laboratory (ORNL) to complete tasks that will result in an NFML addition of samples that were irradiated in the Fast Reactor BOR-60. The samples were previously shipped from Russia to PNNL by TerraPower where they have been stored in an unopened drum. The contracts arranged for the drum to be sent from PNNL to LANL where they will be repackaged and sent on to ORNL. ORNL will then retrieve the

samples, identify them and package them for redistribution for slated research with a portion of the samples being placed in the NFML.

4.3 EPRI (BWXT) 304 SS (in progress)

The NSUF was contacted by EPRI staff regarding BWXT-owned materials remaining from an EPRI-sponsored project. The 304 stainless steel samples include crack and weld mounts from light water reactors. NSUF staff met with INL legal counsel to draft a title transfer that has been sent to EPRI and BWXT contacts for review.

4.4 Irradiated LWR Fuel (in progress)

The Joint Fuel Cycle Studies Program received various used nuclear light water reactor fuels from commercial reactors in FY 2019. The used fuel will be utilized in the Joint Fuel Cycle Studies Integrated Recycling Test. NSUF staff met with JFCS staff to discuss adding a portion of the used fuel to the NFML. A list of the available fuel is being compiled by JFCS staff. The available fuel will be added to the NFML when the complete list and pedigree have been processed.

4.5 TREAT (testing pilot application)

Staff from the INL division of Nuclear Fuels and Materials contacted the NSUF to discuss adding materials from Transient Reactor Test (TREAT) experiments. The materials, if added to the NFML, may or may not be available to researchers. The goal of adding the material to the NFML is to have a documented list of materials and samples to maintain ownership, location, pedigree, etc. The list will be designated in the NFML by program to delineate TREAT materials from generally available NFML material. The list can be viewed by researchers but requests to use the materials will go through TREAT management. A pilot application is being developed on the NFML "Acceptance" website. The "Acceptance" website is used to test new applications and procedures that may be added to the working, "Production," NFML website.

4.6 LAMDA Samples (in progress)

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 FES. ORNL staff are in the process of compiling pedigree information for all the samples.

5. 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 listing samples from various NSUF-awarded projects, EBR-II legacy samples, and donated samples. The online database provides an organized, searchable list of projects with accompanying samples. In 2017, the NSUF retained a full-time web developer who works with NFML staff to continually upgrade the NFML database for a more user-friendly and efficient application.

5.1 Sample Search Improvements

Many upgrades were made to the NFML user interface and administration interface. The most notable improvements focused on making the browse and search functions of the database more efficient for the researcher. The library browser now supports autocomplete keyword searches. Figure 7 displays a screenshot of the autocomplete search function.

