Update of the U.S. DOE WG-MOX Fuel Test Program

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Mixed-Oxide (MOX) Fuel Irradiation Demonstration for the U.S. Department of Energy Fissile Materials Disposition Program (FMDP)

Purpose: Demonstrate Satisfactory Performance of MOX Fuel Fabricated From Weapons Components. Focus on Evaluation of Possible Impacts of Source Material Impurities – Principally Gallium.

Background: Weapons-Derived Plutonium Differs From Reactor-Grade Material in Isotopic Content. Also, the Level of Impurities (Additives For Weapons Purposes) Differs from European Experience.

- **Plutonium From Dismantled Weapons Components (High Concentration of ^{239}Pu)**
- **Fuel Pellets Made at Los Alamos to PWR Dimensions**
- **Fuel Pins and Test Assembly Designed at ORNL**
- **Assembled and Irradiated at the Advanced Test Reactor (ATR) at Idaho**
  - **Eleven Fuel Pins Irradiated**
  - **9.5 inch Rod Length – 15 Pellets per Rod (6 inch Active Fuel Length)**
- **Periodic Post-Irradiation Examinations (PIE) at ORNL Hot Cells (Building 3525)**

PIEs Completed on 6 of 11 Irradiated Capsules

- ~8.6 GWd/MT burnup
  - Final report; ORNL/MD/LTR-172, November 1999
- ~21 GWd/MT burnup
  - Final report; ORNL/MD/LTR-199, December 2000
- ~30 GWd/MT burnup
  - Final report; ORNL/MD/LTR-212, Vol. 1, October 2001
  - "Implications of the PIE Results…," ORNL/MD/LTR-212, Vol. 2, November 2001

Linear Heat Generation Rates (LHGRs) in the MOX Test Irradiation Exceed the U.S. PWR Average

U.S. PWRs:

- Average power: 5.2-6.7 kW/ft
- Peak axial power in average power rod: 6.4-8.4 kW/ft

Disposition Mission Fuel:

- < 6 kW/ft

WG MOX Tests:

- As-run LHGRs for withdrawn capsules

	Irradiation Phase	EFPDs	8.6 GWd/MT		21 GWd/MT		30 GWd/MT		40 GWd/MT	
Capsule			1	8	2	9	3	10	4	13
	I	154.9	8.24	8.26	7.93	8.09	7.85	8.07	5.86	5.90
	II	227.7			8.19	8.27	8.08	8.30	8.99	9.11
	III-Part 1	232.4					5.40	5.57	5.67	5.73
	IV-Part 1	287.4							5.18	5.21
FGR (%)					1.45	1.97	1.50	2.26		

