BNL-NUREG-63282

CONF-950601--31

WIMSD ANALYSIS OF THE POSITIVE COOLANT VOID MECHANISM IN THE CANDU-3 LATTICE

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The Atomic Energy of Canada Technologies (AECLT) of America is submitting the CANDU 3 reactor system for a Design Certification (CD) with the U.S. NRC. The NRC is presently in the preliminary phase of evaluating this natural uranium fueled, heavy water cooled and moderated reactor system. Brookhaven National Laboratory (BNL) is supplying technical assistance and support, particular in the analysis of the positive void feedback effect known to be inherent in the CANDU 3 design. The purpose of this paper is to present some results from the WIMSD (Ref.1) code that was used to study a representative lattice cell of the CANDU 3 reactor under a voided condition.

The CANDU 3 is the latest and smallest version (450 MWe) of the CANadian Deuterium Uranium (CANDU) reactor designed by Atomic Energy of Canada, Ltd. (AECL). Since the moderator is held separately from the coolant system in a low pressure (~ 0.7MPa) and low temperature (70C) calandria tank. The moderator stays intact and continues to moderate the neutrons during coolant voiding. The lost of neutron scattering from the coolant (about 5%) results in a neutron flux spectral shift in the thermal region and generates the positive void reactivity feedback. In contrast to light water reactors (i.e., BWRs and PWRs), the coolant is also used as the moderator . When the lattice cell is voided, inherently it causes a reduction in the thermal neutron flux and generates a negative reactivity feedback to the system.

To analyze the mechanism of the positive void feedback, a unit cell of the CANDU 3 was set up using the Winfirth Improved Multi-group Scheme (WIMS) code, version D (i.e., WIMSD). The unit cell in the WIMSD was represented by a square lattice (28.6 cm) of the CANDU-3 fuel cluster which contains 37 fuel elements arranged in four concentric rings (see insert Figure 1). The discrete ordinate method (DSN), corrected for leakage by Bernoist diffusion coefficient (Ref.2), was used to calculate the transport analysis. A 40-energy group structure was used to represent the cross sections: 8 fast groups between 9.118 keV to 2 MeV, 13 epithermal groups between 4 eV and 9.118 keV, and 19 thermal groups below 4 eV.

The reactivity change in fresh fuel at operating conditions to a 100% void state was predicted to be + 24 mk/gm/cc by WIMSD. The voiding resulted in a re-distribution of the neutron spectrum and consequently affected the fission yield of U-235. The WIMSD prediction showed changes in the neutron flux in approximately 5 energy regions; the lower thermal neutron energy less than 0.08 eV, the upper thermal neutron energy between 0.08 to 0.40 eV, the lower epithermal neutron energy between 0.08 to 13.0 eV, the upper epithermal neutron energy

[1]Work supported by the U.S. NRC

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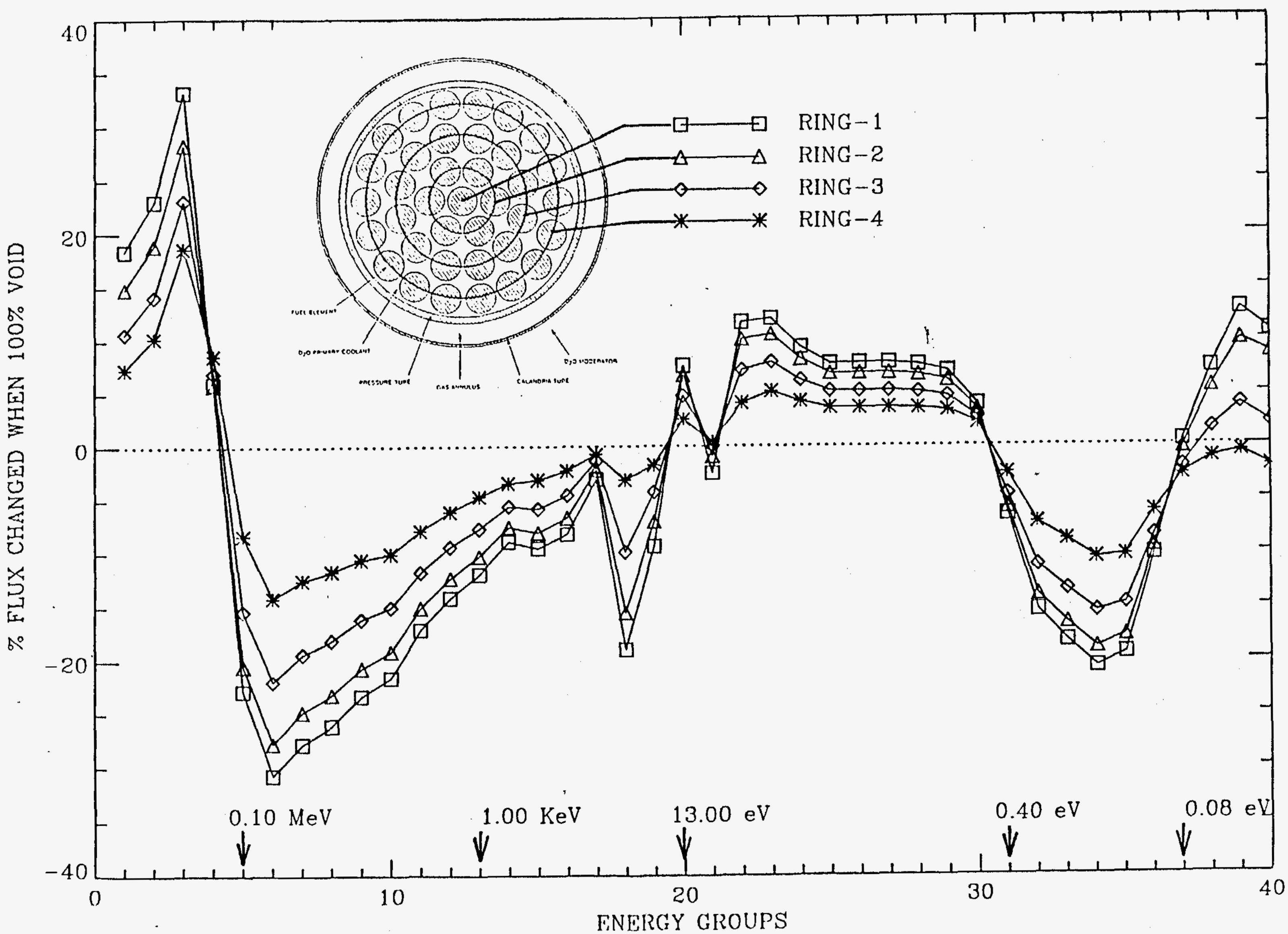

Figure 1. Percent Flux Change in CANDU 3 Fuel Rings