Requirements for including data in the IFPE Database

Introduction

The purpose of the database is to preserve information from fuel performance experiments such that the data are useful and in a form that can be used for code development and validation. Thus, each dataset should include sufficient information to assemble an input file to run a code and information against which to compare predictions. The exception to this rule is for data appropriate to dedicated laboratory experiments which can be used to develop specific models. For example, the IMC data describing out-of-pile annealing experiments where fission gas release from small samples was measured as a function of time at different isothermal annealing temperatures.

Each dataset comprises individual files written in ASCII format. The following is a good method of presenting the data:

1. Summary of data
2. Pre-characterization data
3. Irradiation histories, one for each case
4. Poolside examination and/or non destructive testing (if applicable)
5. Post Irradiation Examination (PIE)
6. READ.ME
7. QA file (acceptable also in WORD, WordPerfect or PDF)
8. Relevant reports and documents (on paper and/or WORD, WordPerfect or PDF)

1. Summary

This is a text file describing the experiment, its objectives and main results. This file contains information on rod identification, material/rod variants etc. This file also contains details of the irradiation and/or test facilities and the conditions employed. For reactor irradiations, relevant information includes: coolant temperature, pressure, mass flow, coolant composition, position of rods in respect to axial height, details of cycle length etc.

2. Pre-characterization

This contains details of the materials used e.g., fuel and cladding, their dimensions, chemical composition, microstructure, impurity levels and any other relevant information. For instance, in the case of cladding, mechanical properties if known and relevant, for the fuel, this could include the results of re-sintering tests, pore size distribution, O/M. The following is a typical check list:

Rod I/D
FUEL PELLET
Composition
Fabrication lot no.
Method of manufacture
Diameter: Max, average, min. mm
Length: Max, average, min. mm
Geometry
Dimple diameter: Max, average, min. mm

Dimple depth: Max, average, min. mm
Uranium isotopic composition wt%: U234, U235, U236, U238
Pore size distribution, % porosity in size range, e.g, 0 – 2, 0 – 5, 0 – 10, >10 microns
Open porosity
Immersion density g/cc
Density %TD
Geometric density %TD
Stoichiometry, O/M
Chemical analysis
Resintering test, e.g., 24 hours at 1700 C in wet hydrogen *(specify)*
Change in %TD:Max, average, min.
Grain size in microns and distribution if available:
Centre pellet, max, av, min
Mid pellet, max, av, min
Pellet periphery, max, av, min

CLADDING
Composition
Heat treatment
Fabrication lot no.
External Diameter: max, average, min. mm
Internal Diameter: max, average, min. mm
Clad wall thickness: max, average, min. mm
Chemical analysis

ROD PARAMETERS
Total length mm
Length of fuel stack mm
Length of plenum mm
Volume of plenum mm^3
Fill gas, composition and pressure at STP:
Number of spacers
Assembly geometry

IRRADIATION
Reactor:
BOC, EOC, EFPD (effective full power days)
Cycle no. EFPD
End of cycle burn-up, MWd/kgU:
Cycle no. Burn-up
Measure of fast flux/fluence
Ratio of thermal heat to total heat for rods
Inlet temperature C
Outlet temperature C
System pressure MPa
Mass flow $Kg/m^2/s$

A re-statement of cross referencing rod identification and design parameters is advisable to aid data retrieval. Where known, uncertainties should be included.

3. Irradiation histories

One file for each case. Histories are constructed with sufficient axial zones as to adequately represent axial power variation. Where segments are cut from larger rods for further irradiation, e.g., in a test reactor, it is advisable to provide a history for the whole rod plus a further history for the segment in question. This should include both the base irradiation and test reactor data in the same format.

The history is provided as a histogram of time and power; a common format which has proved successful is as follows:

TIME STEP NO. TIME(DAYS) DT(HRS) BU(GWd/tU) FLUENCE (*E21 n/cm^2)

TCLAD (DEG C) POWER (kW/m), NODES 1-6

TCLAD (DEG C) POWER (kW/m), NODES 7-12

This is for a full length rod where the history is provided for 12 axial zones Each time step has entries on 3 lines as given in the header. The objective is to provide a format which can be transformed to the required input format of a fuel performance code with the minimum of pre-processing. In this example, the first line starts with a time step number followed by:

TIME	this gives the time from the beginning of the irradiation until the end of the current time step.
DT	this is the duration of the current time step; convention is to report this in hours
BU	burn-up at the end of the current time step
FLUENCE	fast neutron fluence at the end of the current time step

The second line contains entries for local clad temperature and local power for each of six axial zones 1-6. This is continued on the third line for the remaining zones 7-12. For each zone, the temperatures and powers are average values for the given time period. The temperatures are waterside values calculated from the prevailing thermal hydraulic conditions. The powers are thermal powers, i.e., describe the heat flowing out through the cladding and contributing to the temperature distribution across the fuel rod.

4. Poolside examination and/or non destructive examination

For each case, details of visual inspection dimensional measurements, gamma scanning and neutron radiography where applicable. A correspondence between zone and axial height must be given in order for predictions using the history can be compared with measurements. Useful measurements include rod growth, fuel column growth, axial variation in oxide thickness, diameter and ridge height. Gamma scan data are useful for describing axial variation in power and burn-up. Neutron radiography is useful for fuel stack length measurement, hydriding of cladding, pellet dish filling and pellet fragmentation (cracking). Details of failure sites, crack length, appearance and position are important observations if applicable using visual inspection.

5. Post irradiation destructive examination

The type of information that is required:

Results of rod puncturing,	gas pressure, internal volume, gas volume, gas isotopic composition.
Ceramography,	state of pellet, radial and axial distribution of grain size, porosity, pores size distribution, onset radius for grain boundary and/or inter granular porosity. Evidence of dish filling. Evidence of restructuring, e.g., ‘rim’ structure formation.
Metallography,	State of clad, any hydriding, blisters, fuel clad interaction compounds.
EPMA,SEM, TEM etc	any further information that describes the fuel and cladding which is relevant to fuel modelling.

6. READ.ME

This file acts as a contents list and contain a list of files in the dataset, their title and brief description. It contains the date of compilation and the person responsible for the compilation. It contains a comment on the state of verification of the data, any known shortcomings, an identifier and date in the case of re-issue.

7. QA File

The purpose of this file is to assist a third party to verify the methods used in creating the dataset. Sufficient information should be included to link the original data with that in the final dataset.

The file describes the form in which the data was received and the methods used to compile the data into the final form of the dataset. Where possible, reference should be made to reports, tables and/or diagrams used to extract data so that correct retrieval can be checked by a third party. A listing should be included of any program used to process the data, e.g., for compiling the history files, calculating time periods, local powers and temperatures. Specimen input and output files or parts thereof should be included as an appendix.

Where figures have been scanned and digitized, it is worth creating a new diagram from the data for inclusion in this QA file for visual comparison with the original.

8. Relevant reports and documents

Reports used in compiling the items 1. - 7. should also be provided in hard copy or in computer readable form. In fact these reports will be included in the database in order to facilitate access to the original documentation and to facilitate peer review or later improvements.