Status and Availability of OPTD, the Out-of-Pile Transient Database

Nuclear Science & Engineering Division

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Summary

Summary for Status and Availability of OPTD, the Out-of-Pile Transient Database

The DOE Advanced Reactor Technology program has supported knowledge preservation efforts to recover and preserve fuel data from the US sodium cooled fast reactor (SFR) program. Databases have been established containing experimental data generated during the Integral Fast Reactor program (from in-pile experiments at EBR-II, FFTF, and TREAT) and during related out-of-pile examinations of EBR-II-irradiated fuels. The information in these databases is essential to support further development and licensing activities for advanced fast reactor designs. OPTD, the Out-of-Pile Transient Database, is an organized, searchable archive of records describing out-of-pile furnace transient tests conducted on metallic fuels. It includes records of over 150 tests on irradiated fuel pins conducted in furnace apparatuses constructed in the Alpha-Gamma Hot Cell Facility at ANL. This report presents the content, functions, and accessibility of the Out-of-Pile Transient Database (OPTD). It describes the information presently available in the database, the web interface created to provide access to this information, the activities undertaken to build OPTD, and the enabling of online access to the database for DOE users. Plans for FY2021 and beyond are also included.

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1 METALLIC FUEL TESTING PROGRAM

The Integral Fast Reactor (IFR) program, active from 1984 to 1994, produced a large collection of data relating to the performance of metallic fuels in sodium-cooled fast reactors (SFRs). To evaluate fuel/cladding compatibility, tests were conducted under both steady-state and transient conditions. Steady-state tests were first conducted within test reactors to evaluate fuel performance during normal reactor operating conditions. During steady-state reactor operation, solid state interdiffusion at the fuel-cladding interface within a fuel pin causes slight cladding wastage, which is highly dependent on the local power, temperature, and burnup of the fuel. While this wastage is not a concern under normal operating conditions, the metallic fuel pin may be more vulnerable to off-normal events (e.g., loss of coolant flow, loss of a heat sink, or transient overpower events). Transient tests are used to evaluate fuel performance during these off-normal events. During these transient scenarios, the fuel pin will experience elevated temperatures, at which uranium and plutonium from the fuel can react with iron and other components in the cladding, forming liquid phases (eutectic formation). Eutectic formation at the fuel-clad interface reduces the cladding thickness and may compromise its integrity. While these off-normal events can be simulated in-pile (e.g., in the TREAT reactor), they can also be simulated out-of-pile by raising fuel samples rapidly to high temperatures representative of these accident scenarios. The furnace transient testing program conducted in the Alpha-Gamma Hot Cell Facility (AGHCF) used irradiated fuel samples, primarily from EBR-II, with fuel-clad interfaces prototypic of those found in an operating reactor. Records from the transient tests conducted out-of-pile in the AGHCF are archived in the Out-of-Pile Transient Database (OPTD).

1.1 IFR Fuel Compatibility Testing

For a clearer picture of where the AGHCF furnace transient tests fit in the larger landscape of IFR fuel compatibility testing, they can be compared to both the transient testing conducted in TREAT and the steady-state testing conducted in EBR-II. The tests of metallic fuels conducted in EBR-II were lower temperature, steady-state tests to demonstrate the performance of the fuel under normal operating conditions. Records of these EBR-II tests can be found in FIPD [1] and PADB [2]. An extensive long-duration transient testing program was also conducted at EBR-II as documented in the EBR-II Transient Test Database (ETTD) [3]. The transient tests conducted on metallic fuels in the TREAT reactor were high temperature, short duration transient tests to demonstrate the fuel behavior under rapid transient conditions, and their records are found in the TREXR database [4]. The AGHCF furnace tests included in OPTD bridge the gap between the EBR-II and TREAT testing conditions; they exposed irradiated fuel samples to elevated, accident-scenario temperatures for times in the range of minutes to hours, as shown in Figure 1.

Figure 1: Testing regimes for in-reactor and out-of-pile tests on metallic fuels [5].

