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New catalog on (U,Pu)O2 properties for fast reactors and first measurements on irradiated and non-irradiated fuels within the ESNII+ project

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In order to develop the fast neutron systems, three prototypes of the Sodium Fast Reactor, the Gas-cooled Fast Reactor and a heavy liquid metal cooled Accelerator Driven System are studied in Europe: ASTRID (SFR prototype), ALLEGRO (GFR prototype) and MYRRHA (LBE-cooled ADS system related to the ALFRED LFR-demonstrator). The ESNII+ project with its workpackage 7-FUEL SAFETY aims to provide a set of oxide fuel properties needed for the fuel element design of each prototype. The improvement of fuel properties will also reduce uncertainties in safety behavior evaluations, in nominal conditions as well as during transients and will be achieved by the update of the European catalog on the MOX fuel properties.
The uncertainties on the fuel properties have to be rigorously determined; the two main driver criteria for fuel element evaluation are the margin to melt for the fuel and the risk of clad failure.
Property measurements are done on existing fresh and irradiated fuel samples, identified to cover the fuel characteristics for ESNII prototypes. The review of the state-of-the art has shown that the knowledge on the thermal conductivity of irradiated FBR MOX is currently very limited. Only one publication is available providing surprising experimental results: no degradation of thermal conductivity with burn-up was observed. The data and models available in the literature were reviewed and new experimental results are obtained in order to develop an updated recommendation. Fresh and irradiated fast reactor fuel was characterised and its thermal diffusivity was measured. The irradiated fuel has an average burn-up of 13.4 at.% and the thermal diffusivity was measured in 3 radial positions: 0.6 mm, 1 mm and 1.4 mm from the pellet cladding. The thermal diffusivity increases from the pellet periphery to the pellet centre and is significantly higher than for LWR UO2 or MOX fuels with similar burn-up. The impact of the main mechanisms is investigated in depth: radiation damage concentration as a function of the irradiation parameters, effect of the plutonium content, of microstructure, of fission gas atoms, of fission products and O/M. A new correlation for the conductivity is developed on the basis of the phenomena specific to FBR fuel: high irradiation temperature, restructuring, extensive fission gas release, diffusion of plutonium and fission products.

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