



U.S. DEPARTMENT OF  
**ENERGY**

**Nuclear Energy**

*Nuclear Science User Facilities*

# **Nuclear Fuels and Materials Library**

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NFML Coordinator



NSUF Annual Review  
DOE Headquarters  
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INL/MIS-16-40255

# Nuclear Fuels and Materials Library

- Established in ~2009 with the Nuclear Science User Facilities
- The original library included ~3500 specimens
  - Legacy materials
  - Volunteered materials
  - NSUF Project specimens



INL  
Legacy  
materials

Volunteered  
materials  
from outside  
the INL

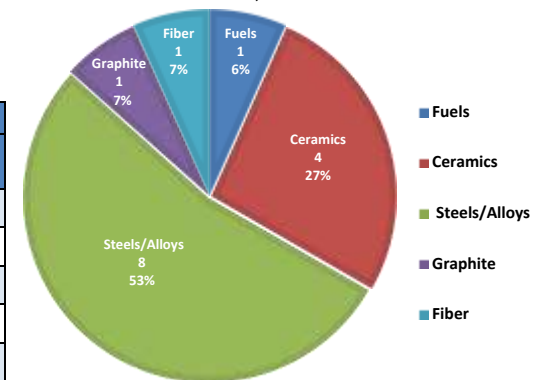
Supporting  
documentation  
related to  
samples

Current Nuclear Fuels and Materials Library					
Project	Material	Specimen Count	Organization	Availability	Library Utilization
*08-75	Ceramics	120	University of Florida	Online and available	
*08-92	Steels/Alloys	665	University of Illinois	Online and available	
*08-96	Steels/Alloys	80	North Carolina State University	Online and available	multiple RTE proposal requests
*08-139	Steels/Alloys	1572	University of California- Santa Barbara	Online and available	
08-331	Steels/Alloys, Ceramics	149	University of Wisconsin	Online and available	RTE & NEET-funded APS requests
*09-157	Ceramics	160	Utah State University	Online and available	
*09-204	Ceramics	72	Drexel University	Online and available	
10-197	Fuels	78	Idaho State University	Online and available	
*65-SURV-81	Steels/Alloys	482	Idaho National Laboratory	Online and available	
70-CREEP-85	Steels/Alloys	49	Idaho National Laboratory	Online and available	
*Legacy	Steels/Alloys	150	Idaho National Laboratory	Available	F. Garner collaborative plan
LANSCCE	Steels/Alloys	2202	Los Alamos National National Laboratory	Online and available	
SAM-1	Graphite, Fiber	55	Idaho National Laboratory	Scheduled July 2017	

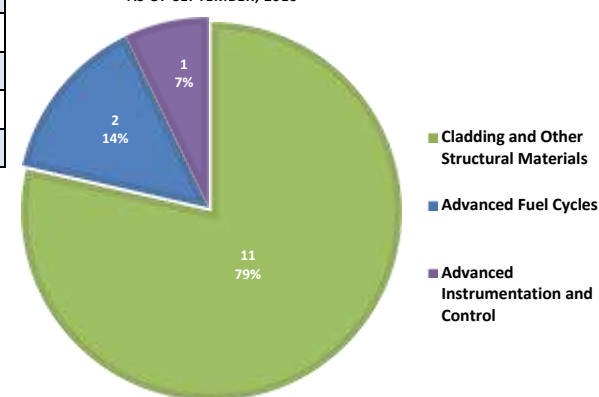
**5834 TOTAL NFML SPECIMENS**

\* Original library

**LIBRARY MATERIAL TYPES**  
AS OF SEPTEMBER, 2016



**LIBRARY MATERIALS  
RESEARCH AREA PER PROJECT**  
AS OF SEPTEMBER, 2016





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# NFML Now and BEYOND



Future Project Specimens & Scheduled/Potential Material Donations

Project	Material	Organization		Availability
10-242 -1, -2, -3	Fuels	University of Central Florida	Low Fluence Behavior of Metallic Fuels	UCF-1 available Feb 2017 UCF-2 and -3 TBD
10-269	Fuels	Boise State University	High Temperature In-pile Irradiation Test of Single Phase U3Si2	projected completion 02/2022 available 02/ 2025
15-8242	F/M Steels, Austenitic Steels/Alloys	Boise State University	Irradiation Influence on Alloys Fabricated by Powder Metallurgy and Hot Isostatic Pressing for Nuclear Applications	projected completion 2022 available 2025
15-8242 add-on's	Metal Alloys/Hf3Al-Al		Add'l material added into empty slots with 8242 irradiation	TBD
16-10537	F/M Steels, Austenitic Steels/Alloys, RPV Steels	Idaho State University	Enhancing irradiation tolerance of steels via nanostructuring by innovative manufacturing techniques	TBD
16-10584	Austenitic Steels/Alloys	Colorado School of Mines	Irradiation performance testing of specimens produced by commercially available additive manufacturing techniques	TBD
16-10393	Austenitic Steels/Alloys	GE Hitachi	Irradiation Testing of LWR Additively Manufactured Materials	TBD
Naval Reactors	Unirradiated and irradiated SiC and conventional & non-ferritic steels	Bechtel Marine Propulsion Corporation	Samples are currently stored at WestOne in Idaho Falls, ATR Canal, and ORNL.	Unirradiated samples received, irradiated in process
Zorita	Austenitic Steels/Alloys	Studsvik	394SS under PWR conditions for 26.5 EFPY	Title Transfer complete deliver to INL TBD
Zion NPP	Low alloy steel	Oak Ridge National Laboratory	RPV & core internals exposed to high doses neutron radiation	Ongoing discussions with ORNL staff
ORNL-IMET		Oak Ridge National Laboratory		Ongoing discussions with ORNL staff
INL	Fuels	INL Fuels & Materials Division	HFIR low dose irradiation materials	Will be shipped to INL when HFEF shutdown ends

