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Revision 0

NSUF Fuels and Materials Library

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September 2015

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EXECUTIVE SUMMARY

The Nuclear Science User Facilities (NSUF) has been in the process of establishing an innovative Fuels and Materials Library concept for maximizing the value of previous and on-going materials and nuclear fuels irradiation test campaigns, including utilization of real-world components retrieved from current and decommissioned reactors. When the ATR National Scientific User Facility was founded in 2007, one of the goals of the program was to establish a library of irradiated samples for users to access and conduct research through a competitively reviewed proposal process. As part of the initial effort, staff at the user facility identified legacy materials from previous programs that are still being stored in laboratories and hot-cell facilities at the INL. In addition, other materials of interest were identified that are being stored outside the INL that the current owners have volunteered to enter into the library. Finally, over the course of the past several years, the ATR NSUF has irradiated more than 3500 specimens as part of NSUF competitively awarded research projects. The logistics of managing this large inventory of highly radioactive materials poses unique challenges. This document will describe materials in the library, outline the policy for accessing these materials, and put forth a strategy for making new additions to the library as well as establishing guidelines for minimum pedigree needed to be included in the library to limit the amount of material stored indefinitely without identified value.

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NSUF Fuels and Materials Library

1. Introduction

The concept for of a fuels and materials library began as a small effort to allow individuals access to materials and components stored at Idaho National Laboratory (INL) and primarily sourced from legacy Experimental Breeder Reactor II (EBR II) hardware and surveillance samples that are being stored in the Hot Fuels Examination Facility (HFEF). Some of these materials have been stored for more than 15 years and have proved valuable for understanding fundamental radiation damage behavior in reactor structural materials after long-term residence in a fast reactor environment. Since the inception of the original "Library" concept, it was recognized that other facilities around the country might have similar materials that researchers would be interested in studying as well as a growing number of excess materials that have been irradiated as part of awarded NSUF research. In order to make these materials available to the research community, it was recognized that a process for cataloguing, storing, tracking, and managing material access needed to be developed that would enable a relatively straightforward interface between users requesting samples through various established mechanisms (peer reviewed proposals, NE funded programmatic work, etc.) and the facilities needed to make the samples available. In addition, general guidelines for acceptance of new materials into the Fuels and Materials Library needed to be developed so that sample pedigree is well defined, including whether unirradiated archive materials are available, so that materials in the library will have the highest research value. This document describes the present state of the NSUF Fuels and Materials Library including an overview of materials in the library, the general policies for accessing and utilizing these materials, guidelines for establishing pedigree, acceptance criteria for adding to the library, and finally a few examples of library utilization and general lessons learned that have occurred during the last several years of Library development.

2. Overview of Materials in the Library

At present, most of the materials in the library include samples that have either been irradiated in EBR II or the Advanced Test Reactor (ATR) with a much smaller number of samples that were proton irradiated at the LANSCE facility at Los Alamos National Laboratory (LANL), irradiated at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) or the Fast Flux Test Facility at Hanford. In general, most of these materials are conventional or advanced reactor structural materials, which has been the focus of much of the awarded NSUF research. Going forward, there should be nuclear fuel and sensor material samples added to the library as the associated experiments are completed. One of the first efforts to manage these samples was to catalogue all the currently available samples and collate all the available information. This was performed by a summer intern who entered all of the data concerning sample condition and irradiation parameters into Excel spreadsheets with the intention of converting these spreadsheets into a searchable database at some point in the future.

Since this initial effort, several additional experiments have been conducted and additional sample data must be entered into either the spreadsheet format or the on-line database once it is created. As new experiments are awarded, there will be a continual need to update and manage the growing inventory of samples. A summary of the currently available samples is shown in Table 1. The table only includes those samples that are currently available to the general user community and not those samples that are currently covered by the exclusive access policy that stipulates PI's of awarded NSUF Irradiation and PIE experiments have 3 (formerly 2) years of exclusive access to samples prior to the unanalyzed samples going into the Materials Library (the section on Materials Library Policies discusses this in more detail.

Table 1 Samples Currently in the NSUF Fuels and Materials Library

Project or Source, Reactors, and General Irradiation Conditions	**Materials Irradiated**	**Sample Geometry**	**Number of samples**
NSUF EBR II Legacy Hardware EBR-II Irradiated 370 to 540°C Up to 45 dpa.	304 and 316 SS	Hexagonal Ducts and Reflector Blocks	~6 full length Ducts ~6 Reflector Blocks
NSUF EBR II Surveillance EBR-II Irradiated 370°C (coolant temperature) 4.0 – 4.5 x 10^{22} n/cm^2	Austentic SS, Inconnel X-750, Ferritic SS, Tool Steel, Ta, Beryllium Cu, Aluminum Bronze, Stellite	Tensile, Hardness, Bend Bars, Impact and Spring	>100 samples
Naval Reactors Donated Materials ATR and HFIR Metallic 220 to 380°C 0.4 to 1.2 dpa SiC 500 – 1200°C 0.4 – 5.5 dpa	SiC, Austenitic SS, ODS Alloys	Flexure, and thermal diffusitivity (SiC) Tensile and Fracture toughness (metals)	More than 300 samples.
EPRI Donated BOR 60 Materials ~320°C 26 and 47 dpa	PWR SS, Simple Fe and Fe-Cr alloys, ODS alloys	TEM Discs	~140 Samples
NSUF University of Wisconsin 2007 ATR Drop in Irradiation 300 to 700°C 3 and 6 dpa	Ferritic-Martensitic and Austenitic SS, ODS alloys, Refractory Alloys, SiC, Metallic Glass	TEM, Tensile	149

