Sufficiency of available MOX experiments for criticality calculation validation of VVER burnup credit applications

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For safe application of burnup credit, a conservative safety margin should be derived, which includes the effect of nuclear cross section errors. Such margin can be derived from analysis of calculation-experiment comparison, if sufficient number of suitable critical experiments is available. The critical experiments, used in the analysis, should be similar to the investigated application. Traditionally, the parameters used in investigation of similarity, were the enrichment, fissile/moderator ratio, isotopic composition of fissile material and some spectral parameters. However, the decision on the similarity was based on the judgment of the analyst to some extent. Recently, more rigorous basis of similarity, based on sensitivity/uncertainty analysis, was developed and incorporated into SCALE program package in the form of similarity indices. The TSUNAMI module of the system evaluates more quantities, quantifying the similarity between an application and a selected experiment. These quantities are based on the sensitivity of k_{eff} to the particular cross sections and the covariance data of these cross sections.

For the actinide-only burnup credit applications, the MOX critical experiments are the possible candidates as applicable for validation of criticality calculations. However, the publicly available MOX experiments, described in the International Handbook of Evaluated Criticality Safety Benchmark Experiments, have quite different uranium/plutonium isotopic composition, than the burned fuel. For this reason, their applicability for validation is questionable.

This question has been investigated using TSUNAMI for the case of VVER-440 fuel in the compact storage pool of Paks NPP. Approximately 300 MOX and UO2 critical experiments were investigated. While high degree of coverage was found, the degree of similarity was poor. The value of c_k index was bellow 0.8 in great majority of the cases, and it was about 0.85 only in a few cases. (The perfect similarity corresponds to 1, and generally c_k higher than 0.9 is expected for validation purpose.) We can conclude that this set of critical experiments, using the presently available methods, is insufficient for burnup credit criticality validation.

Since the completion of this study, new version of SCALE, the SCALE 6 became available. This version includes new methods for investigating the influence of cross section errors (GLLSM for cross section adjustment). Study of these new methods for VVER fuel will start in the immediate future and first results are expected for the time of BUC meeting in 2009 october.