Letters to the Editor

Comment on "Comment on 'Time-Independent Neutronic Analysis of the Chernobyl Accident'"

The letter by Wasastjerna[1] points out a reference[2] that had previously escaped my attention. The authors of Ref. 2 discuss reactivity effects in the RBMK cell due to fuel fragmentation, cooling of the fragmented fuel, and also due to density changes. A very interesting result concerns the influence of density changes on k_∞. The authors find that a *decrease* in the total density of the homogenized fuel-water mixture in the RBMK cell leads initially to an *increase* in k_∞. Only when the density is low enough does k_∞ decrease again (see Table III, Cases 6, 7, and 8 in Ref. 2).

This is surprising because the reactor physicist would usually expect a decrease in k_∞ when fuel (albeit mixed with water) is removed from the cell. The point I want to make is that I am not too happy with the authors' explanation; they say that "this is caused by a decrease of the resonance absorption." This statement is repeated in Wasastjerna's letter.[1] I feel that this result should be explained in terms of the neutron balance, not just a simple reaction rate (resonance absorption).

The explanation I suggest can best be stated in terms of the textbook product pf, where p is the resonance escape probability, and f is the thermal utilization. In the RBMK cell, an increase in the water density leads to an increase in p (additional background scattering in the resonance region) and a decrease in f (increased thermal neutron absorption of the water); the latter effect is larger, leading to a decrease in k_∞. On the other hand, if graphite is added to (or fuel-water mixture removed from) the cell, the additional scattering in the resonance region again leads to an increase in p; however, the "thermal absorption-to-scattering cross section" ratio is an order of magnitude lower than for water, so that the decrease in f is very small, and the net effect is an increase in reactivity.

To put it in simple words, the RBMK cell considered in Ref. 2 (40% void, fragmented fuel) is overmoderated with respect to water (the void coefficient is positive, which is well known to everybody), but it is undermoderated with respect to graphite. This latter point may be new to many readers, and it should be worthwhile to state it explicitly. The safety implications are obvious. In an accident situation, ejection of fuel-water mixture leads initially to a positive reactivity.[2]

It should be noted that the stated increase in k_∞ holds only up to a certain reduced fuel-water density. Below that, the absorption of graphite becomes important, and further reduction of the density leads to a decrease in k_∞.

E. A. Fischer

Kernforschungszentrum Karlsruhe/INR
Postfach 3640
D-7500 Karlsruhe
Federal Republic of Germany

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REFERENCES

1. F. WASASTJERNA, "Comment on 'Time-Independent Neutronic Analysis of the Chernobyl Accident,'" *Nucl. Sci. Eng.*, **110**, 207 (1992).

2. M. RAJAMÄKI and F. WASASTJERNA, "On the Reactivity Effects of Nuclear Fuel Fragmentation with Reference to the Chernobyl Accident," *Nucl. Sci. Eng.*, **101**, 41 (1989).

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In factual content, Fischer's analysis[1] is not very different from the points Rajamäki and I tried to make in a couple of sentences in our paper.[2] However, by expressing the matter in different terms and at somewhat greater length, Fischer helps clarify the physical phenomena involved.

Frej Wasastjerna

Technical Research Centre of Finland
Nuclear Engineering Laboratory
P.O. Box 208
SF-02151 Espoo
Finland

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2. M. RAJAMÄKI and F. WASASTJERNA, "On the Reactivity Effects of Nuclear Fuel Fragmentation with Reference to the Chernobyl Accident," *Nucl. Sci. Eng.*, **101**, 41 (1989).