# Database Design Preparation

## ■ Resource Collection

- Consolidated all files and versions (electronic, hard copy, hand written) into one workbook
- Compared spreadsheets to hardcopy printout of INL facility inventories for storage ID #s and locations
- Searched INL EDMS, (electronic document management system) for reports, drawings, as-runs analysis, raw data in order to populate project spreadsheets.
- Reached out to contacts for additional information or documentation

## ■ IM interface

- Made all project data within spreadsheets consistent (units of measure, scientific notation, consistent ID numbers, etc.
- Worked with IM staff (Learn and improve as-you-go process)
- Reviewed all project information to confirm successful import

## ■ Database design

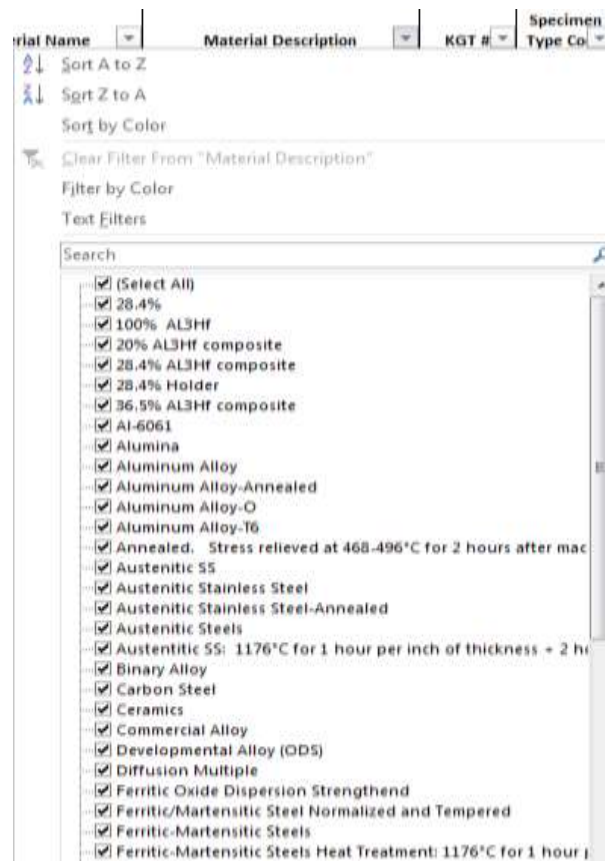
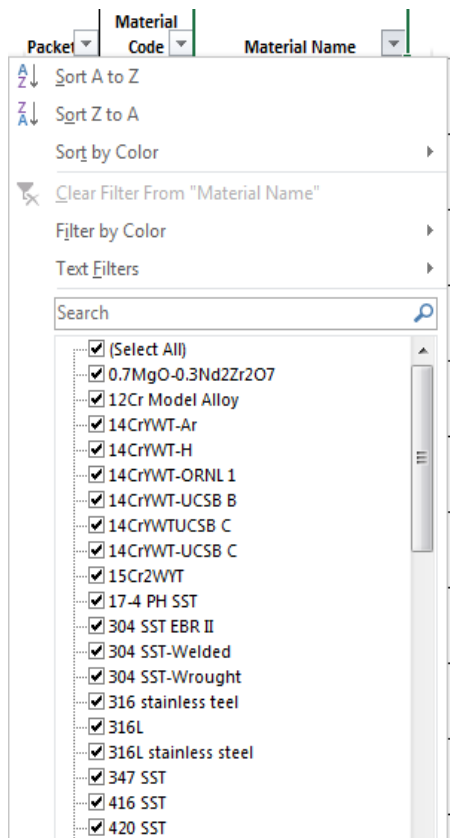
- The NFML contains project information such as abstract, PI, reactor, planned irradiation conditions linked to individual specimens linked to each cycle with as-run irradiation conditions.



