TEL-AVIV UNIVERSITY
SCHOOL OF ENGINEERING
Ramat-Aviv, Tel-Aviv, 69978, Israel

אוניברסיטת תל-אביב
הפאקולטה להנדסה
קרית האוניברסיטה, רמת-אביב, תל-אביב 69978

Tel. 420111 .טל

Summary of Talk by A Radkowsky at Water Safety Conference Nov 7, 1979

THE VARIATION OF THE DOPPLER REACTIVITY COEFFICIENT WITH DEPLETION

Depletion of a core, such as a typical light water BWR causes the production of a large number of new isotopes, as well as a reduction in the density of some, such as the fissile fuel and burnable poisons. The Doppler Reactivity Coefficient, DRC, is affected in several ways: First of all the neutron flux distribution within Group 3, the resolved resonance region is modified so that the relative importance as well as the over-all magnitude of the contributions of the original resonances to the DRC is changed, mostly reduced. Secondly some of the new resonances rapidly approach saturation, particularly ^{240}Pu, thus producing additional contributions to the DRC. Thirdly some of the new resonances are located within the wings of the original resonances so as overlap with the temperature increased absorption cross section in the wing regions; this tends to result in a decrease in the DRC

The last effect, which we shall call the overlap effect, provides a means for fission products, the macroscopic corss section of which is too small to saturate, to affect appreciably the temperature change of Group-3 absorption which is the largest component of the DRC.

An example of a strong overlap effect will be given.

The numerical calculations have been performed for a cell typical of BWR for both U-238 and thorium oxide based fuels in a cell typical of BWR. In each case the U-235 content was 2.8%. The basic data for the unit cell was:

Pellet O.D. 1.041 cm.

Rod to rod pitch 1.615 cm.

Average void content 40%

The depletions considered were 35000 MWD/T for the uranium base fuel and 40,000 MWD/T for the thorium, in order to get similar reactivity losses in each case.

The RABBLE-2 code was employed to calculate resonance interactions and CINDER was utilized for depletion. Since the number of elements which can be handled is

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limited,a special code, GRAF, was prepared to permit visual selection of those isotopes most likely to affect the DRC due to appropriately large macroscopic cross sections and location within the wings of the fertile material resonances. Examples will be given. These fission products were treated explicitly. Others were included within the smooth cross section.

Depletion was accomplished by CINDER in four neutron energy groups with 1000 hour timesteps. Group ratios were adjusted at 7000 hour intervals.

Calculations were performed at two temperatures: 800 K and 1200 K. The results for group 3 absorption were as follows:

		Group 3 Macroscopic 800K	Group 3 macr. 1200 K	Frac. change
Uranium	BOL	0.02510	0.02600	0.0358
	EOL	0.03460	0.03560	0.0289
Thorium	BOL	0.01698	0.01799	0.0595
	EOL	0.02721	0.02821	0.0368

The differences between thorium and U-238 based fuels will be discussed as illustrating the absence of a strongly saturating resonance such as Pu-240 in thorium based fuel.

Problems in translatingthe above group 3 absorption changes to changes in the DRC itself will be discussed. It now appears that many more temperature points will be needed.

Parallel calculations have been run by Professor Rothenstein's group at Technion using the OZMA code which is equivalent to RABBLE HAMMER with tabulated values for the cross sections, rather than Breit Wigner parameter based values. Since OZMA can handle only a much smaller number of isotopes the comparisons with our procedure are more in the nature of benchmark calculations. So far the OZMA calculations agree on the temperature change in Group 3 absorption cross sections but disagree on reaction rates. Possible reasons for the differences will be discussed.

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