1.2 Furnace Transient Tests and Results

The out-of-pile furnace transient tests included in OPTD were conducted in two different furnace apparatuses at the Alpha-Gamma Hot Cell Facility at Argonne National Laboratory: The Whole Pin Furnace (WPF) and the Fuel Behavior Test Apparatus (FBTA). These furnace apparatuses heat-tested fuel pins or pin segments taken from EBR-II subassemblies. Prior to furnace testing the samples, pre-test examinations of the fuel and cladding were made to characterize the as-irradiated structure. To begin the temperature transient test, the sample was installed in the furnace and slowly ramped to a pre-test, priming temperature. The prescribed furnace transient routine then began by increasing the temperature at a predetermined rate (ramp rate) to a peak target temperature. A representative furnace testing routine is shown in Figure 2. The sample was held at the target temperature for a designated period of time or until pin failure. The furnace was scrammed when the test end condition was met (either at the end of the test time, or when pin failure was detected by a pressure spike), and the pin was then allowed to cool by convective heat loss. Following each test, data was collected and post-test examinations were made of the sample.

Figure 2: Furnace testing routine [6].

The FBTA tests were conducted on more than 140 fuel pin segments extracted from EBR-II fuel pins (and a few from FFTF) at constant temperatures from 625 to 850°C for durations from a few minutes up to 36 hours (most had a 1 hr duration). Fuels tested were U-10Zr and ternary fuels (up to U-26Pu-10Zr), with claddings composed of HT9, D9, or 316 stainless steel and peak burnups from 2.3 to 17%. A few tests were also conducted on ternary fuels with varying Zr content. The results of the FBTA tests established the time- and temperature-dependence of eutectic cladding penetration in the metallic fuel samples as well as rough threshold temperatures for liquefaction. The Whole Pin Furnace (WPF) tests were conducted on *intact* fuel pins from EBR-II, rather than segments, to study synergistic effects of fission gas pressure loading and fuel-cladding interaction. Seven WPF tests determined modes of pin failure, established safety margins and fuel failure thresholds, and examined fuel motion within the pin. More detailed descriptions of the furnace apparatuses, tests conducted, and key results can be found in [7].

2 DATABASE CONTENT

The term “database” is used here to refer to an ordered and indexed library of information. The OPTD exists as a digital archive of scanned and saved records of documents (in PDF form) and accompanying spreadsheets of tables storing related metadata. The database can be thought of as having three primary components: 1) A table which describes each of the approximately 150 out-of-pile furnace tests, 2) a digital archive of records relating to those tests, and 3) a table describing each of the records. The database is made available to an end user through a web interface described in Section 3.

2.1 Test Parametric Information

The database is constructed to contain details and descriptions of each test conducted as a part of the furnace testing program using the FBTA and WPF test apparatuses. Metadata describing each of the tests is recorded in a test table. Each furnace test has a unique name (of the form “yy-##” for the FBTA tests and “FM-#” for the WPF tests). Each record includes the composition and condition of the tested fuel pin (or pin segment), the test objectives and conditions, measurements taken during and post-test, and calculated results (for FBTA tests) where available. This collection of test information is shown in Figure 3. Each test is represented by one row of the table, and each metadata item in Figure 3 corresponds to a column (or columns). Fully characterizing each of the tests in this way and linking the metadata allows a user to group tests with similar characteristics (such as those done on the same fuel pin, under the same imposed test conditions, or with similar objectives and analysis).

Furnace Apparatus	<ul style="list-style-type: none"> •Whole Pin Furnace (WPF) •Fuel Behavior Test Apparatus (FBTA)
Sample Description	<ul style="list-style-type: none"> •Pin ID & subassembly (from EBR-II) •Fuel & cladding composition •Peak Burnup of the tested pin •Geometry (segment axial location or fuel/plenum volume ratio)
Test Description	<ul style="list-style-type: none"> •Test date, brief description, and status •Test objectives •Target maximum temperature •Test duration •Measurements taken
Test Results (FBTA)	<ul style="list-style-type: none"> •Maximum depth of liquid-phase cladding attack •eutectic penetration rate •% liquefaction

Figure 3: Summary of furnace test information available in OPTD.

