Decay Heat Calculation Methodology And Application To LVRF[1]

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ABSTRACT

Techniques earlier developed for calculation of decay power in CANDU natural uranium (NU) fuel have been updated and extended, and the resulting methodologies applied to the prediction of decay power in CANFLEX® low void reactivity fuel (CANFLEX-LVRF) bundles.

Methods based on the formulation and data provided in the ANSI/ANS-5.1 Standard (intended for calculating decay heat power in Light Water Reactors) have previously been adapted for the prediction of decay power from fission products and heavy elements in CANDU reactor fuel. In the current work, the approach has been further updated to make use of the most recently released version of the standard, ANSI/ANS-5.1-1994, which incorporates enhanced fissile nuclide representation, as well as improved decay heat data and uncertainties. At the same time, the opportunity has been taken to upgrade the means for providing the fuel-specific information needed to support the method, so that all required parameters are now derived directly from lattice physics calculations, e.g. from WIMS simulations, or from readily available data sources such as ENDF/B-VI.

The ANSI/ANS-5.1-1994 based method has first been applied for 37 element NU fuel, and the resulting decay power values benchmarked against predictions using ORIGEN-S, in conjunction with the burnup-dependent neutron cross-section libraries available for CANDU 37 element fuel. Using equivalent parameters derived specifically to reflect the CANFLEX-LVRF bundle, the method has also been implemented and tested for LVRF decay power purposes. A small additional term has been added to the ANSI/ANS-5.1 Standard formulation to represent the incremental decay power attributable to activation products of dysprosium, present as a burnable neutron absorber in the central pin of the LVRF bundle.

Concurrently with decay heat method development based on the ANSI/ANS-5.1 approach, work has been carried out in parallel to extend the capability for ORIGEN-S library generation. The current CANDU libraries for 37 element and 28 element NU fuel were generated using the SAS2W suite of codes, created to run under the SCALE driver, by linking WIMS with other cross section processing modules included within SCALE 4.2. Because of the different fuel compositions and element types present within the CANFLEX-LVRF fuel bundle, as well as the strong thermal neutron flux gradient radially across the bundle, it is necessary to derive separate cross section libraries for each ring of fuel elements present. An approach was devised whereby the existing SAS2W method originally created for single-region cross-section generation could be extended to generate multi-region libraries. The technique was applied first to the generation of a multi-region library for the 4 rings of the 37 element NU fuel bundle, yielding results which compared as expected with those using the single-region CANDU 37 element library. A multi-region library for the 4 rings of the 43 element LVRF fuel bundle was then produced, facilitating the use of ORIGEN-S for characterization of radiation properties, including decay heat, associated with irradiated CANFLEX-LVRF fuel bundles.

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Two quite independent methods for calculating LVRF decay power have been developed during the course of this work, with good agreement evident where expected over relevant cooling time ranges. The primary application to date is the specification of the short-term decay heat curve for loss of coolant accident analysis purposes, but further applications of the respective techniques are considered.