Modeling the activity of I-129 and Cs-137 in primary coolant at PWR

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I-129, which is a low energy beta emitter (max energy = 0.15 MeV) with half-life of 1.57×10^7 year, is a critical nuclide for low and intermediate level waste disposal because it is a significant hazardous radionuclide in ground water due to its high mobility in underground water. Due to the difficulty in direct measurement of this nuclide in waste packages, I-129 is generally evaluated using a scaling factor between I-129 and easier measured Cs-137. The determination of scaling factor is difficult because of the much lower concentration of I-129. Therefore, Theoretical approaches have been proposed to estimate I-129 activity or scaling factor. In this study, mathematical models have been derived to describe the activities of I-129 and Cs-137 in the primary coolant during constant power operation in a PWR. The current model for I-129 coolant activity is based on the primary coolant activity model for I-129 in a CANDU reactor. The models, which account for the source releases from defective fuel rod(s) and tramp uranium, rely on the contribution of chemical & volume control system (CVCS) resin and boron recovery system (BRS) as a removal process. Figure 1 shows a schematic diagram of mass balance for volatile fission products in interested regions. To distinguish the difference in behaviour for each nuclide, differentiable correlations of model parameter between I-129 and Cs-137 for gap escape rate coefficient, diffusivity and removal efficiency were applied for the rationalized application to the PWR. The plant-specific source-related information such as gap escape rate coefficient, fission rate and diffusivity in defective fuel, and amount of tramp uranium can be estimated from the short-lived radioiodine analysis. Figure 2 shows an example of predicted coolant activities of I-129 and Cs-137 with burnup. And, they were derived by using the measured reactor coolant system (RCS) data. The contributions of tramp uranium to activities in coolant will be generally negligible when meaningful fuel defects exist. The current models were validated through measured coolant activities for Cs-137. The resultant scaling factors of I-129/Cs-137 agree reasonably well with the results of the test resin and the actual resins in French and US PWRs. It can be known that predicted activities in current models shows relatively better agreements than ones in Lewis model. Further study wll be conducted for the discrimination of SF in coolant and spent resin generated from the primary coolant, especially based on the RCS data in Korean NPPs.

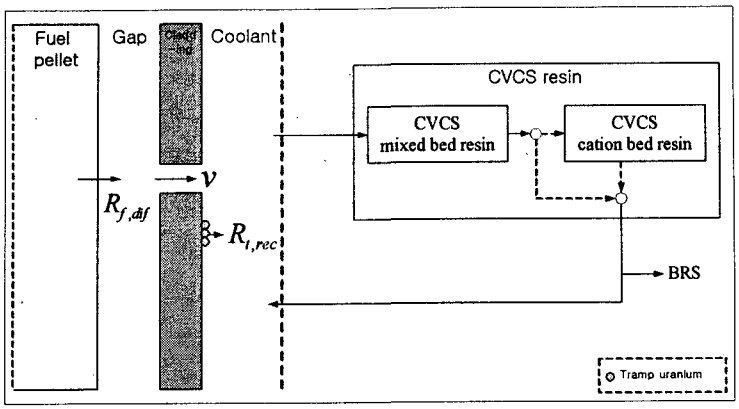

Figure 1 . Schematic diagram of mass balance

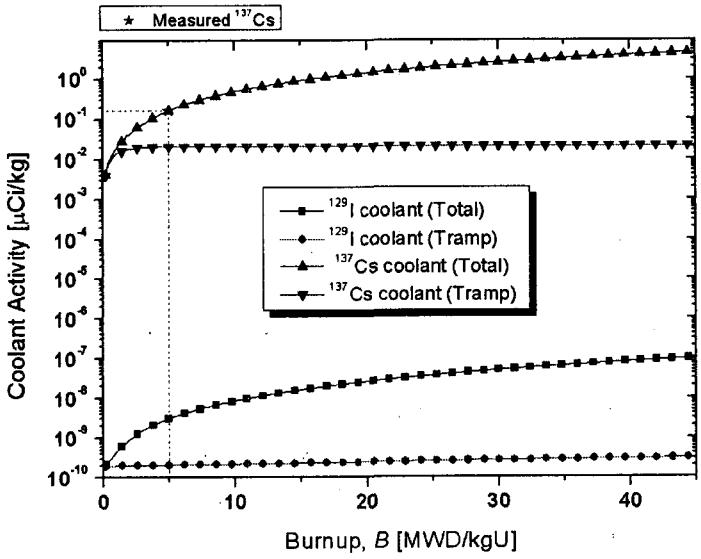

Figure 2. Coolant activities of I-129 and Cs-137 as a function of burnup