# Database Design Challenges

## ■ Lessons Learned/Challenges

- We need a process/task for library coordination early in the project design process
- Need to create standard (mandatory) categories to use when adding sample information to library



# Database Design Challenges

## ■ Lessons Learned/Challenges (continued)

- How do we confirm specimen locations and track shipments/transfers?
- How do we keep track of what specimens are being/have been used or have been totally depleted
  - Gap analysis for library inventory?
- How do we display (or hide) fuel specimens in the library
  - Determine access levels

## ■ Storage

- Need physical space for new samples
- Storing and retrieving samples from HFEF is time consuming, expensive, and introduces contamination to otherwise clean specimens

## ■ Donations to the Library

- We need a transfer of ownership procedure/process for donated material
- Do we decline volunteered samples that don't have adequate provenance?

## ■ Export Control

- Documentation attached to projects needs to be export controlled





# Database Design

## Where We Were

The NFML had ~3500 specimens listed in various composition spreadsheets

The NFMAL had ~3500 specimens listed in various composition spreadsheets

Material ID	Al	Ba	Ca	Cd	Cr	Pb	Sr	Na	Si	Fe	Mn	Hf	Ga	Ni	Ti	Cu	Zn	Zr				
MgOx1.5Al <sub>2</sub> O <sub>3</sub>		<1	<7	<4	1	<3	<3	12	14	8			<4	<1	2	<3	<1	8				
MgAl <sub>2</sub> O <sub>4</sub>		<1	<7	<4	1	<3	<3	12	14	8			<4	<1	2	<3	<1	8				
MgO	9	<1	<7	<4	<1	<3	<3															
Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	20		80		<1	2		5	400	<100	<1	<75		<1	<1	50	2					
0.7MgO-0.3Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	20	<1	<7	<4	<1	<3	<3	5	400	<100	<1	<75		<1	<1	50	2					
Mg <sub>2</sub> SnO <sub>6</sub>	9	<1	40	<20	<10	170	<3			220	10			<10		60	<10					
Material ID	Tb	Dy	Al	Ho	Er	P	Tm	S	Y	Yb	K	La	Lu	Hg	Ce	Se	Mg	Sm				
Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	<5	<10	20	<1	<1	<1	<1	10	10	<1	5	60	<1	<0.1	30	<0.1	2	20				
0.7MgO-0.3Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	<5	<10	20	<1	<1	<1	<1	10	10	<1	5	60	<1	<0.1	30	<0.1	2	20				
Material ID	Bi	V	Eu	Th	Cr	Gd	U	Hf	Sb	In	Co	Ag	As	Pr								
Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	<0.2	<1	<5	<0.4	<1	<10	<0.4	<75						100								
Mg <sub>2</sub> SnO <sub>6</sub>	30								260	<20	10	<20	<200									
0.7MgO-0.3Nd <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub>	<0.2	<1	<5	<0.4	<1	<10	<0.4	<75						100								
MA956, ODS	7.7	0.15 max		bal	0.1 max	0.5 max	-	4.75	0.02 max	0.4	20	0.3 max	0.3 max									
MA754 ODS	8.8		78	1	0.05			0.3		0.5	20											
† Composition in weight percent																						
T91	7.59	0.14	0.28	0.02	0.01	0.21	9.24	0.47	Bal	0.16	0.96											
HT9	7.73	0.2	0.38			0.3	11.95	0.6	0.6	1	0.52											
MA957	7.72	0.014	0.019	0.1	0.006	<0.005	1.05	0.048	13.87	0.06	83.042	0.13	0.3	0.083Co	0.22Y <sub>2</sub> O <sub>3</sub>							
800H	YB	14C-YWT-UCSB B (1000°C)	7.6	14.00	0.50	t	t	t	t	t	t	t	t	t	t							
800H-TMP	YC	14C-YWT-UCSB C (1150°C)	7.6	14.00	0.50	t	t	t	t	t	t	t	t	t	t							
9Cr Model	CS	Cast SS	8.0	17.71	t	2.01	-	t	0.010	5.14	0.45	0.300	12.60	t	t							
12Cr Model	CA	9Cr2WYT	7.9	9.01	0.23	t	0.36	0.08	0.140	0.09	0.06	0.005	0.03	t	t							
HT-UPS-AX																						
D9	EBR-II		7.89	-	-	-	-	0.02	-	-	-	-	0.02	13.35	1.70	bal	16.27	0.01	-	1.55	-	Co: 0.03
NF709	ORNL		7.89	0.0047	0.078	0.102	-	-	0.47	0.016	0.0001	-	-	20.41	0.99	bal	26.0	-	0.34	1.50	-	
Super 304H ORNL			7.89	0.002	0.08	0.107	0.012	0.01	0.24	0.018	0.004	<0.01	0.06	19.13	0.47	bal	9.19	3.00	0.50	0.15	0.02	Co: 0.11
C276 0.25 mm	E730	-	<0.002	15.46	-	6.22	0.39	15.82	Bal	0.007	<0.002	<0.02	-									
A15052 0.75 mm	L409	Bal.	-	0.15-0.35	0.1	0.4	0.1	-	-	-	-	0.25	-									





# Database Design

## Where We Are

### PROJECT DATABASE

#### PROJECT NAME

Project ID	Start Date	Project Type
Proposal	End Date	Material Type
CINR #	PI Name	Research Area
RTE #	Tech Lead	<b>INSTITUTION</b>
NSUF Call	Facility Tech Lead	<b>FACILITY</b>
Award Date	Collaborators	Related Documentation

