CONF-841105--23-Abst

ABSTRACT

CONF-841105--23-Abst.

DE84 014730

FINAL

A Steady-State and Transient Fission Gas Release and Swelling Model for LIFE-4*

A. Villalobos, Y. Y. Liu and J. Rest

Applied Theory and Analysis
Materials Science and Technology Division
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

June 1984

cab

Distribution

1-2. M.F. Adams
3. F. Y. Fradin
4. R. W. Weeks
5. J. Rest
6. A. Villalobos
7. Y.Y. Liu
8. A. Ward (TMC/RF&M)
9. M. Wiater
10. K. L. Kliewer

MASTER

*Work supported by the U.S. Department of Energy.
To be submitted to the 1984 Winter Meeting of the American Nuclear Society, Washington, DC, November 1-6, 1984.

A Steady-State and Transient Fission Gas Release and Swelling Model for LIFE-4*

A. Villalobos, Y. Y. Liu and J. Rest

The fuel-pin modeling code LIFE-4 and the mechanistic fission gas behavior model FASTGRASS[1-3] have been coupled and verified against gas release data from mixed-oxide fuels which were transient tested in the TREAT reactor. Design of the interface between LIFE-4 and FASTGRASS is based on an earlier coupling between an LWR version of LIFE and the GRASS-SST code[4]. Fission gas behavior can significantly affect steady-state and transient fuel performance. FASTGRASS treats fission gas release and swelling in an internally consistent manner and simultaneously includes all major mechanisms thought to influence fission gas behavior. The FASTGRASS steady-state and transient analysis has evolved through comparisons of code predictions with fission-gas release and swelling data from both in- and ex-reactor experiments. FASTGRASS was chosen over other fission-gas behavior models because of its availability, its compatibility with the LIFE-4 calculational framework, and its predictive capability. The mechanistic treatment of fission gas phenomena has the potential for a predictive capability outside the range of conditions used for model verification. In addition, FASTGRASS provides LIFE-4 with a transient fission-gas behavior model which is required for a realistic application of LIFE-4 to the transient regime. By adjusting the less-well-known materials properties (such as gas atom diffusivity) in FASTGRASS within realistic experimental limits, LIFE-4/FASTGRASS predictions for fission gas release, cladding strain and thermocouple temperature histories are found to be reasonably close to the experimental data. Figure 1 compares LIFE-4 (Rev.0)/FASTGRASS predictions of total (steady-state and transient) gas release with measured results for pins HUT3-5A, HUT3-7A, HOP3-1B, and HUT5-7A from static-capsule tests performed in the TREAT reactor. All four pins had been previously irradiated in EBR-II in the PNL-9, PNL-10, and

---

*Work supported by the U.S. Department of Energy.

PNL-23A assemblies. The code predictions are in reasonable agreement with the experimental data.

The coupled code is presently being used to assess the role of the retained fission gas in low-power, high-burnup pins undergoing slow operational transients. Results obtained to date indicate significant retained-gas-induced swelling, as well as some weaknesses in the LIFE-4 fuel deformation models. Specifically, the LIFE-4 fuel hot-pressing model was found to significantly overpredict fuel hot pressing at low temperatures. Analysis of experimental data(5) shows an order-of-magnitude overprediction at 1600°C, and an overprediction by 2 to 3 orders of magnitude at temperatures lower than 1600°C. This finding is critical in our assessment of slow-transient oxide-pin performance. Retained-gas-induced swelling and fuel and cladding deformation must be examined together as they all affect fuel/cladding mechanical interaction (FCMI) during transients. Some anomalies were also noted in the LIFE-4 cladding deformation model. FCMI was found to be generally higher at the bottom of the fuel pin than at other axial locations. The calculated cladding equivalent stresses are higher than the cladding ultimate tensile strength, but lower than the cladding flow stress in the LIFE-4 Hart equation of state (EOS) model. As a result, no appreciable cladding high-strain-rate deformation was predicted during the transient. The Hart EOS model in LIFE-4 (Rev. 0), which is being revised by code developers at Westinghouse, appears too stiff at low temperatures.

References:

1. J. Rest, The Prediction of Transient Fission-Gas Release and Fuel Microcracking Under Severe Core-Accident Conditions, Nucl. Technol. 56, 553 (1982).