Table 1 (Continued) Samples Currently residing in NSUF Sample Library

Originating Source, Reactors, and General Irradiation Conditions	**Materials Irradiated**	**Sample Geometry**	**Number of Irradiation Conditions**
NSUF University of Florida 075-2008 ATR Drop In Irradiation 200 and 700°C 1 and 2 dpa	Inert Matrix Materials, MgO, $MgAl_2O_3$, $Nd_2Zr_2O_7$, MgO-$Nd_2Zr_2O_7$, $MgSnO_4$	TEM and Diffusivity Discs	~120 Samples
NSUF North Carolina State University 2008 ATR Drop In Irradiation 65 – 85°C 1 and 2 dpa	Coarse and Nano grained Cu, Ni, Carbon Steel, ODS and Friction Stir Welded ODS	TEM, Hardness and Tensile	~80
NSUF University of Illinois 2008 ATR Drop In Irradiation 300, 450 and 550°C 0.01, 0.1, 0.5, 1.0, 5.0 and 10.0 dpa	Fe-Cr, Fe-Cr-C, HT-9, T-91, MA-957 ODS,	TEM and Tensile	~ 760
NSUF University of California Santa Barbara UCSB-1 2008 ATR Drop In Irradiation 275 -750°C 1.7 – 6.2 dpa	Commercial F-M alloys, Model RPV Steels, ODS alloys, Cast Austenitic SS,	8 mm DMC, Tensile, Disc Compact Tension, Compression, Chevron Wedge	~1500
NSUF Drexel University 2009 100, 650 and 1000°C 0.1, 1 and 9.0 dpa	Ti_3SiC_2, Ti_3AlC_2, SiC	Resistivity, TEM and Tensile	~153
NSUF Utah State University 2009 ATR Drop In Irradiation	Al_3Hf, Al_3Hf-Al composite	Density, Thermal Diffusivity, TEM, Hardness, Tensile	196

The materials in the sample library are physically located at several facilities including:

- The ATR canal at INL
- HFEF at INL
- EML at INL
- CMR Hot Cell Facilities Los Alamos National Laboratory
- HFIR at Oak Ridge National Laboratory

When experimental capsules from ATR are transferred to HFEF they are broken down to individual samples or small groups of common samples and stored in sample vials referred to as KGT with each vial assigned a unique identifier. Figure 1 shows the containment box in HFEF where many of the samples in KGT are stored prior to removal from the hot-cell for analysis.

Figure 1 HFEF containment box where capsules are disassembled, catalogued and frequently stored prior to retrieval.

As it stands, the only INL facility capable of receiving a cask from ATR, conducting capsule disassembly, and cataloguing and storing a large number of highly irradiated library samples is HFEF. Unfortunately, since this facility is also the main nuclear fuel PIE facility at the INL, it is heavily alpha radiation contaminated. Many facilities external to INL cannot accept alpha contaminated samples so significant effort frequently needs to be devoted to decontaminating samples removed from HFEF prior to shipping to external analysis facilities.

The NSUF staff has worked to identify facilities and processes that will expedite retrieval of samples to support user requests. Within this effort is consideration of establishing new capabilities to sort and catalog samples in alpha free hot cell facilities either at INL or externally. The major limitation of these external facilities is the inability to accept transportation casks directly from ATR. Longer-term plans to bypass HFEF for capsule disassembly and cataloguing are being considered, however, in the near term the extra steps associated with the need to decontaminate samples prior to transfer to the analysis capability increases retrieval cost and reduces throughput. Temporary shielded storage cabinets such as shown in Figure 2 are also being utilized to speed retrieval.

Figure 2 Shielded storage cabinet to support temporary storage and rapid retrieval of samples requested by users.