2.2 Records

2.2.1 Test Records

For each of the tests, there is a collection of related records ranging from informal, internal memoranda to formal programmatic progress reports, conference submissions, and other publications. The experiment (and post-experiment) records may include sample transport, shipping, and storage records, fuel pin sectioning diagrams, metallographic images of the sectioned samples, and experimenter notes. Furnace apparatus and test schematics, design documents, and test procedures are also included where available. The scanned and saved digital records were logged in a table and indexed by the filename. Each file is represented in its own row of the table, and metadata describing the type of record, the experiment to which it pertains, and bibliographic information is recorded in columns. The information included for each record is shown in Figure 4. The metadata is linked such that records with similar characteristics can be related (e.g., all design specifications or progress reports).

Figure 4: Record Descriptors in the database.

To populate the database, all available hard copy records pertaining to the out-of-pile furnace tests were collected, scanned, and saved as text-searchable PDF files in a digital archive. To fill the database tables, these records were individually reviewed to identify the appropriate metadata tags for each record and to extract the relevant test information for the test table.

2.2.2 Test Apparatus and Program Records

Many records are also included in the archive that do not pertain to a particular test, but rather to the development of the testing program or one of the furnace test apparatuses. These records are also logged in the records table. They are tagged with the test apparatus they pertain to and with the remaining metadata fields, including the content descriptor (generally “planning” or “procedures”).

3 OPTD WEB INTERFACE

The database described in the previous section, made up of a digital file archive and metadata tables, is maintained locally. The content is made accessible to users via a web interface. The website for OPTD, available at <https://optd.ne.anl.gov/>, uses the same design as Argonne’s other ART databases. It is easy to navigate and will be familiar to users of FIPD or TREXR [4, 1].

3.1 Site Map

The OPTD site map is shown in Figure 5. The home page contains general information about the database. “About” and “Program” pages are also made available publicly so new visitors to the site are able to learn background information about the Out-of-Pile experimental test program, the utilized test apparatuses, and the content available in the database, before requesting access. All other database content (e.g., test details, documents, etc.) is restricted to approved users, and a link to request access to the database has been enabled.

The “Tests” section provides information about individual tests. A full test listing is included here, and all tests can be searched by name and/or filtered by test descriptor according to any of the metadata filters. For example, a user could search for a ramp-and-hold heating test conducted on a U-10Zr/HT9 segment. The results would display the tests that meet the selected filter criteria. Clicking on the test name brings the user to a test details page that provides abbreviated test summary information and links to related test records. Searches for documents can likewise be done by document title and/or by metadata filter (e.g., filtering for “memo” or “progress report”). These views are presented in detail in section 3.2.

Figure 5: OPTD Site Map.

3.2 Page Views and Functions

This section includes page views to illustrate some of the key functions of the OPTD website.

3.2.1 Home page

The OPTD home page (found at <https://optd.ne.anl.gov/>) is publicly accessible. As shown in Figure 6, it includes a brief description of the database and the navigation bar at the top of the page includes the “About” and “Program” information pages described previously. Clicking on “Tests,” “Documents,” or the green “Login” button at the top right of the navigation bar will bring the user to the login page.

Figure 6: OPTD Home Page.

3.2.2 Login Page

The login page is shown in Figure 7. It includes a warning to remind users that test documentation available in OPTD may be subject to access restrictions and must be controlled accordingly. User

account requests can be submitted by clicking the blue “Request access” button under “Get an Account.” Existing users can log in via the green button. Due to the nature of the content in OPTD, multi-factor authentication is required. After logging in with a username and password, the secondary authentication prompt will appear from Duo Security, the approved MFA provider (see Figure 8).

OPTD Home About Tests Documents Program Login

Login

Much of the available test documentation is subject to access restrictions. Logged-in users should be aware that documents may contain technical information whose dissemination is restricted by US export control regulation and must be controlled accordingly. The documents should not be disseminated outside of project control without a formal export control review. Please log out when done.

Please login with one of the following options to view content.

Existing Users

If you already have a user account, follow the link below to authenticate.

Log in

Get an Account

Please use this e-mail link to request access. Requests for access are individually reviewed, and may take some time to complete.

Request access

Figure 7: OPTD Login page.

Secondary Authentication Required

Choose an authentication method

- Duo Push RECOMMENDED Send Me a Push
- Call Me Call Me
- Passcode Enter a Passcode

[What is this?](#) [Need help?](#)

Powered by Duo Security

Figure 8: Secondary authentication prompt.