- Many more thermal cycles than normal commercial experience

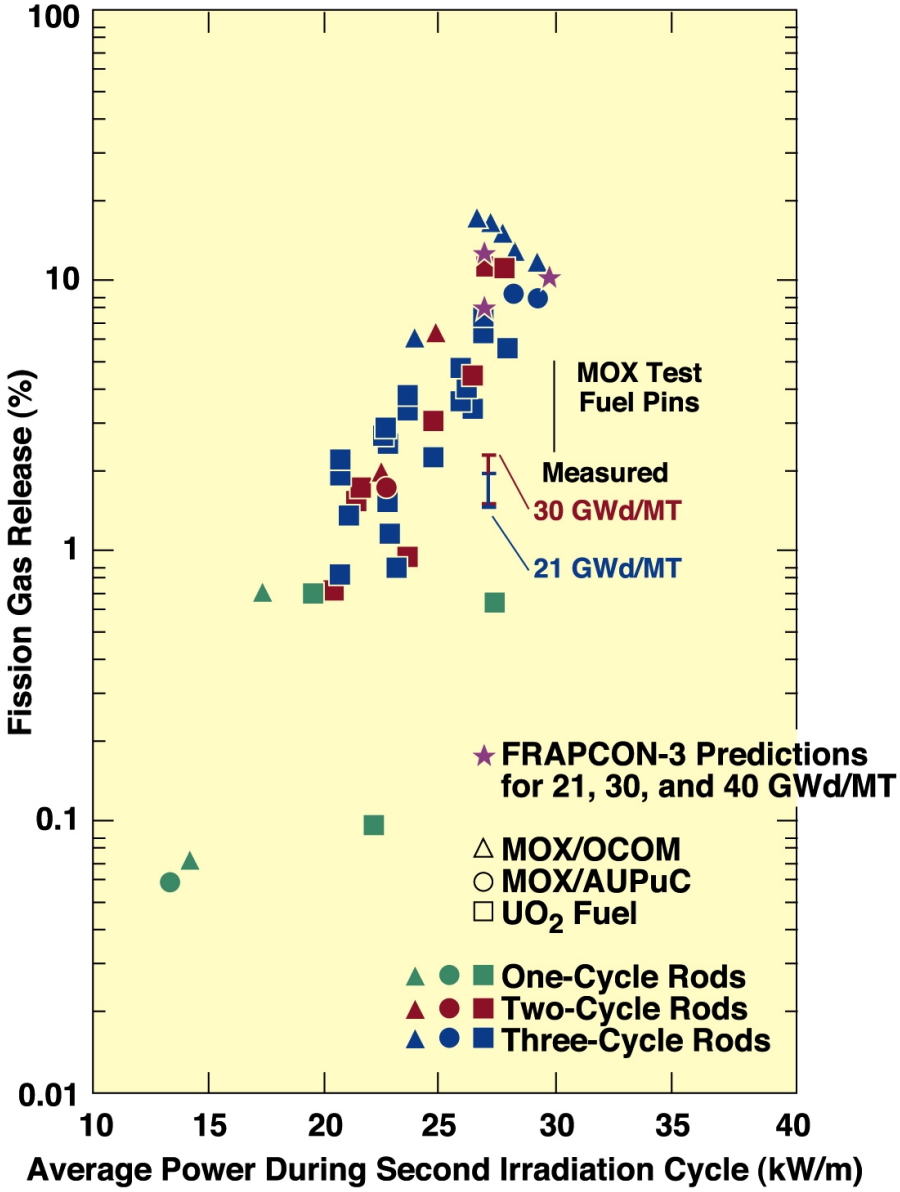
Test Capsules 4 and 13

- Irradiation completed on 9 March 2002
  - 902.4 EFPDs
  - Final burnup of ~38.9 GWd/MT (MCNP estimates)
- Received in ORNL hotcells on 22 April
- Non-destructive examinations completed (9 May)
  - Capsule dimensions and temperatures
  - Capsule gamma scans
  - No abnormalities observed
- Fission gas measurements (week of 29 July, delay required for ^{131}I decay)
- Fuel pin profilometry and volume back-fill (mid-August)
- Metallographic mounts, samples for Ga and burnup analyses, etc. (fall 2002/winter 2003)
- Quick look report (end-November)
- Final PIE report (June 2003)

Test Capsules 5, 6, and 12

- Irradiation to be completed in Fall of 2003
  - Capsule 5
    - ~1433 EFPDs
    - ~49 GWd/MT burnup
  - Capsules 6 and 12
    - ~1279 EFPDs
    - ~50 GWd/MT burnup
- Final PIE report (December 2004)

The MOX Test Fuel Pins Exhibit Gas Release Fractions in Accordance with Linear Heat Generation Rate Experience



*Fission gas release as reported by Goll et al. (1993)

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UT-BATTELLE

ORNL 2002-0154C EFG

This WG-MOX Fuel Exhibits Normal Swelling, Densification, and Fission Gas Release.

Important Findings:

1. Outward clad creep due to lack of external coolant pressure.
2. No significant difference between TIGR-treated and non-TIGR-treated MOX fuel performances.
3. Gamma scans and burnup analyses are in accordance with MCNP code predictions. Observed fuel swelling is as expected from CARTS and FRAPCON-3 code predictions.
4. The gas release fraction (implied from pressure and ^{85}Kr activity measurements) is within expectations based on the European MOX experience.
5. Pellet densification is prototypic of commercial MOX fuel. (~2%)
6. Clad outward creep is about 0.015 mil per GWd/MT of burnup.
7. No evidence of gallium migration to the clad.
8. This test fuel prepared with weapons-derived plutonium is behaving as expected.

More Severe Test Conditions Bound Mission Fuel Predictions

- Higher LHGRs
  - Higher fuel temperatures
- More thermal cycles
- Very small initial pellet-to-clad gaps
- Larger PuO_2-rich agglomerates
  - Less homogeneous fuel
- Much greater concentrations of gallium
- Higher plutonium concentration

Session on "WG-MOX Fuel Research and Development" at the 2002 ANS Spent Nuclear Fuel and Fissile Materials Management Topical, Charleston, South Carolina, USA, 17-20 September 2002

- First public release of information on the U.S. DOE MOX Fuel Test Program
- Five papers (ORNL and INEEL)
- Web site http://ans.snffmm.org/