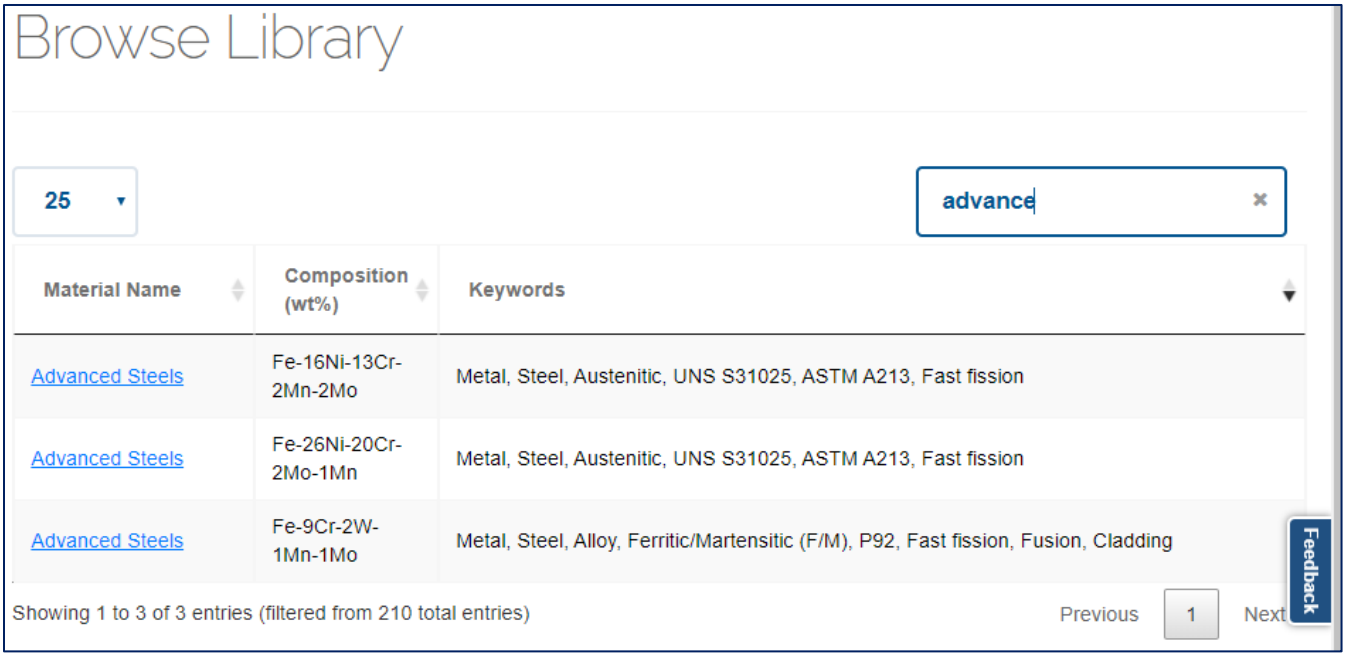


Figure 7. NFML screenshot displaying the autocomplete keyword search

Previously, when browsing or searching the NFML, results returned a list of PROJECTS containing samples that matched the search criteria. However, a user had to search though each project's list of samples to find a sample matching their needs. The updated search is now "sample" centric rather than "project" centric. Browsing or searching results will return all SAMPLES that match the criteria, as seen in Figure 8.

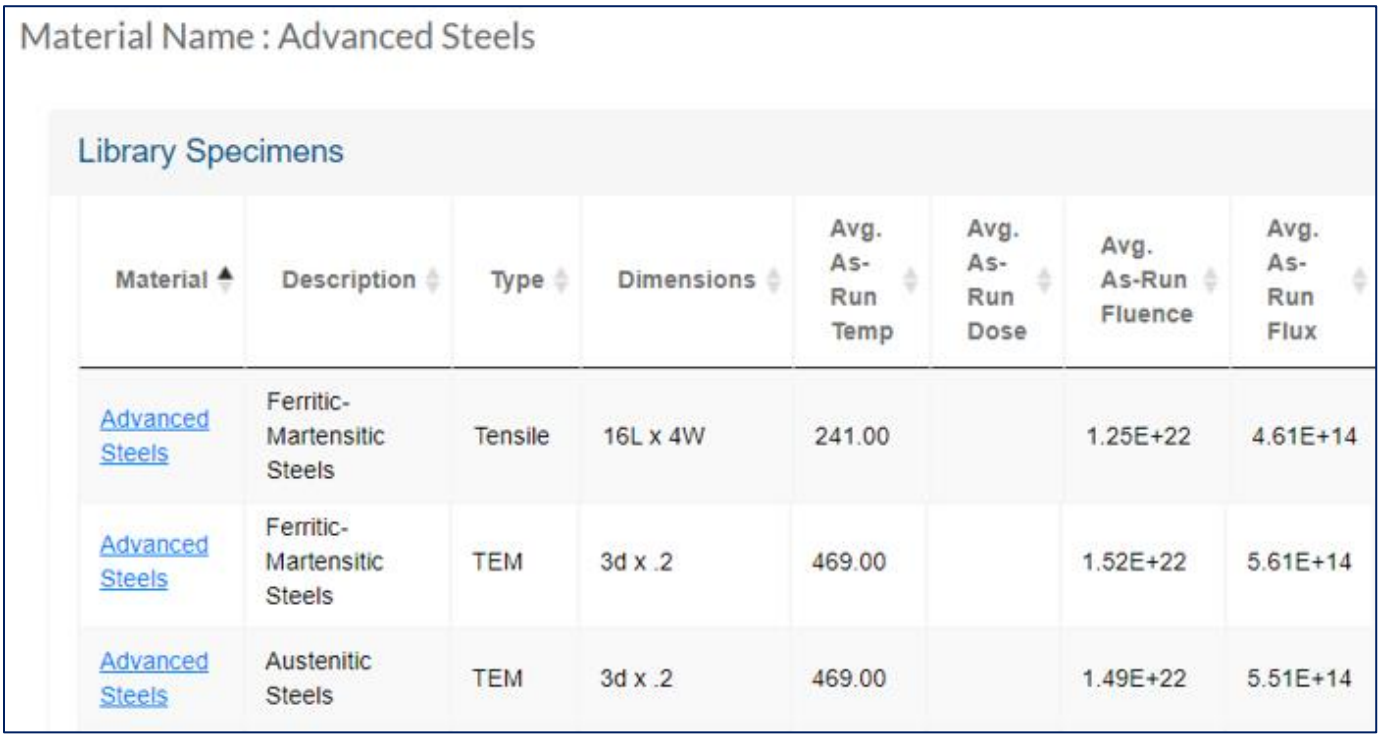


Figure 8. NFML screenshot displays the sample-centric search results.