3.2.3 Tests

Once logged in, a user can access the Tests section from the navigation bar (see Figure 9). This dropdown menu includes an option to view a full test listing with test parameters (called “All Tests

Listing”), view metadata tags by category (e.g., test sample characteristic tags like fuel composition and cladding type), or search all tests by title and/or metadata filter (the blue button).

Figure 9: Example Tests dropdown menu view.

Summary information for all tests in the database is available in the full test listing, as shown in Figure 10. This table includes the furnace test name, brief description, information about the tested fuel pin (fuel/cladding makeup, pin/subassembly IDs, peak burnup), maximum temperature of the furnace test, and time spent at this temperature. In the future, as calculated test results are extracted from the test records and digitized, they may be added to this table.

Test Listing

Name	Description	Fuel Composition	Cladding Type	Pin	Subassembly	Peak Burnup (at-%)	Max Test Temp (°C)	Test Duration (hr)
87-70 6 docs	FBTA tests 87-70 through 87-73 were early screening tests conducted to provide data on compatibility between irradiated high-Pu fuel and ...	U-19Pu-10Zr	HT9	T459	X425	3	800	0.08
87-71 6 docs	FBTA tests 87-70 through 87-73 were early screening tests conducted to provide data on compatibility between irradiated high-Pu fuel and ...	U-19Pu-10Zr	HT9	T459	X425	3	880	0.08
87-72 5 docs	FBTA tests 87-70 through 87-73 were early screening tests conducted to provide data on compatibility between irradiated high-Pu fuel and ...	U-19Pu-10Zr	HT9	T459	X425	3	700	0.08
87-73 5 docs	FBTA tests 87-70 through 87-73 were early screening tests conducted to provide data on compatibility between irradiated high-Pu fuel and ...	U-19Pu-10Zr	HT9	T459	X425	3	750	0.08
87-74 6 docs	FBTA tests 87-74 through 87-76 were conducted to determine the depth of cladding attack in U-19Pu-10Zr/HT9 specimens of 3 a/o ...	U-19Pu-10Zr	HT9	T459	X425	3	700	1
87-75 6 docs	FBTA tests 87-74 through 87-76 were conducted to determine the depth of cladding attack in U-19Pu-10Zr/HT9 specimens of 3 a/o ...	U-19Pu-10Zr	HT9	T459	X425	3	750	1
87-76 6 docs	FBTA tests 87-74 through 87-76 were conducted to determine the depth of cladding attack in U-19Pu-10Zr/HT9 specimens of 3 a/o ...	U-19Pu-10Zr	HT9	T459	X425	3	780	1
88-01 6 docs	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Test 88-01 held the sample at 800C for ...	0% Pu (U-10Zr)	HT9	T437	X425	3	800	1
88-02 5 docs	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Test 88-02 held the sample at 850C for ...	0% Pu (U-10Zr)	HT9	T437	X425	3	850	1
88-03 4 docs	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Results discarded on account of an open gap ...	0% Pu (U-10Zr)	HT9	T437	X425	3	750	1

Figure 10: Full Test Listing page.

Selecting “Search All Tests” brings the user to a search page where they can search for a test by name and filter by selected metadata tags. In Figure 11, an example search for ramp-and-hold type tests on U-10Zr fuel with HT9 cladding is shown. The search parameters are checked in blue on the left of the window. The tests meeting those criteria are displayed as results on the right. Clicking any individual test name on the right will bring the user to the test details page.

Find a Test

Search Parameters

Reset

Search

Name

Also searches alternate names

Content Options

Test Status

Fuel Composition

☒ 0% Pu (U-10Zr)
 ☐ U-19Pu-10Zr
 ☐ U-19Pu-14Zr
 ☐ U-19Pu-6Zr
 ☐ U-26Pu-10Zr
 ☐ U-29Pu-10Zr

Cladding Type

☐ 316 SS
 ☐ D9
 ☒ HT9
 ☐ HT9M

Transient Measurement

Experimental Objective

☐ ID Pin Breach Mode & Mechanism
 ☐ In-cell Checkout
 ☒ Ramp-hold

Results Loaded.