### SME DATABASE

PI/SME Name

Research Area/Subject Matter

**INSTITUTION**

**NEID**

**INSTITUTION**

**FACILITY**

**REACTOR**

**REACTOR POSITION**

#### → PROJECT NAME

**REACTOR**

**REACTOR POSITION**

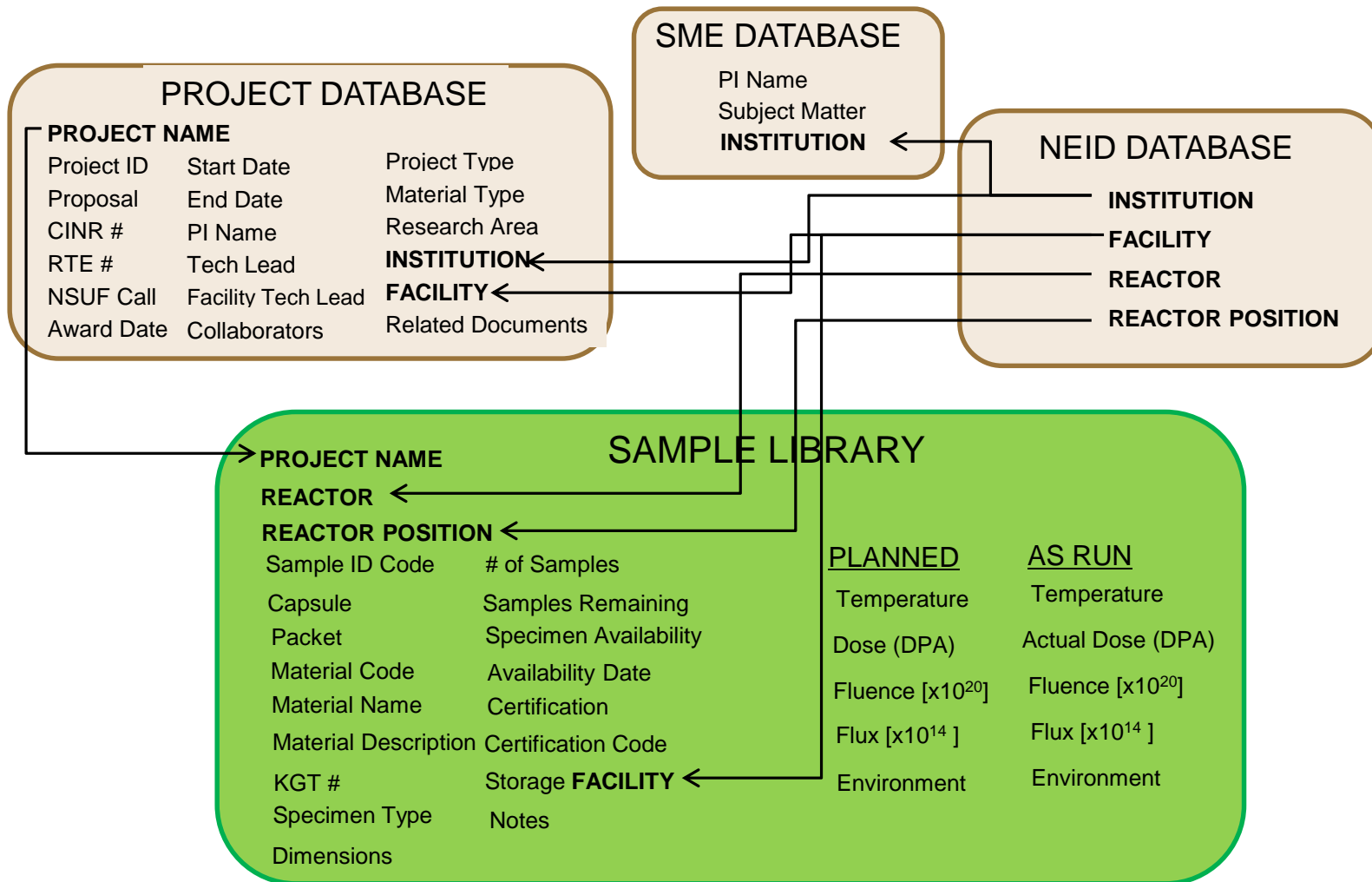
### SAMPLE LIBRARY

Sample ID Code	# of Samples	<u>PLANNED</u>	<u>AS RUN</u>
Capsule	Samples Remaining	Temperature	Temperature
Packet	Specimen Availability	Dose (DPA)	Actual Dose (DPA)
Material Code	Availability Date	Fluence [x10 <sup>20</sup> ]	Fluence [x10 <sup>20</sup> ]
Material Name	Certification	Flux [x10 <sup>14</sup> ]	Flux [x10 <sup>14</sup> ]
Material Description	Certification Code	Environment	Environment
KGT #	Storage <b>FACILITY</b>		
Specimen Type	Notes		
Dimensions			



