

# LETTERS TO THE EDITOR

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## COMMENTS ON "EVALUATION OF VOLATILE AND GASEOUS FISSION PRODUCT BEHAVIOR IN WATER REACTOR FUEL UNDER NORMAL AND SEVERE CORE ACCIDENT CONDITIONS"

In the paper by Rest,<sup>1</sup> the words "diffusion" and "diffusion coefficient" are used to evaluate the behavior of noble gas bubbles, iodine, cesium, CsI, etc., in irradiated nuclear fuel.

Since formation of compounds and gas bubbles implies precipitation from super-saturated solutions, and since precipitates of gas bubbles and molybdenum-ruthenium "ingots" and cesium iodide have been identified in or on irradiated  $\text{UO}_2$ , it is clear that irradiated  $\text{UO}_2$  is multiphase.<sup>2,4</sup> The thermodynamic principles associated with the phase rule tell us that there are negligible macroscopic chemical activity gradients associated with the elements in multiphase systems at equilibrium. Since diffusion is usually driven by activity gradients, it appears that the author may not have selected a physically realistic mechanism for the migration of fission product precipitates within and out of  $\text{UO}_2$  at temperatures above 1500 K.

Let's get our homework done without requiring another Three Mile Island Unit 2 (TMI-2). It may be helpful to estimate the quantities and, hence, provide an indication of the maximum possible concentration gradients of  $^{131}\text{I}$  and  $^{133}\text{Xe}$  in a typical power reactor core at full power. About 20 millimicrograms (nanograms) of each of these radioactive fission products were present in the entire TMI-2 core at the time of the accident. About 10% of the  $^{133}\text{Xe}$  was released from the containment and ~40% of the  $^{131}\text{I}$  was released to the coolant. The model presented is not consistent with these data at any temperature. It predicts just the opposite behavior of these isotopes.

Radioisotopes are frequently employed as "tracers" in "carrier" media in which they may be moved about, not by diffusion, but by gravitational forces, convection, or mechanical forces that move the carrier.<sup>5</sup> Perhaps our understanding of fission product transport *in* and *out* of  $\text{UO}_2$  needs to be reoriented along these lines.

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## REFERENCES

1. J. REST, "Evaluation of Volatile and Gaseous Fission Product Behavior in Water Reactor Fuel Under Normal and Severe Core Accident Conditions," *Nucl. Technol.*, **61**, 33 (1983).
2. *Proc. Conf. Fast Reactor Fuel Element Technology*, R. FARMAKES, Ed., American Nuclear Society (1971).
3. D. CUBICCIOTTI and J. E. SANECKI, "Characterization of Deposits on Inside Surfaces of LWR Cladding," *J. Nucl. Mater.*, **78**, 96 (1978).
4. T. M. BESMANN and T. B. LINDEMER, "Chemical Thermodynamics of the System Cs-U-Zr-H-I-O in the LWR Fuel Cladding Gap," *Nucl. Technol.*, **40**, 297 (1978).
5. R. A. LORENZ, J. L. COLLINS, and A. P. MALINAUSKAS, "Fission Product Source Terms for the LWR Loss-of-Coolant Accident," *Nucl. Technol.*, **46**, 404 (1979).

## REPLY TO "COMMENTS ON 'EVALUATION OF VOLATILE AND GASEOUS FISSION PRODUCT BEHAVIOR IN WATER REACTOR FUEL UNDER NORMAL AND SEVERE CORE ACCIDENT CONDITIONS' "

Chubb's<sup>1</sup> contention that fission product transport in solid  $\text{UO}_2$  fuel is controlled "by gravitational forces, convection, or mechanical forces" and "not by diffusion" is counter to observation<sup>2-6</sup> and theory.<sup>2,7-9</sup> Chubb is mistaken about the fundamental processes of fission product transport in solid  $\text{UO}_2$  fuel. Clearly, gravitational forces are much too weak to affect the migration of precipitates through a solid crystal lattice. Convection applies to the transference of heat by the circulation or movement of the heated parts of a liquid or gas and *not* to the migration of precipitates in a solid. If by mechanical forces Chubb is referring to the effect of stress gradients on precipitate motion, then these effects have been considered in the development of FASTGRASS: Stress gradient effects were found to be much weaker than temperature gradient related processes. Chubb's hypothesis that diffusion is not "a physically realistic mechanism for the migration of fission product precipitates within  $\text{UO}_2$ " because "there are negligible macroscopic chemical activity gradients associated