Results **16**

Filters: **Fuel Composition: 0% Pu (U-10Zr)** **Cladding Type: HT9** **Experimental Objective: Ramp-hold**

Test	Documents	Date	Description
88-01	6	10/12/1987	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Test 88-01 held the sample at 800C for 1hr. It had a posttest residual fuel-cladding gap of approximately 1 mil maximum and showed essentially no cladding attack.
88-02	5	10/14/1987	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Test 88-02 held the sample at 850C for 1hr. It showed a posttest residual fuel-cladding gap (as for 88-01), but showed extensive fuel melting & FCCI.
88-03	4	10/19/1987	FBTA test 88-01 through 88-03 were conducted on U-10Zr/HT9 at 3 a/o. Results discarded on account of an open gap between fuel and cladding.
88-04	5	11/12/1987	FBTA test 88-04 is a repeat of test 88-01 (U-10Zr/HT9 at 3 a/o held for 1 hr at 800C). Compared to 88-01, this test had a "closed" fuel-cladding gap.
88-05	5	11/17/1987	FBTA test 88-05 is a repeat of test 88-03 (U-10Zr/HT9 at 3 a/o held for 1 hr at 750C). Compared to 88-03, this test had a "closed" fuel-cladding gap. FCCI was observed, necessitating a lower-temp test (88-06).
88-06	4	11/24/1987	FBTA test 88-06 was added as a lower-temperature complement to tests 88-04 and 88-05. Sample had a closed fuel-cladding gap.

Figure 11: Example Search for Tests page.

The test details page for test FM-1 is shown in Figure 12. At the top of the page there will be a written description of the test. Below that are 3 tabs. The first tab, “Related Documents,” displays all document records related to the test by title with direct links to the respective PDFs. The second tab is reserved for “Digital Data” that will be extracted and digitized from the scanned documents as available. The third tab, “Related Tests,” is displayed in the figure. This tab includes all of the metadata associated with the test (from the test metadata categories listed in Figure 3). The tags that are linked appear in blue. The number next to each of these tags indicates the number of tests that also share this tag. For example, looking at the test sample labels, the subassembly tag of “X425” is shared by 17 tests. Clicking this tag would display all tests with that tag. The relational linking built into the database simplifies finding related tests and information.

Test Details

Name

FM-1

Description

The first Whole Pin Furnace (WPF) test, an In-cell checkout test. U-10Zr/HT9 pin of low burnup (2.9 at% peak, pin T418 from EBR-II subassembly X425) breached ~76 min into the constant-temperature hold at 820C and was successfully detected by the pressure transducers. Pin breached at x/L = 0.7, where much of the fuel was solid.

Related Documents

66

Digital Data

0

Related Tests

This test is associated with the following content tags. Click a tag to view all tests associated with the selected tag.

General Characteristics

Experimental Objectives

ID Pin Breach Mode & Mechanism

4 tests

In-cell Checkout

1 test

Ramp-hold

146 tests

Test Apparatus

Whole Pin Furnace

9 tests

Diagnostics and Analyses

Transient Measurements

Fission Gas Collection

5 tests

Fission Gas Detection

29 tests

TCS

150 tests

Post-test Analyses

None linked

Post-test Examinations / Measurements

Analysis of Collected Fission Gasses

6 tests

Dimensional Measurements and visual examinations

15 tests

Gamma Scans & Pin Profilometry (NDE)

7 tests

Macrophotography (No-magnification Photos of pins, failure location)

47 tests

Microphotography (Hi-Magnification Photos)

149 tests

Test Sample Characteristics

Fuel Composition

0% Pu (U-10Zr)

46 tests

Cladding Type

HT9

84 tests

Test Sample Labels

Pin

T418

1 test

Subassembly

X425

17 tests

Additional Test Data	
Peak Burnup (a/o)	2.9
Plenum/Fuel Volume Ratio	1.0
Axial Location (x/L)	None
Test Temperature (°C)	820.0
Test Duration (hours)	1.27

Figure 12: Example Test Details page.

3.2.4 Documents

The documents section also includes a dropdown menu to browse by individual metadata tag or “Search All Documents” by name and filters. An example search result for “journal articles” containing an “experiment summary” for tests done in the “whole pin furnace” is shown in Figure 13.