3. Sample Library Policy

The NSUF manages the materials in the library as a custodian for the Department of Energy (DOE) who has legal ownership of the materials in the library. In the original User Agreements, established with first awarded projects, it was unclear who had legal ownership of the samples after they had been irradiated in the ATR. It was recognized that although the originating proposers of awarded research may have significant intellectual capital invested in the experiments and even supplied the materials to be irradiated, it was believed that the true research value of samples came from cost free irradiations provided by NSUF. In order to realize this value, it was also recognized that once the original proposers project was completed within the established funding and time guidelines, any excess materials should be made available to the broader research community. The original library policy, solicited by the NSUF Scientific Director, was developed in coordination with the NSUF Users Organization. The sample library policies have been evolving as the NSUF has grown and the mechanisms for awarding research have changed. The policy concepts are now incorporated into the proposal calls as well as any revised and new User Agreements. A draft of the policy statements is as follows:

NSUF Fuels and Materials Library Policy Points

1. Unless otherwise agreed to, the Department of Energy (DOE) owns the material specimens that the NSUF supported for irradiation.
2. Unless otherwise agreed to, DOE owns the material specimens offered to and accepted into the NSUF Fuels and Materials 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 Fuels and Materials Library, manages their utilization, and maintains specimen pedigree documentation.
4. All sample specimens in the Fuels and Materials Library are managed according to the policies and processes of the NSUF.
5. Agreement to the policies of the NSUF Fuels and Materials Library is required. If not agreed to, either the proposed material specimens offered from a third party will not be accepted into the library or the project supporting the production of the sample specimens will not be awarded or supported by the NSUF.
6. Unless part of an ongoing awarded NSUF supported project, NSUF support will be given only to sample specimens in the Fuels and Materials Library. Proposals are welcomed for competitive review under NSUF policies and processes on sample specimens residing outside of the Fuels and Materials Library wherein clear agreement must be demonstrated between material specimen owner and the proposer.
7. Exclusive rights to material specimens for a 3 year period of PIE following the completion of the irradiation portion of an awarded irradiation experiment will be given to the project lead for those material specimens with demonstrated intellectual investment unless other conditions are agreed to such as earlier open availability.
8. After the 3 year period, material specimens will be made available to the general research community for subsequent competitively awarded proposals.
9. As a courtesy, subsequent proposers will be put in contact with original project lead for collaboration. The original project lead may collaborate or not but may not deny access to samples in the Fuels and Materials Library if proposal is successful and awarded according to the independently reviewed competitive process of the NSUF.
10. NSUF reserves the right to fabricate, irradiate, and add to the Fuels and Materials Library additional material specimens as part of any irradiation project supported by the NSUF.
11. In the case of dispute over the admittance of sample specimens to the Fuels and Materials Library for which DOE NE has supported or enabled in their production (including sample specimens produced prior to the publication of this policy statement), the final arbiter of decision will reside with the DOE NE Selection Officer.

Certain materials may have more user demand than others. In general, if multiple users propose to use the same sample or group of samples, proposal review scores will be used to provide recommendations for priority with the final decision residing with the NSUF Director and the DOE NE Selection Officer.

4. Establishing Material Specimen Pedigree

Establishing the pedigree of the materials in the library is critical to producing high quality research results and is essential if results from the test irradiations are to be used to support programs that demand stringent quality assurance (QA) requirements be met. Some of the elements that can be used to establish pedigree include:

Pre-Irradiation Pedigree Elements

Commercial alloy certifications

Independent chemical analysis

Thermomechanical processing conditions

Microstructural Characterization (grain size, precipitate size and density etc.)

Texture analysis

Specimen Geometry, dimensions and tolerances

Thermomechanical and thermophysical properties characterization

Post-Irradiation Pedigree Elements

Experiment design information

Irradiation temperature

Irradiation flux

Irradiation fluence

As-built and as-run neutronic analysis

As-built and as run thermal analysis

Source term information

Much of this pedigree information is required to ensure adequate safety margins in the irradiation experiments conducted in ATR or other similar test reactors so will be an integral part of experiment design. Thus, ensuring pedigree may just be a matter of keeping track of relevant documents within the database eventually developed to support the library. A list of documents in the INL Electronic Document Management System (EDMS) associated with NSUF ATR experiments is provided in Appendix A, which serves as a start for establishing pedigree. Additional reports are included in this list that were generated to define the irradiation conditions of several of the EBR II surveillance materials and reflector assemblies that are in the Fuels and Materials Library.

In addition to the as-built data needed for experiment safety verification, as-run data at the individual sample level is needed to support researcher data interpretation and publication. Frequently, the models developed to evaluate neutronics and thermal analyses have to be modified and actual reactor powers incorporated to obtain the needed level of information to support accurate analysis and interpretation of post irradiation examination data. It is also important for the experimenter to understand the limitations of the analysis as well as the level of uncertainty in the calculations provided. If temperature or flux monitors were used during the experiment, this data and associated reports also need to be included with the pedigree documentation.

5. Accepting New Additions to Library

As mentioned in the policy statements, new additions to the library may be generated by the NSUF, for instance in dedicated experiments designed to populate the sample library, or through third party donations. The main stipulation of acceptance is that the samples can be freely used as part of all NSUF proposal call initiatives without restriction and that all data generated is non-proprietary. The individual or entity donating the samples must relinquish all legal ownership of the materials and transfer this ownership to DOE with the NSUF as the custodian. Whether or not the samples have to be physically moved to the INL or one of the NSUF's partner facilities can be determined at the time of donation. Additionally, donations must meet the following criteria.