# Database Design

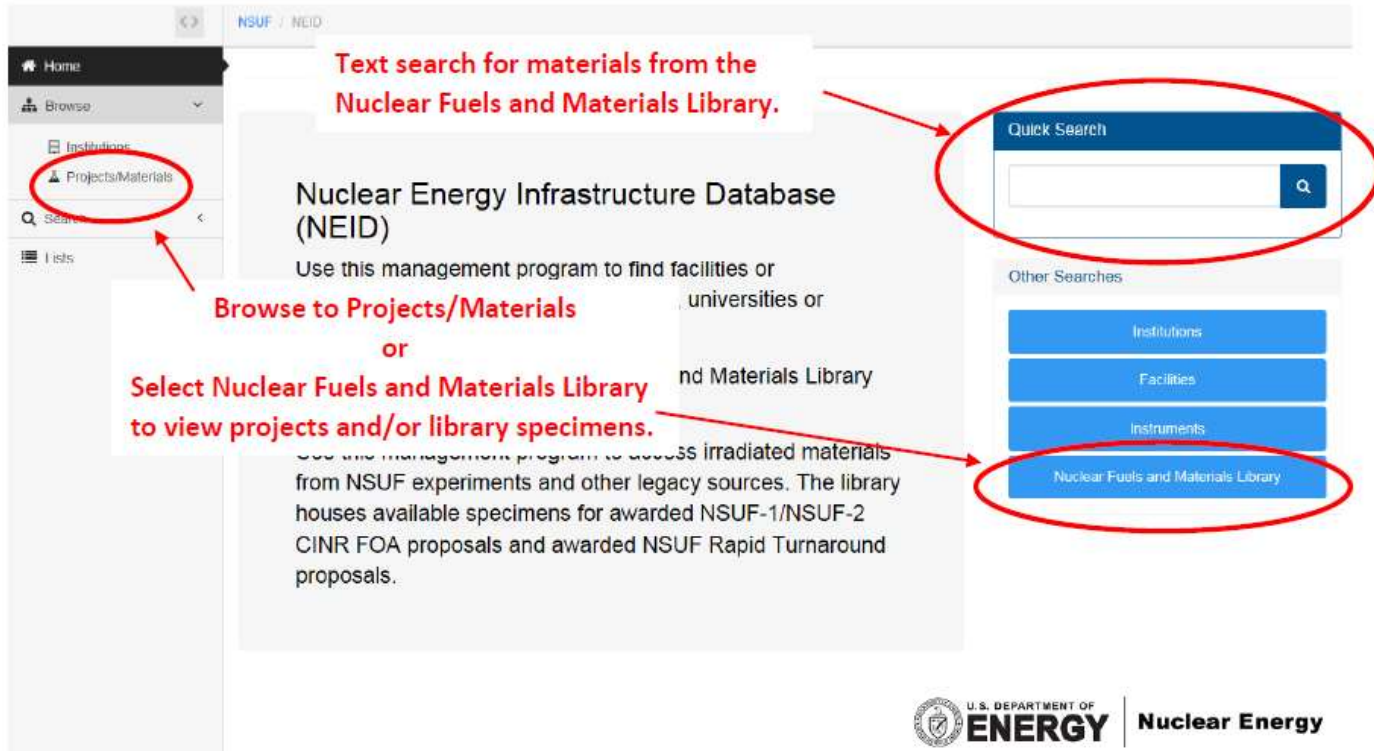
## Where We're Going



# NFML Database

## Current Version of NFML

- Access is granted at the NSUF homepage log-on



The screenshot shows the NSUF homepage with several key elements highlighted by red circles and arrows:

- Left Navigation Menu:** The "Projects/Materials" link is circled in red. An arrow points from this link to the text: "Browse to Projects/Materials or Select Nuclear Fuels and Materials Library to view projects and/or library specimens."
- Quick Search:** The "Quick Search" box is circled in red. An arrow points from this box to the text: "Text search for materials from the Nuclear Fuels and Materials Library."
- Other Searches:** The "Nuclear Fuels and Materials Library" link is circled in red. An arrow points from this link to the text: "Select Nuclear Fuels and Materials Library to view projects and/or library specimens."

The main content area displays the "Nuclear Energy Infrastructure Database (NEID)" and provides information about the management program to find facilities or universities or the Nuclear Fuels and Materials Library. It also mentions that the management program is used to access irradiated materials from NSUF experiments and other legacy sources, and that the library houses available specimens for awarded NSUF-1/NSUF-2 CINR FOA proposals and awarded NSUF Rapid Turnaround proposals.

