Annals of Nuclear Energy 110 (2017) 779–788

Contents lists available at ScienceDirect

Annals of Nuclear Energy

journal homepage: www.elsevier.com/locate/anucene

SFCOMPO-2.0: An OECD NEA database of spent nuclear fuel isotopic assays, reactor design specifications, and operating data

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ARTICLE INFO

Article history:
Received 28 March 2017
Received in revised form 18 July 2017
Accepted 19 July 2017
Available online 2 August 2017

Keywords:
SFCOMPO
Spent nuclear fuel database
Radiochemical assay data
Experimental isotopic compositions
Nuclear fuel depletion

ABSTRACT

SFCOMPO-2.0 is the new release of the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) database of experimental assay measurements. These measurements are isotopic concentrations from destructive radiochemical analyses of spent nuclear fuel (SNF) samples. The measurements are supplemented with design information for the fuel assembly and fuel rod from which each sample was taken, as well as with relevant information on operating conditions and characteristics of the host reactors. These data are necessary for modeling and simulation of the isotopic evolution of the fuel during irradiation. SFCOMPO-2.0 has been developed and is maintained by the OECD NEA under the guidance of the Expert Group on Assay Data of Spent Nuclear Fuel (EGADSNF), which is part of the NEA Working Party on Nuclear Criticality Safety (WPNCS). Significant efforts aimed at establishing a thorough, reliable, publicly available resource for code validation and safety applications have led to the capture and standardization of experimental data from 750 SNF samples from more than 40

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http://dx.doi.org/10.1016/j.anucene.2017.07.022

Nuclear fuel evolution
Code validation
Integral benchmarks

reactors. These efforts have resulted in the creation of the SFCOMPO-2.0 database, which is publicly available from the NEA Data Bank. This paper describes the new database, and applications of SFCOMPO-2.0 for computer code validation, integral nuclear data benchmarking, and uncertainty analysis in nuclear waste package analysis are briefly illustrated.

1. Introduction

The management of spent nuclear fuel (SNF) is a key issue faced by the nuclear industry. Spent fuel pools used for storage of SNF at many nuclear facilities are reaching capacity, and dry fuel storage and final repository design activities are increasing. Many countries are considering implementing extended interim dry storage of SNF: dry storage repositories in Finland and Sweden are expected to be operational in the next decade, and some countries have implemented or are in the process of implementing burnup credit methodologies as part of their licensing protocols and regulatory practices. These practices aim at increasing and optimizing SNF storage capacities in existing facilities in compliance with the required safety margins.

Computational modeling and simulation capabilities are used widely to support and provide the technical basis for SNF safety applications and licensing evaluations. These methodologies, along with their associated codes and data, must be validated before they can be approved for use in safety studies. Validation requires demonstration of accurate prediction of SNF isotopic compositions. Measured nuclide concentrations in SNF are essential benchmarks for calculations to discern fuel evolution (depletion or burnup). Validation of these calculations requires access to (1) accurately measured experimental nuclide concentrations with estimated uncertainties for the nuclides being considered, and (2) accurate design specifications and operating data for the nuclear systems being modeled.

To address this need, the NEA worked with Oak Ridge National Laboratory (ORNL) to develop the Spent Fuel Composition SFCOMPO-2.0 database. This was accomplished under the purview of the NEA Expert Group on Assay Data for Spent Nuclear Fuel (EGADSNF) (http://www.oecd-nea.org/science/wpncs/ADSNF/). In 2013, the EGADSNF initiated an international effort to expand the database and modernize the application used to access and search the database (Michel-Sendis et al., 2014; Gauld et al., 2014). The result, SFCOMPO-2.0, is a structured query language (SQL) Java H2 database accessible through a graphical user interface.

SFCOMPO-2.0 contains reviewed experimental datasets for a wide variety of reactors, and it includes the open source bibliographical references from which the data were retrieved. Experimental data for 750 SNF samples are included in SFCOMPO-2.0. These data primarily comprise nuclide concentration measurements made by destructive radiochemical assay of SNF samples. These measurements are typically made using chemical separations and mass spectrometry techniques. Measurement data obtained using gamma ray spectroscopy, alpha counting, and beta counting are also included. SFCOMPO-2.0 is a central resource of reliable, well-documented experimental assay data. It includes design specifications and operating information for use by the international scientific community, industry, and regulatory authorities.

2. Background

2.1. EGADSNF

In 2007, EGADSNF was formed as an NEA Expert Group under the criticality safety area to provide a reliable, publicly available SNF database to the criticality safety community. Since its creation, EGADSNF has been a multidisciplinary group of international experts whose areas of expertise include radiochemical analysis, waste management, reactor physics, and criticality safety. This group coordinates information sharing about international isotopic assay data activities, and it facilitates interactions between countries applying or developing data measurement programs for SNF applications. This framework for cooperation and information exchange is highly beneficial for entities attempting to navigate the complexity and high costs of measurement campaigns that require handling of SNF, as well as challenges using high-precision destructive radiochemical assay measurements. This is especially the case for those with limited resources and/or experience conducting experimental programs. Experimental assay data also have important applications outside of criticality safety, so EGADSNF participants include representatives from other NEA committees, such as the technical Committee on the Safety of Nuclear Installations (CSNI) and the Integration Group for the Safety Case (IGSC) of the NEA Radioactive Waste Management Committee.

Since its inception, EGADSNF has worked to document, review, and improve the quality of experimental assay data, reactor fuel and design data, and reactor operating information. EGADSNF has developed guidelines for review and evaluation of experiments (OECD NEA, 2016) and has initiated development of benchmarks that provide a more complete description and evaluation of the experiments.

2.2. The first SFCOMPO database

The first open compilation of SNF experimental measurements was initiated by the Japan Atomic Energy Research Institute (JAERI) in the early 1990s (Naito et al., 1993). This predecessor of the first SFCOMPO database (Kurosawa et al., 1997; Suyama, 1997) was a collection of assay data documents from post-irradiation experiments as retrieved from the open literature at the time. The database included information for 246 samples from 7 pressurized light water reactors (PWRs) and 7 boiling light water reactors (BWRs). Over the following years, SFCOMPO underwent a series of improvements; it was converted into hypertext markup language (HTML) format for hosting on a website, and it was migrated to NEA for website maintenance in 2001. Little development ensued until EGADSNF undertook to rebuild and update the database.

2.3. Towards SFCOMPO-2.0

The need to expand SFCOMPO and modernize the database structure and interface prompted ORNL to develop, in 2012, an early prototype to help establish the relational structure for a new database application. This prototype was the basis of the work undertaken by the NEA Data Bank to build the present SFCOMPO-2.0 application, which integrates modular programming components and structures similar to other NEA databases such as the recent DICE database (Hill et al., 2014a) developed for the International Criticality Safety Evaluation Project (ICBSEP) and the International Reactor Physics Experiment Evaluation Project (IRPhE) handbook (Hill et al., 2014b).