- The materials being donated have demonstrated relevance to the research community.
- The materials are relatively unique or in high demand..
- There is strong supporting pedigree information in the form of available data, reports or peer reviewed journal information that establishes most of the elements described in the previous section.

In addition, whenever possible, archive material should be supplied with donated irradiated materials. Ultimately, it will be up to the NSUF staff to make a recommendation to the NSUF Director on what new samples should be entered into the sample library.

6. Library Utilization and Lesson Learned

Since the inception of the NSUF, a variety of research projects have utilized samples made available through the NSUF Fuels and Materials Library. A list of some of the major projects is provided in Table 2. In some cases, users have requested samples that still reside in HFEF. When this happens, it becomes necessary to conduct radiological readings on the samples prior to removal from the hot cell to confirm that the radiation levels of the sample(s) are below what can be handled by the analysis facility. Frequently, samples have had to be downsized in the hot cell prior to transfer to EML for final decontamination.

In the case of larger components, such as the full reflector assemblies containing solid hex blocks, significant effort needs to go into sectioning and downsizing to enable removal from HFEF. An image of such a duct being machined is shown in Figure 3. In this case, material from the duct was requested to support the Drexel University PIE only project.

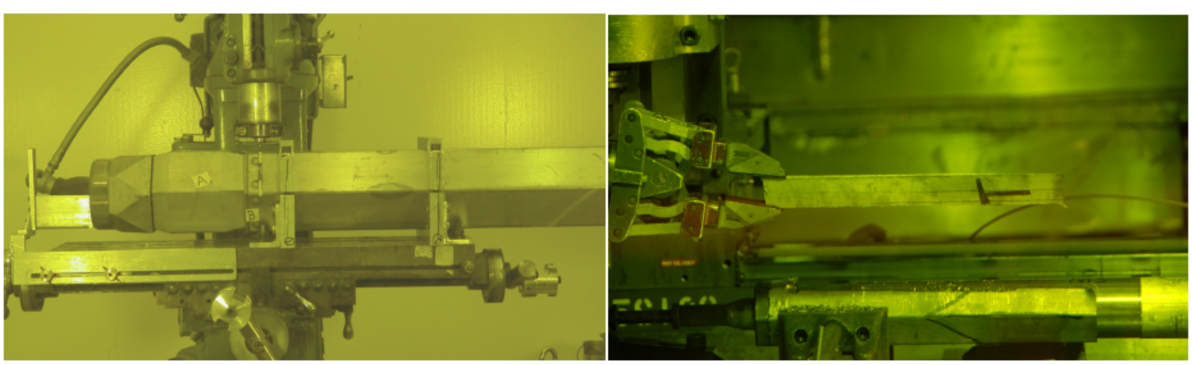

Figure 3 Images of hexagonal duct being machined prior to removal from HFEF.

Table 2 Awarded research and programmatic work supported by materials available through the NSUF Fuels and Materials Library

AECL X-750 Spacer Material provided by CNL (formerly AECL)	• Peter Hosemann, University of California Berkeley, RTE Project entitled
University of Wisconsin Pilot Project Experiment	• Janelle Wharry, BSU- Ferritic and Ferritic-Martensitic Steels provided to for RTE's in CAES (on-going). • Samples requested by Meimei Li, ANL for NEET funded APS experiment (on-going).
Legacy EBR-II Hardware	• Hex Blocks 304 SS continues to be studied by Emmanuelle Marquis and Yong Dong University of Michigan - PIE Only experiment (completed). • Mitra Taheri and Chris Barr, Drexel University- EBR-II 304 and 316 Hex Ducts and LANSCE Proton Irradiated Samples, Awarded PIE Only experiment (completed). • Sebastien Teysseyre, INL Fabrication of compact tension samples for LWRS program experiments (on-going)
UCSB 1 Materials	• Stu Maloy, Los Alamos National Laboratory, Tensile and Fracture Toughness tests on Fast Reactor Ferritic Martensitic Alloys for FCRD programmatically funded work (completed).

The duct materials had been analyzed in the past by INL researchers [1-5] yet Drexel graduate student Chris Barr was able to conduct analysis on the samples retrieved from the library using a new suite of characterization tools (available through the Center For Advanced Energy Studies (CAES) Microscopy and Characterization Suite (MaCS)), that had not been conducted previously. For instance, the focused ion beam was utilized in conjunction with electron backscattered diffraction (EBSD) analysis to extract individual grain boundaries for analysis in the transmission electron microscope (TEM) and the local electrode atom probe (LEAP). This effort allowed characterization of the local grain boundary chemistry changes at the nanometer scale that occurred during irradiation and aids in the understanding of the relationship between the materials microstructure and degradation processes that can occur during irradiation. Images in Figure 4 illustrate results from this work.