# NFML Database

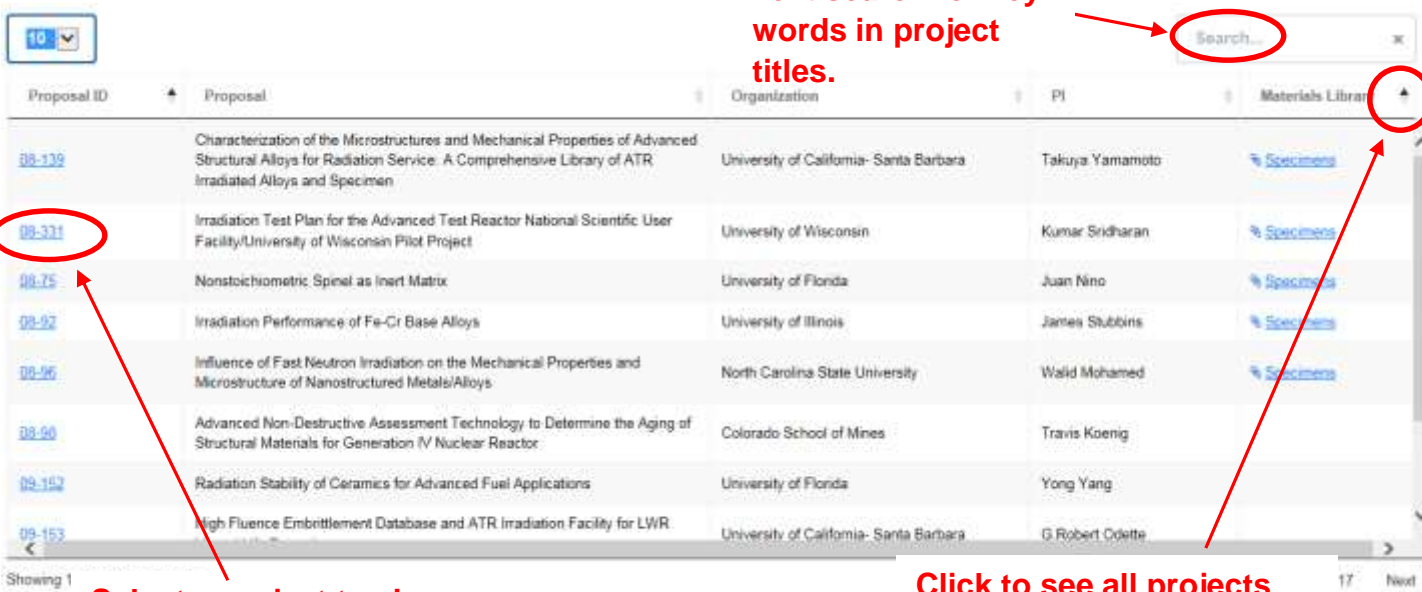
## Current Version of NFML

Users have access to projects, corresponding specimens, and supporting documentation from one screen.

**Text search for key words in project titles.**

**Select a project to view information and specimens.**

**Click to see all projects that contain library specimens.**



The screenshot displays the NFML Database interface. At the top left, there is a dropdown menu showing '10'. Below it is a table with the following columns: Proposal ID, Proposal, Organization, PI, and Materials Library. The table lists several projects, with the first one highlighted. A red circle highlights the '09-331' project ID, and a red arrow points to it with the text 'Select a project to view information and specimens.' Another red circle highlights the 'Search...' input field at the top right, with a red arrow pointing to it and the text 'Text search for key words in project titles.' A third red circle highlights the 'Materials Library' column header, with a red arrow pointing to it and the text 'Click to see all projects that contain library specimens.'

Proposal ID	Proposal	Organization	PI	Materials Library
<a href="#">08-139</a>	Characterization of the Microstructures and Mechanical Properties of Advanced Structural Alloys for Radiation Service. A Comprehensive Library of ATR Irradiated Alloys and Specimen	University of California- Santa Barbara	Takuya Yamamoto	<a href="#">Specimens</a>
<a href="#">09-331</a>	Irradiation Test Plan for the Advanced Test Reactor National Scientific User Facility/University of Wisconsin Pilot Project	University of Wisconsin	Kumar Sridharan	<a href="#">Specimens</a>
<a href="#">08-75</a>	Nonstoichiometric Spinel as Inert Matrix	University of Florida	Juan Nino	<a href="#">Specimens</a>
<a href="#">08-92</a>	Irradiation Performance of Fe-Cr Base Alloys	University of Illinois	Jamies Stubbins	<a href="#">Specimens</a>
<a href="#">08-26</a>	Influence of Fast Neutron Irradiation on the Mechanical Properties and Microstructure of Nanostructured Metals/Alloys	North Carolina State University	Walid Mohamed	<a href="#">Specimens</a>
<a href="#">08-90</a>	Advanced Non-Destructive Assessment Technology to Determine the Aging of Structural Materials for Generation IV Nuclear Reactor	Colorado School of Mines	Travis Koenig	<a href="#">Specimens</a>
<a href="#">09-162</a>	Radiation Stability of Ceramics for Advanced Fuel Applications	University of Florida	Yong Yang	<a href="#">Specimens</a>
<a href="#">09-153</a>	High Fluence Embrittlement Database and ATR Irradiation Facility for LWR	University of California- Santa Barbara	G Robert Odette	<a href="#">Specimens</a>

Showing 1

# NFML Database

## Current Version of NFML

Further drill down accesses in-depth information about the project and individual specimens.

