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#07-202 A comparison of bounding approach with isotopic correction factors and Monte Carlo sampling in burnup credit method

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In nuclear criticality safety analysis, burnup credit is an approach that credits the reduction in reactivity due to fuel burnup. The calculation using burnup credit method consists of two main steps: a burnup calculation, which estimates nuclide concentrations in the spent fuel, and criticality calculation, which uses the nuclide concentrations determined in the first step. However, computational prediction of fuel composition introduces an additional source of bias or uncertainty. There are several methods that deal with these uncertainties and in general, they can be divided into two main categories: bounding methods and best-estimate methods.

The bounding approach aims to get the most conservative result by adjusting the concentrations of nuclides in a system. This can be done using isotope correction factors (CF), which are determined based on the difference between the experiment and the calculation results (E/C) and are part of validation of each calculation code. The concentration of selected nuclides in the model is then multiplied by these factors so that concentrations of fissile nuclides are increased and concentrations of absorbing nuclides are decreased. This leads to a more reactive system with the conservative estimate of multiplication factor keff.

The best-estimate methods aim to determine the uncertainty in spent fuel in a more accurate and realistic way. This can be done using Monte Carlo sampling of the different parameters in a model based on their uncertainty and selected distribution. Other options, such as direct-difference method or sensitivity calculations, are also possible.

In this work, the comparison of bounding approach with correction factors and Monte Carlo sampling was made on the model of spent fuel pool. The isotopic composition of the fuel was calculated for different values of burnup using TRITON code from SCALE code system. In a bounding approach calculation, we have considered 48 nuclides to which the correction factors were applied. The criticality calculation was then made by KENO-VI code from SCALE. In a Monte Carlo sampling calculation, the concentrations of nuclides were multiplied by a factor, which was sampled with normal distribution based on average E/C value and its uncertainty. A total of 5,000 sampled input files were then calculated using KENO-VI code. The average multiplication factor keff of the results and its standard deviation σ were subsequently determined.

The comparison of results of both methods shows how much conservative the bounding approach is. In this case, the multiplication factor is higher by 0.02935, which is about 5.4× more than the value of the standard deviation of the sampled Monte Carlo tasks. The using of Monte Carlo sampling method can reduce the maximum multiplication factor for models where the coefficient is slightly above the legislative limit based on the current conservative burnup credit methodology. This could lead to an alleviation of possible restrictions resulting from the exceed of the limit. However, the Monte Carlo sampling approach requires a calculation of large number of tasks and is therefore more computationally demanding.

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