Correction Factors derived from French experiments with the recent JEFF3.1.1 library for PWR-UOx BUC applications

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Abstract

The concept of taking credit for the reduction of the reactivity of nuclear spent fuel due to their burnup is referred to as "Burnup Credit" (BUC). Allowing reactivity credit for spent nuclear fuels (SNF) offers many economic incentives. The increasing ^{235}U enrichment and need for fuel transport and storage point out the interest for BUC methods. A recent and rigorous methodology[1] was developed by the CEA and AREVA-NC, carrying out the French BUC calculation route based on the code systems DARWIN[2] and CRISTAL[3]. It is accounting of:

1. 15 poisoning FPs, stable and non-gazeous, in addition to the actinides;
2. Conservative hypotheses for the depletion calculations;
3. The qualification of the spent fuel inventory obtained with DARWIN and of the reactivity worth of BUC nuclides calculated with CRISTAL;
4. A bounding axial profile of assembly BU.

The impact from recent improvements of BUC nuclide evaluation in the JEFF3.1.1 library[4] and on the validation of the French BUC code systems are mainly described in this paper. Namely, a set of conservative Correction Factors (CF), to be applied to the isotopic concentrations obtained from the depletion calculations, was established for each BUC nuclide involved in PWR-UOx Burnup Credit. These CF are one of the key of the French BUC method proposed to guarantee the conservatism of the fuel reactivity in safety-criticality calculations. They allow the conservatism of the isotopic concentrations with regards to the calculation - experiment bias of the code DARWIN as well as the conservatism of the BUC nuclide worth in CRISTAL. These conservative CF are derived from two kinds of experimental programs[5,6]. These programs involve two kinds of experiments, chemical analyses and microprobe measurements of PWR irradiated fuel pins on one hand, and reactivity worth measurements of the BUC nuclides in the MINERVE reactor on the second hand.

The recent qualification results of spent fuel inventory and reactivity worth calculations using the recommended libraries and code versions for fuel cycle applications, show many improvement of the bias trends. Therefore, new CF for PWR-UOx BUC application are calculated and presented, including a comparison with the previous ones based on JEF2.2[7]. The reduction of the biases (C-E)/E between the calculated isotopic concentrations and the experimental values for some important BUC nuclides (^{242}Pu, ^{153}Eu, ^{155}Gd) are especially highlighted, leading to a reduction of the penalty on the keff, calculated in the case of a PWR-UOx pool storage.

References

[1] A. Santamarina, "Burnup Credit implementation in spent fuel management", *FISS'98*, Cadarache (France).
[2] A. Tsilanizara, et al., "DARWIN: an evolution code system for a large range of applications", *ICRS-9*, Tsukuba, Japan, October 1999.
[3] J.M. Gomit et al., "The new CRISTAL Criticality-Safety Package", *Proc. of Int. Conf. on Nuclear Criticality Safety ICNC'99*, Versailles, France, Sept. 20-23, 1999.
[4] A. Santamarina et al., "The JEFF3.1.1 Nuclear Data Library validation results from JEF-2.2. to JEFF-3.1.1", JEFF Report 22, OECD 2009-NEA N°6807.
[5] A. Santamarina et al., "Experimental validation of Burnup Credit calculations by reactivity worth measurements in the MINERVE reactor", *Proc. of Int. Conf. on Nuclear Criticality Safety ICNC'95*, Albuquerque, USA, Sept. 17-21, 1995.

[6] B. Roque, et al., "The French Post Irradiation Examination Database for the validation of the depletion calculation tools", *Proc. of Int. Conf. on Nuclear Criticality Safety ICNC 2003*, JAERI, Tokai, Japan, Oct. 20-24, 2003.
[7] L. San Felice and al., "BUC implementation for a transport cask application using penalty factors from French experiments", submitted to GLOBAL'09.