OPTD Home About Tests Documents Program Welcome Carolyn (ctomchik) Logout

Find a Document

Search Parameters

Reset Search

Title

Author

Test Apparatus

☐ Direct Electrical Heating Apparatus

☐ Fuel Behavior Test Apparatus

☒ Whole Pin Furnace

Document Type

☐ Collection of documents

☐ Conference proceeding

☐ Draft as submitted for publication

☒ Journal article

Results Loaded.

Results 2

Filters: Document Type: Journal article Content Type: Experiment Summary

Test Apparatus: Whole Pin Furnace

- Behavior of EBR-II Mk-V-type Fuel Elements in Simulated Loss-of-Flow Tests (93jaxliu.pdf)
- Modeling the Behavior of Metallic Fast Reactor Fuels During Extended Transients (93jaxkram.pdf)

Figure 13: Example Find a Document page.

4 DATABASE VISIBILITY AND ACCESS

A central page for all the ART fast reactor databases, located at <https://frdb.ne.anl.gov/>, delivers information about all of the related ART databases so anyone interested can understand and request access to the full collection of available resources. This central page briefly describes the content and purpose of each database, details how one can request access, and provides direct links to the website for each individual database, including OPTD [8].

OPTD is now open to select users outside of Argonne during initial testing. Announcement of the availability of OPTD is planned for early FY21, following this test period. The site utilizes the tiered access system introduced for the TREXR database, described in ANL-ART-127 [9].

4.1 User Authentication

Each user wishing to access individual test information or records in OPTD must have their own user account. Primary authentication of users is accomplished by Argonne's Active Directory service, which is maintained by Argonne's central IT department. All OPTD users must therefore have an Argonne username/password. For users who are not Argonne employees, Argonne collaborator accounts are created using the ANL Cyber Gate Pass system [10]. To comply with the requirements of Argonne's Cybersecurity Office for accessing potentially sensitive content, OPTD access requires multi-factor authentication (MFA). After initial authentication using password credentials, secondary authentication is performed using Duo multifactor authentication service, which allows users to authenticate via a smartphone app, text message, or phone [11].

4.2 User Access to Content

Requests for access to OPTD can be made directly from the website and are manually reviewed. When approved, users are assigned to a group according to their affiliation (see Figure 14). The user group determines what categories of content a user can access. A full description of user groups, content classifications, and the full user/content access matrix is provided in ANL-ART-127 [9]. Most of the available test records in OPTD are internal and informal documents never intended for distribution outside ANL (content class IV). This content is only accessible by U.S. citizens with ANL or other DOE affiliation (including those in DOE offices, laboratories, and the NRC). While there is nothing preventing the creation of user accounts for non-DOE users, at present they would be able to view only 8 individual records (those in the open literature or ANL reports with only a legacy AT marking). We are therefore only recommending access accounts for DOE-affiliated users at this time. If and when more content can be cleared for access by other groups (including industry or university users), users from these groups will be granted user accounts to view content cleared for their use.

Figure 14: OPTD User Groups.

5 OPTD STATUS, PROGRESS, AND PLANS

OPTD is now open to select U.S. citizens affiliated with DOE offices, laboratories, or the NRC during initial testing of the online database. This section summarizes progress made in previous years and details plans to further improve and add to the database in FY2021 and beyond.

5.1 Previous Years' Progress

Extensive effort was dedicated in FY2018 and FY2019 to locating any and all out-of-pile test records available at Argonne and preserving them before they were lost. Records were solicited and collected from individual contributors, the Alpha-Gamma Hot Cell Facility archives (in both hard copy and digital form), and various miscellaneous file cabinets. All located records were sorted, scanned, and preserved in the OPTD digital archive. It is possible that more records may be found unexpectedly at some time in the future. The records collection is certainly incomplete, but remaining records may or may not exist in a recoverable form somewhere at the laboratory. If and when additional unique records surface (active searching for hard copies is not expected to turn up anything further), they will be reviewed and added to the archive.