The user can then choose the sample that meets the criteria to view the sample irradiation conditions (Figure 9).

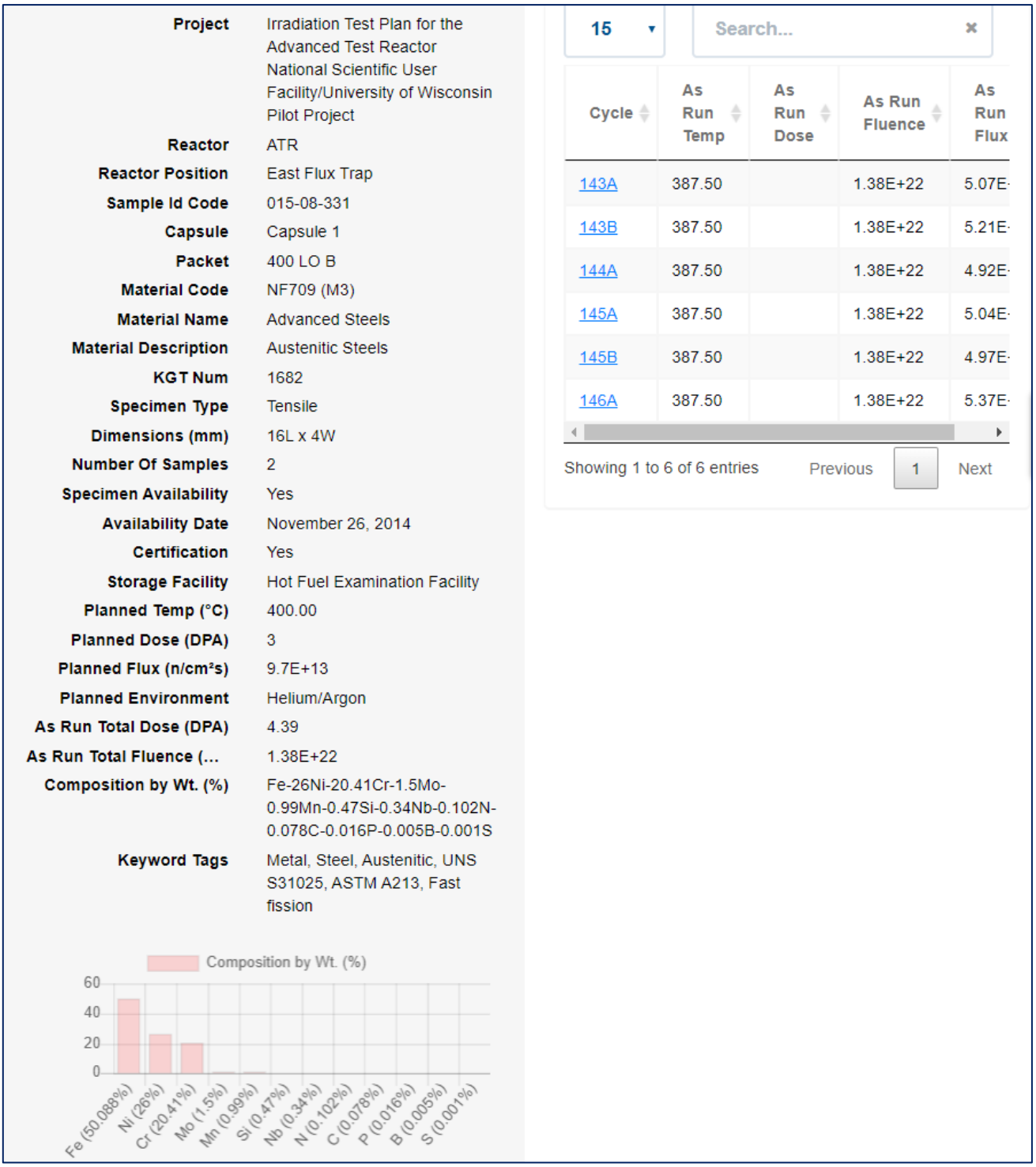


Figure 9. NFML screenshot displaying sample information

6. CONCLUSION

The NFML inventory increased in FY 2019 with samples from previously awarded projects becoming available. Additional inventory will be added to the NFML after ongoing PIE and pedigree processing are complete. 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.