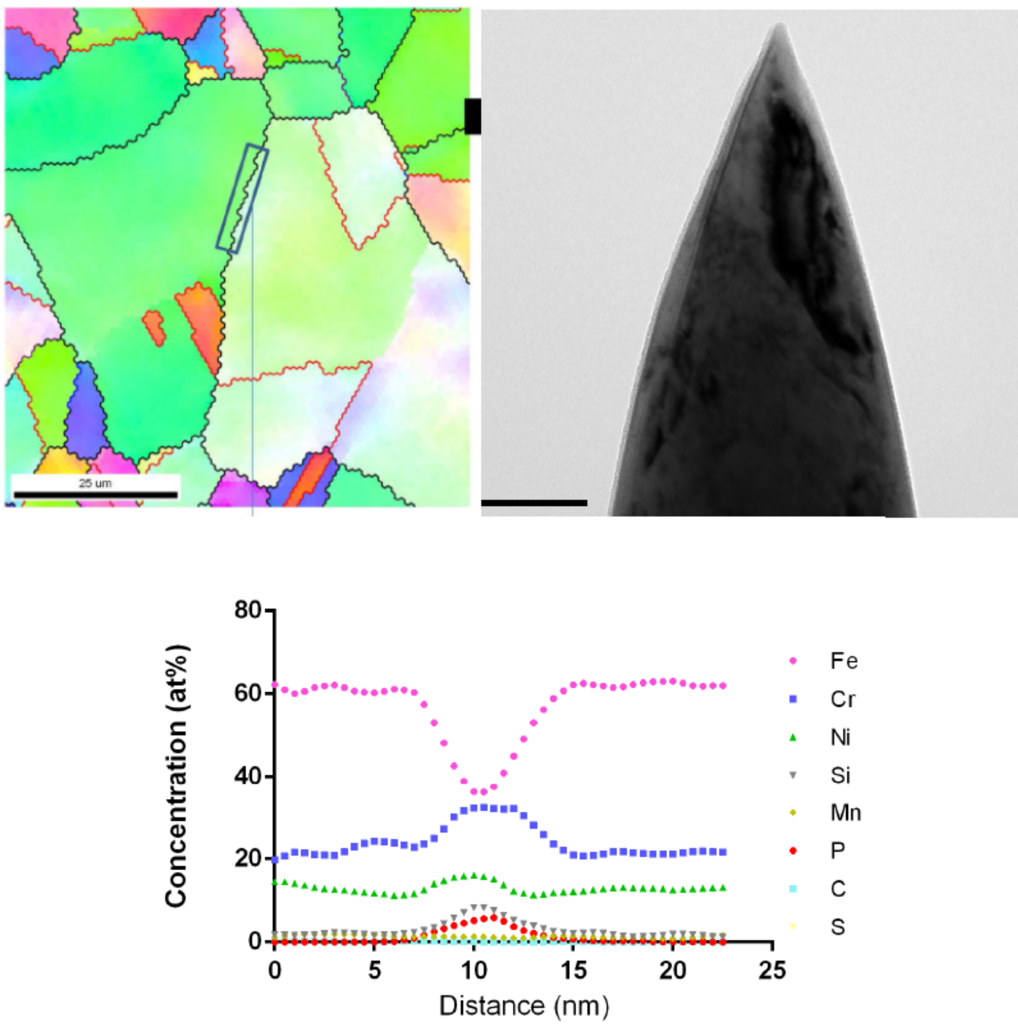

Figure 4 EBSD image, TEM image and radiation induced segregation profile of grain boundary extracted from irradiated 316 stainless steel EBR II hexagonal duct.

As a final example of the utility of the Fuels and Materials Library concept, particularly when the materials, although tracked by the NSUF program, are not physically located at the INL. A majority of the library materials from the UCSB-1 experiment were transferred to LANL with a subset of these materials intended to support FCRD Core Materials R&D efforts. The rest of the samples will remain at LANL to be distributed as requests are made through successfully awarded proposals.

A large number of high chromium tempered martensitic steels (TMS) were irradiated in the UCSB-1 experiment. These materials are primary candidates for transmutation fuel cladding as they have good resistance to radiation-induced swelling, yet there have been few comparisons of all the available alloys irradiated under similar conditions to determine which alloys show the most promise. LANL conducted tensile tests on five of the TMS alloys and one additional oxide dispersion strengthened (ODS) steel. The results give clues to hardening and embrittlement behavior of these materials under irradiation and a better understanding of the changes in the way these materials will undergo plastic deformation once irradiated. The data and analysis from this study led to a peer reviewed journal publication [6] and also gave additional insight into how these alloys should be fabricated to achieve the greatest resistance to radiation damage. The plots in Figure 5 indicate how yield and ultimate tensile strength change in the alloys as a result of irradiation. One of the more interesting findings of the study was that a particular heat of the alloy HT-9 that had been recently fabricated showed much better uniform elongation than previously tested heats. This finding has shed some light on how alloy fabrication processes might be altered to improve irradiation properties.