**Project Type** Irradiation/PIE  
**Fiscal Year** 2008  
**Project Code** 00-331  
**Proposal** Irradiation Test Plan for the Advanced Test Reactor National Scientific User Facility/University of Wisconsin Pilot Project  
**Abstract** The Idaho National Laboratory, through the Department of Energy Idaho Operations Office, has been assigned the responsibility of irradiating experiments for the Advanced Test Reactor (ATR) National Scientific User Facility (NSUF).  
**Organization** University of Wisconsin  
**NSUF Call** FY08 Call for User Proposals  
**PI Name** Kumar Sridharan  
**PI Email** kumar@engr.wisc.edu  
**PI Phone** 208-526-5209  
**Tech Lead** Rory Kennedy  
**Collaborators** Todd Allen  
**Irradiation Facility** ATR  
**PIE Facility 1** MFC, CAES MACS, UNLV, ORNL  
**PIE Facility 2** NIST, LANL, University of Wisconsin  
**Material Type** Ferritic-Martensitic steels, Austenitic steels, Ceramics, Refractory Alloys and Silver, Amorphous Metals  
**Research Area** Cladding and Other Structural Materials  
**Document Name** 00-331-Material-Compositions.xlsx

**Specimens**

15

ID	RGT	Description	Material	Facility	Specimen
<a href="#">001-00-331</a>	261	Ferritic-Martensitic Steels	HT-9 EBR-II	HFEF	Tensile
<a href="#">002-00-331</a>	261	Ferritic-Martensitic Steels	HT-9 LANL	HFEF	Tensile
<a href="#">003-00-331</a>	261	Ferritic-Martensitic Steels	HT-9 ORNL	HFEF	Tensile
<a href="#">004-00-331</a>	402	Ferritic-Martensitic Steels	NF616	HFEF	Tensile
<a href="#">005-00-331</a>	403	Ceramics	SiC	HFEF	Tensile
<a href="#">006-00-331</a>		Ferritic-Martensitic Steels	9Cr Model Alloy	HFEF	TEM
<a href="#">007-00-331</a>		Ferritic-Martensitic Steels	12Cr Model Alloy	HFEF	TEM
<a href="#">008-00-331</a>		Ferritic-Martensitic Steels	HT-9 ORNL	HFEF	TEM
<a href="#">009-00-331</a>	261	Ferritic-Martensitic Steels	HT-9 EBR-II	HFEF	Tensile
<a href="#">010-00-331</a>	267	Ferritic-Martensitic Steels	HT-9 LANL	HFEF	Tensile
<a href="#">011-00-331</a>	207	Ferritic-Martensitic Steels	HT-9 ORNL	HFEF	Tensile
<a href="#">012-00-331</a>	287	Ferritic-Martensitic Steels	NF616	HFEF	Tensile
<a href="#">013-00-331</a>	287	Ceramics	SiC	HFEF	Tensile
<a href="#">014-00-331</a>		Austenitic Steels	HT-1/PS-AX-6	EMC-ANL	Tensile
<a href="#">015-00-331</a>		Austenitic Steels	NF709	HFEF	Tensile

Showing 1 to 15 of 149 entries

Previous 1 2 3 4 5 10 Next

Select a specimen to view cycle and irradiation information.



# NFML Database

## Current Version of NFML

Planned and As-Run conditions are listed per specimen, per cycle.

Project	Irradiation Test Plan for the Advanced Test Reactor National Scientific User Facility/University of Wisconsin Pilot Project
Reactor	ATR
Reactor Position	East Flux Trap
Sample Id Code	008-08-331
Capsule	Capsule 1
Packet	300 LO
Material Code	H1
Material Name	HT-9 ORNL
Material Description	Ferritic-Martensitic Steel
Specimen Type	TEM
Dimensions (mm)	3d x .2
Number Of Samples	1
Specimen Availability	Yes
Availability Date	November 26, 2014
Certification	Yes
Storage Facility	Hot Fuel Examination Facility
Planned Temp °C	300.00
Planned Dose (DPA)	3
Planned Flux (n/cm <sup>2</sup> s)	8.7E+13
Planned Environment	Helium/Argon
As Run Total Dose (DPA)	0
As Run Total Fluence	0

