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Estimation of Hydrogen Production from PWR Spent Fuel Due to Alpha Radiolysis

Authors : Sivakumar Kottapalli, Abdesselam Abdelouas, Christoph Hartnack

Abstract : Spent nuclear fuel generates a mixed field of ionizing radiation to the water. This radiation field is generally dominated by gamma rays and a limited flux of fast neutrons. The fuel cladding effectively attenuates beta and alpha particle radiation. Small fraction of the spent nuclear fuel exhibits some degree of fuel cladding penetration due to pitting corrosion and mechanical failure. Breaches in the fuel cladding allow the exposure of small volumes of water in the cask to alpha and beta ionizing radiation. The safety of the transport of radioactive material is assured by the package complying with the IAEA Requirements for the Safe Transport of Radioactive Material SSR-6. It is of high interest to avoid generation of hydrogen inside the cavity which may to an explosive mixture. The risk of hydrogen production along with other radiation gases should be analyzed for a typical spent fuel for safety issues. This work aims to perform a realistic study of the production of hydrogen by radiolysis assuming most penalizing initial conditions. It consists in the calculation of the radionuclide inventory of a pellet taking into account the burn up and decays. Westinghouse 17X17 PWR fuel has been chosen and data has been analyzed for different sets of enrichment, burnup, cycles of irradiation and storage conditions. The inventory is calculated as the entry point for the simulation studies of hydrogen production by radiolysis kinetic models by MAKSIMA-CHEMIST. Dose rates decrease strongly within ~45 µm from the fuel surface towards the solution(water) in case of alpha radiation, while the dose rate decrease is lower in case of beta and even slower in case of gamma radiation. Calculations are carried out to obtain spectra as a function of time. Radiation dose rate profiles are taken as the input data for the iterative calculations. Hydrogen yield has been found to be around 0.02 mol/L. Calculations have been performed for a realistic scenario considering a capsule containing the spent fuel rod. Thus, hydrogen yield has been debated. Experiments are under progress to validate the hydrogen production rate using cyclotron at > 5MeV (at ARRONAX, Nantes).

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