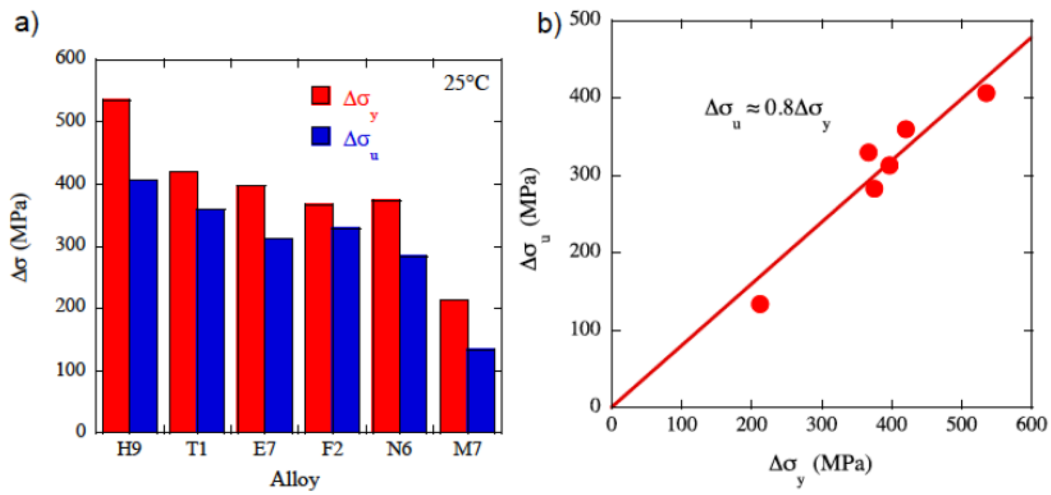

Figure 5 Change in room temperature yield and ultimate tensile strength as a function of alloy irradiated at 295°C to a dose ~6.5 dpa [6].

7. Summary

The NSUF has embarked on an effort to create a library of irradiated materials that can be made available to the research community through a peer reviewed proposal process or through direct programmatic request. At present, the library has several elements in development including best practice strategies for physical storage, cataloguing and sample retrieval as well as development of a database tracking system that can be modified and searched through a web-based interface. Such an interface will greatly enhance and enable the distributed nature of the library to be realized as samples can be physically located at multiple facilities while tracking and coordination can be performed through a centralized shared web interface. Going forward it is anticipated that new materials will be added to the library and it is envisioned that a variety of government, academic, and commercial institutions will consider providing excess irradiated materials that would otherwise be disposed of.

8. References

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2. J. I. Cole, H. Tsai, T. R. Allen, T. Yoshitake, N. Akasaka, I. Yamagata, and Y. Nakamura,,"Strain-Rate Effects on Microstructural Deformation in Irradiated 316 SS", J. Nucl. Mater. 351(1-3) (2006) 316-323.

3. T. R. Allen, J. I. Cole, C. L. Trybus, D. L. Porter, H. Tsai, F. Garner, E. A. Kenik, T. Yoshitake, Joji Ohta, The effect of dose rate on the response of austenitic stainless steels to neutron radiation, J. Nucl. Mater. 348 (2006) 148.

4. J. I. Cole, T. R. Allen, H. Tsai, T. Yoshitake, I. Yamagata, N. Akasaka and Y. Nakamura, "Low Strain-Rate Microstructural Deformation Behavior in 316 Stainless Steel Irradiated in EBR-II" Journal of ASTM International, February 2006, Vol. 3. No. 2, JAI12400.

5. T. Yoshitake, I. Yamagata, N. Akasaka, Y. Nakamura, H. Tsai, J. I. Cole and T. R. Allen, "Behavior of Irradiated Type 316 Stainless Steels under Low-Strain-Rate Tensile Conditions", Journal of ASTM International (JAI), JAI12346.

6. S.A. Maloy, et al., Characterization and comparative analysis of the tensile properties of five tempered martensitic steels and an oxide dispersion strengthened ferritic alloy irradiated at z295 _C to z6.5 dpa, Journal of Nuclear Materials (2015), http://dx.doi.org/10.1016/j.jnucmat.2015.07.039

Appendix A

List of Experiment Reports

Project	Document ID	Title	Rep
331-2008 University of Wisconsin	ECAR-223	Gamma Heat Rates And Helium Production Rates For Design And Safety Evaluations For The ATR NSUF University Of Wisconsin Pilot Project	EDMS
	ECAR-338	Bounding Linear Heat Rate Analysis For The ATR NSUF University Of Wisconsin Pilot Project	EDMS
	HFEF-LI-0080	NSUF - University of Wisconsin PIE	EDMS
	PLN-2765	ATR National Scientific User Facility - University Of Wisconsin Pilot Project	EDMS
	PLN-2784	Irradiation Test Plan For The ATR National Scientific User Facility - University Of Wisconsin Pilot Project	EDMS
	PLN-2789	Fabrication Control Plan For The ATR National Scientific User Facility - University Of Wisconsin Pilot Project: Samples, Rodlets, And Capsules	EDMS
	PLN-2790	Inspection Plan For The ATR National Scientific User Facility - University Of Wisconsin Pilot Project: Samples, Rodlets, And Capsules	EDMS
	TFR-538	Technical And Functional Requirements For The ATR National Scientific User Facility - University Of Wisconsin Pilot Project: Samples And Rodlets	EDMS
075-2008 University of Florida	ECAR-422	ATR Physics Evaluation For The University Of Florida Experiments In The B-1 Position	EDMS
	ECAR-454	Structural Analysis Of ATR NSUF University Of Florida Experiment	EDMS