**Specimen  
Availability**

**Planned and as-run total irradiation  
conditions for experiment**

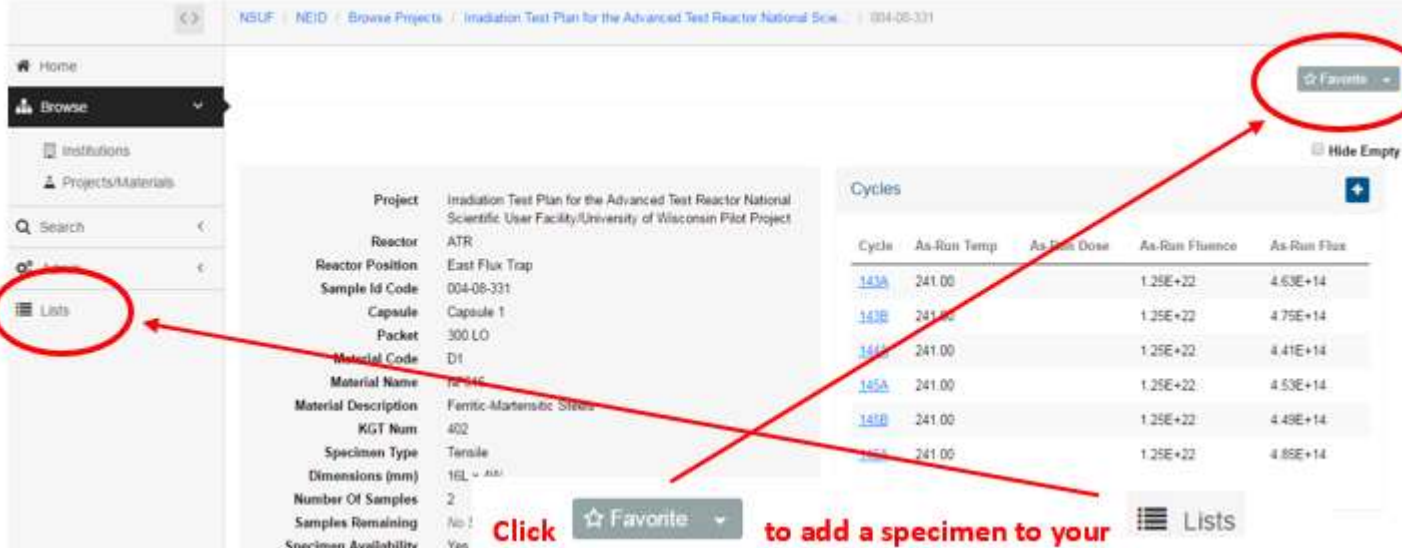
☒ Hide Empty

Cycles				
Cycle	As-Run Temp	As-Run Dose	As-Run Fluence	As-Run Flux
143A	328.50		1.24E+22	4.68E+14
143B	328.50		1.24E+22	4.42E+14
144A	328.50		1.24E+22	4.53E+14
145A	328.50		1.24E+22	4.44E+14
145B	328.50		1.24E+22	4.8E+14
146A	328.50		1.24E+22	4.64E+14

**As-run irradiation conditions per  
cycle**



NEID lists provide a way create a wish list of specimens for proposals.



The screenshot shows the NFML Database interface. On the left sidebar, the 'Lists' menu item is circled in red. In the main content area, the 'Cycles' table is displayed. The 'Favorite' button is circled in red in the top right corner. A red arrow points from the 'Favorite' button to the 'Cycles' table. Another red arrow points from the 'Lists' menu item to the 'Cycles' table. A red circle is also around the 'Favorite' button in the bottom right corner.

**Project:** Irradiation Test Plan for the Advanced Test Reactor National Scientific User Facility/University of Wisconsin Pilot Project

**Reactor:** ATR

**Reactor Position:** East Flux Trap

**Sample Id Code:** 004-08-331

**Capsule:** Capsule 1

**Packet:** 300 LO

**Material Code:** D1

**Material Name:** 12-146

**Material Description:** Ferritic-Martensitic Steels

**KGT Num:** 402

**Specimen Type:** Tensile

**Dimensions (mm):** 16L x 16W

**Number Of Samples:** 2

**Samples Remaining:** No

**Specimen Availability:** Yes

**Cycles Table:**

Cycle	As-Run Temp	As-Run Dose	As-Run Fluence	As-Run Flux
<a href="#">143A</a>	241.00		1.25E+22	4.63E+14
<a href="#">143B</a>	241.00		1.25E+22	4.75E+14
<a href="#">144A</a>	241.00		1.25E+22	4.41E+14
<a href="#">145A</a>	241.00		1.25E+22	4.53E+14
<a href="#">147B</a>	241.00		1.25E+22	4.49E+14
<a href="#">148A</a>	241.00		1.25E+22	4.85E+14

**Click** **Favorite** **to add a specimen to your** **Lists**

## NFML Database Future Vision of NFML

- Text searches will be more efficient and faster
- Common queries can be run for reports
- Dropdown searches with standardized material names and types
- Attributes can be added to searches
- All databases within NEID will be linked (pages can be accessed from any database)
- Work with the NEID Database Review Panel to learn their vision
- Project documents and provenance information will be linked to library

## Additional Usability Improvements

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### **In order to better support the users of the NSUF access programs:**

- Request for Information (RFI) in FY 17 for additional materials (Level 3 milestone due 3/31/2017)
- Survey the NSUF Users Organization for input
- Possible characterization and location confirmation for NSUF samples within HFEF
- FY 2017 report on the status of the NFML:
  - Results of the RFI
  - NFML policy and user agreements
  - Future development plans
  - Level 3 milestone due 9/29/2017

## Licensing Quality Data

- Possible collaboration w/ Gen IV Handbook – William Corwin
- Nuclear Data Management and Analysis System (NDMAS) - <https://ndmas.inl.gov>



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# Contact Information



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"Sorry, bub. You're not in the database."

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