Recommended bounding axial profiles in BUC applications from actual burnup measurement of French PWR assemblies

C. Riffard[a] A. Santamarina[a], J.-F. Thro[b], F. Lavaud[c]

[a] *CEA, DEN, DER, SPRC, CEA-Cadarache, F-13108 Saint Paul lez Durance, France.*
[b] *AREVA-NC, F-92084 Paris La défense, France.*
[c] *EDF R&D, F-92141 Clamart, France.*

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[4,6]. The previous method using a uniform mean BU gives a non realistic cosines axial flux and is therefore not conservative for BU > 30 GWd/t [5].

As a consequence, because of the so-called “end-effect” (low irradiation of the extremities of the irradiated assembly) the use of a burnup profile becomes necessary in criticality studies. The definition of a bounding profile to be recommended for criticality studies has been studied on the basis of a representative set of axial traces obtained from gamma spectrometry measurement in La Hague facilities on spent fuel assemblies before the dissolution step[7]. More than 200 measurements were studied here, extracted from the extensive database obtained by AREVA/LH on French 17x17 PWR-UOx FAs. This important basis gives a reliable and representative range of shapes of burnup profiles. The study shows that a simplified description of the axial profile using 11 zones is sufficient, as follows from the bottom to the top of the assembly : 11 – 22 – 33 – 45 – 73 – H-98 – H-63 – H-42 – H-23 – H-11 – H, where is the fissile column height (in cm).

We recommend the use of a profile (normalized to 1) deduced from the most conservative one among the measurements of FAs of BU > 30 GWd/t in the experimental basis. It is characterized by a maximum en effect on the top of the assembly. Its conservativeness compared with the use of a mean burnup profile amounts to 860 to 1400 pcm at the BU of 30 GWd/t, depending on the cooling time from 0 to 5 years. A more asymmetric profile is also recommended for FAs with low BU < 30 GWd/t, although the end effect becomes here less sensitive to the shape of the profile.

References

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