	ECAR-455	Thermal Analysis Of ATR-NSUF University Of Florida Experiment	EDMS
	ECAR-467	University Of Florida Radionuclide Source Term	EDMS
	ECAR-489	Heat Transfer Analysis After Pump Shutdown Of ATR NSUF University Of Florida Experiment	EDMS
	PLN-2870	ATR National Scientific User Facility - University Of Florida Project	EDMS
	PLN-2874	Irradiation Test Plan For The ATR National Scientific User Facility - University Of Florida Project	EDMS
	PLN-4077	ATR NSUF - University Of Florida PIE (FY12)	EDMS
096-2008 North Carolina State University	ECAR-430	ATR Physics Evaluation For The North Carolina State University Experiments In The East Flux Trap	EDMS
	PLN-2871	ATR NSUF - North Carolina State University Project Execution Plan	EDMS
	PLN-2902	Fabrication Control Plan For The ATR National Scientific User Facility - North Carolina State University Project: Sample, Sample Holders, Capsule, and Basket	EDMS
	PLN-2903	Inspection Plan for the ATR National Scientific User Facility - North Carolina State University Project: Samples, Sample Holders, And Capsules	EDMS
	PLN-3389	North Carolina State University And University Of Idaho Post Irradiation Examination Plan	EDMS
	ECAR-406	ATR NSUF NCSU Project Pressure Estimates And Evaluation For Inclusion In The AFCI Safety Envelope	EDMS
	ECAR-452	Hydrodynamic Anaysis Of The ATR NSUF NCSU Experiment	EDMS
	ECAR-468	NCSU Radionuclide Source Term	EDMS

	PLN-2906	NCSU And U Of I ATR NSUF Project, "Influence Of Fast Neutron Irradiation On The Mechanical Properties And Microstructure Of Nanostructured Metals/Alloys"	EDMS
092-2008 University of Illinois	ECAR-645	ATR Physics Evaluation For The University Of Illinois Experiments In The A-11 Position	EDMS
	ECAR-655	Projected Source Term For The University Of Illinois Experiment In The A-11 Position	EDMS
	ECAR-705	Thermal Analysis Of The ATR-NSUF University Of Illinois And University Of California Experiments	EDMS
	ECAR-1293	THERMAL ANALYSIS - ATR NSUF UNIVERSITY OF ILLINOIS HSIS EXPERIMENT	EDMS
	ECAR-1327	ATR Neutronics Evaluation For The University Of Illinois Experiment In The HSIS	EDMS
	HFEF-LI-0002	Disassembly And Cataloging Of NSUF University Of Illinois Samples	EDMS
	PLN-2991	ATR National Scientific User Facility - University Of Illinois Project Execution Plan	EDMS
	PLN-2998	Irradiation Test Plan For The ATR National Scientific User Facility - University Of Illinois Project	EDMS
	TFR-697	RESEARCH AND DEVELOPMENT ADVANCED TEST REACTOR UNIVERSITY OF ILLINOIS HYDRAULIC SHUTTLE IRRADIATION SYSTEM EXPERIMENT	EDMS
139-2008 University of California Santa Barbara 1	ECAR-650	ATR Physics Evaluation For The University Of California Santa Barbara Experiment In The ATR A-10 Position	EDMS

	ECAR-662	Projected Source Term For The University Of California Santa Barbara Experiment In The A-10 Position	EDMS
	PLN-2988	ATR National Scientific User Facility - University Of California-Santa Barbara Project	EDMS
	PLN-2996	Irradiation Test Plan For The ATR National Scientific User Facility - University Of California Santa Barbara	EDMS
	ECAR-696	Bounding Analysis Of Free Convection Cooling Of The NSUF UI And UCSB Experiments In Air	EDMS
153-2009 University of California Santa Barbara 2	ECAR-1232	Thermal Analysis Of The ATR-NSUF University Of California Santa Barbara Instrumented Lead-Out Experiment	EDMS
	ECAR-1487	SHIELDING CALCULATION FOR THE SCIENTIFIC USER FACILITY-UNIVERSITY OF CALIFORNIA SANTA BARBARA-2 RPV STEEL IRRADITION EXPERIMENT	EDMS
	PLN-3308	IRRADIATION TEST PLAN FOR THE ATR NATIONAL SCIENTIFIC USER FACILITY - UNIVERSITY OF CALIFORNIA SANTA BARBARA-2 RPV STEEL IRRADIATION EXPERIMENT	EDMS
	DOP-1.4.1.15	ATR UCSB-2 Control System Operability Test	EDMS
	ECAR-1107	Argon-41 Radiological Data For The UCSB Leadout Experiment	EDMS
	ECAR-1195	UCSB-2 TEMPERATURE CONTROL GAS PURGE SYSTEM ORIFICE SIZING CALCULATIONS	EDMS
	ECAR-1220	ATR PHYSICS EVALUATION OF THE UCSB LEADOUT EXPERIMENT IN THE I-22 POSITION	EDMS
	ECAR-1252	UCSB-2 EXPERIMENT STRUCTURAL ANALYSIS	EDMS