2. J. Rest, Evaluation of Volatile and Gaseous Fission Product Behavior in Light Water Reactor Fuel Under Normal and Severe Core Accident Conditions, Nucl. Technol. 61, 33 (1983).

3. J. Rest, An Improved Model for Fission Product Behavior in Nuclear Fuel Under Normal and Accident Conditions, to be published in J. Nucl. Mater. (1984).

4. J. Rest, SST: A Computer Code to Predict Fuel Response and Fission Product Release From Light-Water Reactor Fuels During Steady State and Transient Conditions, Trans. Am. Nucl. Soc. 22 (1), 462 (1975).

5. J. Routbort, J. C. Voglewede and D. S. Wilkinson, Final-Stage Densification of Mixed Oxide Fuels, J. Nucl. Mater. 80 (1979).

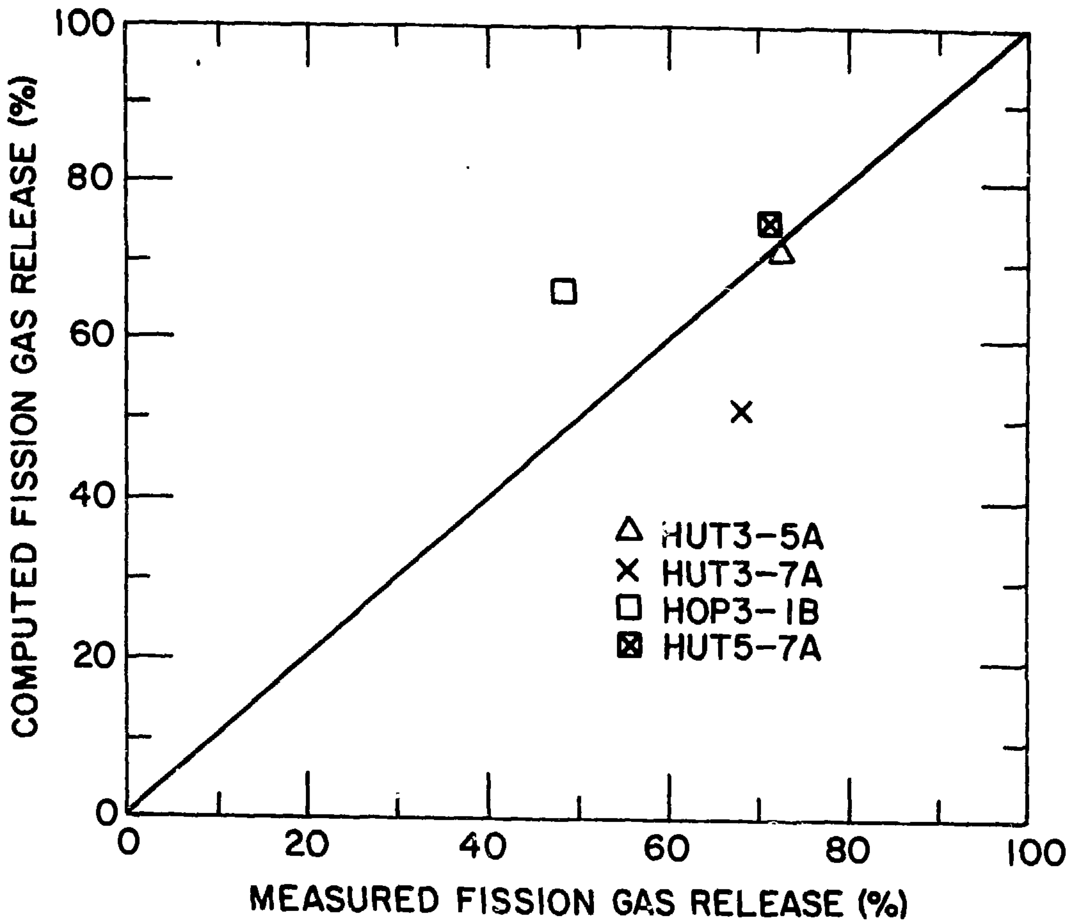
COMPUTED FISSION GAS RELEASE (%)
MEASURED FISSION GAS RELEASE (%)
0
20
40
60
80
100
HUT3-5A
HUT3-7A
HOP3-1B
HUT5-7A

Figure 1. LIFE-4/FASTGRASS-predicted Gas Release vs. Experimental Data.