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#4-168 Design of oscillation experiments at the VENUS-F zero power reactor

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One of the challenges for the deployment of advanced, heavy-metal-cooled reactor technologies is to improve nuclear data of key materials in the fast energy range. VENUS-F, the zero-power fast spectrum research reactor operated at SCK CEN, can play a major role in addressing this challenge. Sample reactivity worth experiments can be performed in VENUS-F to measure the reactor response to a sample material insertion in well-defined spectral conditions, testing the sample evaluated nuclear data. Oscillation techniques, in particular, are employed to increase the precision of such measurements when dealing with small reactivity effects of the order of 1 to 10 pcm.

This work analyses the requirements for the experimental setup to be used in VENUS-F oscillation experiments. Oscillation techniques can be classified based on the following features: the use reactivity compensation by automated pilot rod to maintain stable the reactor power in the closed loop configuration, as opposed to the open loop configuration without compensation and with reactor power fluctuation, the oscillation frequency and waveform and the detector location (local and global). The open loop configuration is preferred to the closed loop in VENUS-F. They have equivalent accuracy and the former is technologically easier to implement since no reactivity compensation mechanism is required. In open loop experiments, the global detectors (far from the oscillator location) provide the global system response. The sample reactivity worth is obtained by processing the global detectors' output with inverse point kinetics algorithms. The validity of point kinetics for the range of perturbations envisaged for the experiments is tested by assessing the consistency of the signal coming from different detectors during a preliminary experimental test. Pseudo-square oscillations are considered for experiments in VENUS-F. The development of a hybrid pile oscillator combining both the local and global signal perturbations is considered for the first time in a fast reactor. Synthetic oscillation simulations and the preliminary experimental tests are analyzed to investigate the optimal oscillation frequency as well as to select the best detector positions. With this process we seek uncertainty reduction of the measured response, estimated as the reactivity worth variations over the repeated oscillations.

Both design and interpretation of the experiment rely on the modeled reactor response. The integral response and its energy and reaction channel breakdown are simulated in the design phase using the Serpent Monte Carlo code. On the one hand, the experimental zone is selected to increase the sensitivity to specific reactions. On the other hand, the experimental channel is dimensioned based on the sample masses, which must cause a measurable reactivity effect. Oscillation experiments interpretation consists of the analysis of calculation-to-experiment discrepancies, which trace back to the nuclear data. This information is eventually used to improve the sample nuclear data for specific applications.

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