	ECAR-2426	AS-RUN SOURCE TERM FOR THE UCSB-2 LEADOUT EXPERIMENT IN 1-22	EDMS
	HFEF-LI-0096	UCSB-2 Disassembly	EDMS
	MFC-EQP-0188	UCSB 2 Experiment Disassembly Equipment Phase I & II Qualification Procedure	EDMS
	PLN-3696	Verification And Validation (V&V) Plan ATR Capsule Distributed Control System Changes For UCSB-2 Experiment	EDMS
	TFR-667	UCSB-2 Experiment Temperature Control Gas System	EDMS
	TFR-748	UCSB-2 EXPERIMENT LEADOUT AND TEST TRAIN	EDMS
157-2009 Utah State Universtiy	ECAR-1318	Thermal Analysis Of Utah State University ATR NSUF Irradiation Experiment	EDMS
	ECAR-1350	Utah State University Physics Analaysis	EDMS
	ECAR-1365	Structural Analysis Of Utah State University ATR NSUF Irradiation Experiment	EDMS
	HFEF-LI-0004	Disassembly and Cataloging of NSUF Utah State Samples	EDMS
	PLN-3559	MANUFACTURING PROCESS SPECIFICATION FOR UTAH STATE UNIVERSITY ATR NSUF EXPERIMENT SPECIMENS	EDMS
	PLN-3909	ATR NSUF - Utah State University (FY12)	EDMS
	SOW-12361	UTAH STATE UNIVERSITY LASER THERMAL GAP RESISTANCE STUDY	EDMS
	PLN-3269	USU ATR Nsuf Project: Irradiation Effect On Thermophysical Properties Of a Hafnium-Aluminide Composite: A Concept For Fast Neutron Testing At ATR	EDMS

204-2009 Drexel University	ECAR-1083	Thermal Analysis Of The ATR-NSUF Drexel University Experiment In The East Flux Trap	EDMS
	ECAR-1121	ATR Physics Evaluation For The Drexel University Experiment In The East Flux Trap	EDMS
	ECAR-1137	Projected Source Term For The Drexel University Experiment In The East Flux Trap	EDMS
	ECAR-1210	ATR Physics Evaluation For The Drexel University Experiment In The A-3 Position	EDMS
	ECAR-1223	Projected Source Term For The Drexel University Experiment In The A-3 Position	EDMS
	ECAR-1237	MCNP-Calculated Temperature Reactivity Coefficients For Water In EFT (AFC-2, UW, And Drexel)	EDMS
	ECAR-1292	THERMAL ANALYSIS - ATR NSUF DREXEL UNIVERSITY HSIS EXPERIMENT	EDMS
	ECAR-1304	ATR NEUTRONICS EVALUATION FOR THE DREXEL UNIVERSITY EXPERIMENT IN THE HSIS	EDMS
	ECAR-1313	Thermal Analysis Of The ATR-NSUF Drexel University Experiment In The A-3 Position	EDMS
	PLN-3493	Irradiation Test Plan For The ATR National Scientific User Facility - Drexel University Project	EDMS
	PLN-3506	Advanced Test Reactor National Scientific User Facility (NSUF) - Drexel University Experiment	EDMS
	TFR-759	RESEARCH AND DEVELOPMENT ADVANCED TEST REACTOR DREXEL HYDRAULIC SHUTTLE IRRADIATION SYSTEM EXPERIMENT	EDMS

EBR - II Legacy Materials	ANL 7624	THE EBR-II MATERIALS-SURVEILLANCE PROGRAM: I. Program and Results of SURV-1	NSUF Shared Drive
	ANL 7682	THE EBR-II MATERIATS.SURVEILLANCE PROGRAM: II. Results of SURV-2	NSUF Shared Drive
	ANL-98/4	THE EBR-II MATERJALS-SURVEILLANCE PROGRAM: V. Results of SURV-S	NSUF Shared Drive
	Intra Lab Memo	Subject: Neutron Fluences for EBR-II Reflector Assemblies U9902, U9003, U9005, U9006 and U9027	NSUF Shared Drive