Review of the scanned archive files began in FY2019. Records were reviewed with the aim of constructing a database framework that would capture the salient details of the tests and properly categorize the associated records. Tests and records were described using the selected metadata tags and categories. As each record was reviewed, its corresponding row in the records table and information in the test table was filled in. The structure of the tables was altered as needed to accommodate newly-discovered details contained in the tests and records. This database structure design and record categorization (table filling) is an iterative process, as represented by Figure 15. At the end of FY2019, the database structure was estimated to be near its final form, though only a fraction of records had undergone a first review.

Figure 15: Iterative Record Review Cycle

Because of particular interest in the Whole Pin Furnace tests, review in FY2019 focused on items related to the WPF tests. In response to urgent interest from researchers working on BISON code validation, abbreviated benchmarking descriptions of the testing routine and measurements made during the FM-4 and FM-6 WPF tests on U-19Pu-10Zr/HT9 pins (DP-22 and DP-39 from EBR-II subassembly X441A) were compiled and provided directly to code developers. The web interface was also built during FY2019, but not yet populated with records or test information.

5.2 Progress during FY2020

Effort during FY2020 was dedicated to reviewing the hundreds of digital archive records to fill in the document and test metadata tables. Over 400 individual records were reviewed and categorized. Duplicate, irrelevant, or misplaced records were removed. There are roughly three dozen remaining records in the archive that have not yet been appropriately tagged and added to the database (because it is not immediately clear what they are a record of or to which test they apply). If these records can be clearly identified, they may be added to the database in FY2021.

The records table describing the documents in the digital archive now contains 428 unique records, each corresponding to a scanned PDF file. All related metadata has been filled in for each entry. This includes full bibliographic information, tests to which the record relates (whether or not the tests are identified by name), and the type of content included. The test table has been filled with all test information available for each of the 152 tests, including all metadata listed in Figure 3. Some inconsistencies were found in the recorded results for liquefaction percentage, eutectic penetration depth, and penetration rate for the FBTA tests conducted during 1991. These inconsistencies are noted in the table and will require further work to resolve. The calculated numerical FBTA penetration results have therefore not been included in the online version of the database at this time. Resolving the inconsistencies in these values is work planned for FY2021.

The web-accessible database was fully populated with the most up-to-date versions of the tables and digital records archive. Improvements were made to the website page views for clarity and readability, and a link to request a user account directly from the website was enabled. User accounts to access the database content can now be granted to interested persons. Figure 16 shows the completed steps taken to build OPTD and make it accessible.

Figure 16: Database Development Steps

5.3 FY2021 Plans and Future Work

Announcement of the availability of OPTD to eligible users is planned for early FY2021, following a limited initial testing period. Effort for the remainder of FY2021 will be dedicated to making the information contained in the OPTD records more readily visible and easily understood. The first part of this effort involves presenting numerical data in digital form by extracting it from the written records. Digital representations will be added for all available data. For the FBTA tests, the percent liquefaction, eutectic penetration depth, and penetration rates will be added. Inconsistencies found during review of the records will be resolved through an exhaustive search of published reports and journal articles related to these test series and, as needed, by independent

examination and measurement of metallographic images in the archive. Sample characterization data will also be added for all tests for which it is available. For the FBTA tests, this will include tested sample dimensions and weights. For the WPF tests, this can also include digitized records of non-destructive examinations conducted to describe fuel motion within the pins (e.g. radiography, gamma scans, and/or profilometry). To assist in modeling efforts, time-temperature and (where possible) time-pressure history functions will be generated for each of the tests. No raw instrument readout data has been located, nor have any video records of the WPF tests. If and when these original data are found, they will be added to the database. As substitute, all printed plots of instrumental data available in the archive can be digitized.

The second part of FY2021 effort will be to write a summary report for the out-of-pile furnace tests by test group. The report will explain the purpose and objectives of each test group, describe the fuel samples and test conditions, and present key results. This report will be intended for open access by the public, allowing interested persons without DOE affiliation to view key information about the tests in one place without necessitating clearing all related background documents for open access.

As users provide feedback about the content, structure, and functionality of OPTD, ongoing effort will be dedicated to better meeting the needs of the user base. While the pin identification for each sample is indicated in the database, it is not presently linked to the full subassembly and irradiation history information provided in existing EBR-II databases. Depending on how users wish to use the information, it may be advantageous to link each pin in OPTD directly to its irradiation history by coordinating with the other ART databases, like FIPD, sometime in the future.

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