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Mechanical loading tests on irradiated LWR fuel rods

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During reactor operation, the mechanical properties of a nuclear fuel rod are radically altered. After discharge, alpha-decays and accumulated radiation damage or other processes associated to potential thermal variations occurring during interim storage, contribute to further ageing of the spent nuclear fuel (SNF). However, during all stages of the SNF management (han-dling, retrieval, packing and transportation to final disposal or reprocessing) safety must be guaranteed.
Assessment of the SNF mechanical stability against external stresses, which might be accidentally applied, requires rep-resentative reference data. Explicit tests simulating accidental conditions are conducted in the hot cells of JRC - Karlsruhe, in the frame of a multi task collaborative research programme. Three-point bending and gravitational impact devices were developed and installed in the hot cells to investigate the SNF rods response under quasi-static or dynamic loads. Load-deflection curves are generated in the 3-point bending tests, whereas a high-speed camera records the rod rupture during impact tests.
Results from investigations on LWR commercial fuel rods over an extended burn-up range are presented in this paper. SNF segments, pressurized at the original fuel rod pressure after discharge, were subjected to bending and impact tests. Similar masses, significantly less than a single fuel pellet, of fuel disperse upon pin rupture in both types of experiments. Only fuel fragments from the immediate vicinity of the rod fracture release. An image analysis methodology was developed to elaborate the sample's behaviour under dynamic loads. Optical and electron microscopy were used to observe the morphology, orienta-tion and population of the cladding hydrides, whereas the overall hydrogen concentration in the cladding was measured with hot extraction technique. Size distribution analysis on the released fuel particles was also performed. The study is augmented by modelling approach to evaluate the individual phenomena and parameters affecting the SNF properties.

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