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Low-void-effect sodium-cooled core: Uncertainty of local sodium void reactivity as a result of nuclear data uncertainties

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Safety robustness by all means is still an open issue for Generation IV Sodium-cooled Fast Reactors (SFR) that needs to be demonstrated in particular with respect to severe accidents. For reliable safety analyzes it is important among other things not only determining 3D maps of reactivity coefficients which can then be used in corresponding transient analyzes within a point kinetics code; in view of a first step towards design optimizations, it is equally paramount assessing uncertainties resulting from nuclear data uncertainties. These uncertainties can be propagated to the overall transient behavior together with uncertainties from other sources.

It is in this framework, since sodium boiling a priori cannot be excluded by means of safety measures alone, that for one of the promising French SFR low-void-effect cores, the uncertainty of regional reactivity effects due to coolant density reductions including the void effect in those regions has been studied in different situations. In the calculations, ERANOS (Edition 2.2-N) has been used in conjunction with JEFF-3.1 cross-sections and COMMARA-2.0 variance/covariance data in 33 neutron energy groups which is an ENDF/B-VII.0 based library. The sensitivity coefficients required for uncertainty assessments have been obtained by means of Equivalent Generalized Perturbation Theory (EGPT) on the basis of nodal diffusion-theory applied to a 3D model of the full heterogeneous core.

It turns out that the uncertainty of the void coefficient due to nuclear data uncertainties may result particularly large especially in relative terms, sometimes making the sign of the analytical coefficient even questionable in cases where the uncertainty exceeds 100%. This effect occurs primarily in supposed scenarios in which only lower parts of the upper axial plenum near the upper core region are voided; more precisely when the loss of coolant involves just portions of the core/plenum interface. Whereas the uncertainty of the overall negative reactivity effect resulting from hypothetical voiding of the whole core is of the order of 20%. Another interesting result allowing extrapolations to non-explicitly computed voided configurations is that such uncertainties are largely adding with respect to space and Na mass removed.

On the basis of unadjusted COMMARA-2.0 data, the main contributors to the uncertainty of the void coefficient due to nuclear data uncertainties are in general 238U, especially the inelastic scattering cross-section, and 23Na, particularly the elastic scattering cross-section.

Country/Int. Organization

Switzerland /Paul Scherrer Institute

Primary author: Dr PELLONI, Sandro (Paul Scherrer Institute)

Co-authors: Prof. PAUTZ, Andreas (Paul Scherrer Institute); Ms PANADERO, Anne-Laurene (Paul Scherrer Institute); Dr MIKITYUK, Konstantin (Paul Scherrer Institute)

Presenter: Dr PELLONI, Sandro (Paul Scherrer Institute)

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