Status of the U.S. Plutonium Disposition Program

L. J. Ott
Oak Ridge National Laboratory

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Outline of Presentation

- Status of U.S. Plutonium Disposition Program
- Update on DOE MOX Fuel (Pu from weapons components) Irradiation Experiment

Preferred Domestic U.S. Option*

- MOX-based reactor disposition with high quality Pu (some material, formerly slated for immobilization, purified in enhanced MOX Fuel Fabrication Facility)
  - All 34 MT of U.S. plutonium to be converted to MOX and irradiated
  - **No** immobilization [Plutonium Immobilization Plant (PIP) canceled]
  - Total life cycle cost implemented over 20 years: ~$3.84 billion
    - Pit Disassembly and conversion Facility (PDCF): ~1.69 billion
    - MOX FFF: ~$2.15 billion
  - Savings of ~$2-3 billion from March 2001 cost report
    - Elimination of PIP
    - Optimized PDCF
    - Shortened operating lifetimes
  - Peak yearly funding reduced by sequential construction of MFFF and PDCF
  - Results in removal from SRS of **all** surplus defense plutonium
  - Facilitates closure of Rocky Flats Plant by 2006 and removal of Pu from other DOE sites

*NNSA report submitted to Congress February 15, 2002

U.S. Pu Disposition Program

- Pit Disassembly and Conversion Facility
  - To be built at the SRS
  - Completion of design: 2004
  - Equipment procurement and site preparation: 2005-2006
  - Start of construction: 2006
  - Startup: 2009
  - Industrial-scale operation: 2010-2017
- MOX Fuel Fabrication Facility
  - To be built at the SRS (DOE's January 2000 ROD)
  - A consortium of Duke, COGEMA, Stone & Webster (DCS) will design, construct, and operate the facility
  - Completion of design – 2003
  - Start of construction – 2004
  - Start-up – 2007
  - Industrial-scale operation – 2008
- MOX fuel qualification
- MOX FFF licensing

U.S. Pu Disposition Program
MOX Fuel Fabrication Facility (MFFF)

- Quality Assurance (QA) plan
  - Submitted by DCS – June 2000
  - Approved by NRC – October 2001
  - Revision 3 submitted by DCS – March 2002
  - Revision 3 approved by NRC – January 2003
- Environmental Report (ER)
  - Submitted by DCS – December 2000
  - NRC public scoping meetings – April 2001
  - NRC EIS scoping document issued – August 2001
  - Updated ER – submitted by DCS July 2002
  - NRC issued draft EIS for public comment – February 2003
  - Target date for final EIS – September 2003
- Construction Authorization Request (CAR)
  - Application submitted by DCS – February 2001
  - Draft SER issued – April 2002
  - Updated CAR – submitted by DCS October 2002
  - Target date for final SER – September 2003
  - Target date for licensing decision – September 2003
  - Start of construction (if authorized) – October 2003

U.S. Pu Disposition Program
MOX Fuel Qualification

- FANP as subcontractor to DCS
- July 2000, MOX fuel qualification plan (FQP) submitted to NRC
- July 2000, MOX LA project at LANL canceled
- April 2001, revised FQP submitted to NRC
- Lead Assemblies (LA)
  - Fabricate LAs in Europe with U.S. PuO_2
  - Insertion in McGuire NPP in Spring 2005

U.S. Pu Disposition Program

- Estimated life cycle costs for PDCF and MFFF are ~$3.8 billion (including credits for LEU fuel displaced by MOX fuel)
- Revised approach
  - Focus on MOX/irradiation – key to bilateral agreement with R.F.
  - Sequential design and construction of major U.S. facilities
    - Proceed with MFFF design
    - Followed by PDCF design
  - Completes disposition mission within original timeframe and supports U.S./R.F. agreement

RF Design for MOX Fuel Facility Being Integrated with DCS Design Efforts

- Build-to-print design concept was accepted by RF in Fall of 2002
- Current efforts (TVEL/ORNL/DCS contract) are focused on obtaining a licensed RF MFFF design patterned after the DCS plant*

*which is patterned after the French MELOX plant

NRC Has Established a Website Containing Current Information on Licensing Activities for the MFFF

- **August 2000, NUREG-1718 (Standard Review Plan for MFFF) issued by NRC**
- **March 2002, NRC web-site for MOX licensing activities http://www.nrc.gov/materials/fuel-cycle-fac/mox/licensing.html**
- **Links for**
  - **License applications**
  - **NRC staff guidance documents**
  - **MOX fuel newsletter**
  - **Frequently asked questions**
  - **Upcoming meetings**
  - **Mechanism for providing public comment**
  - **Additional information**

Summary of U.S. Program Status

- All facets of U.S. Disposition Program (MFFF, fuel qualification, etc.) appear to be on schedule
- No significant changes in scope or direction of program

Update on 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 8 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
- ~40 GWd/MT burnup
  - Final report; ORNL/MD/LTR-241, Vol. 1, June 2003
  - "Implications of the PIE Results…," ORNL/MD/LTR-241, Vol. 2, July 2003

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

U.S. PWRs:

- Average power: 17–22 kW/m
- Peak axial power in average power rod: 21–28 kW/m

Disposition Mission Fuel:

- < 20 kW/m

WG MOX Tests:

- Average as-run LHGRs (kW/m)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	27.03	27.10	26.02	26.54	25.75	26.48	19.23	19.36
	II	227.7			26.87	27.13	26.51	27.23	29.49	29.89
	III-Part 1	232.4					17.72	18.27	18.60	18.80
	IV-Part 1	289.1							16.99	17.09
FGR (%)					1.33	1.89	1.47	2.29	7.63	8.46

- Many more thermal cycles than normal commercial experience
- Capsules 4 and 13: 3 cycles in Phase II (84.8 EFPDs) at LHGRs of 32.8–35.4 kW/m

Test Capsules 5, 6, and 12

- Irradiation to be completed in January of 2004
  - Capsule 5
    - ~1465 EFPDs and ~49.8 GWd/MT burnup
  - Capsules 6 and 12
    - ~1310 EFPDs and ~50.4 GWd/MT burnup
- Average as-run LHGRs (kW/m) for 50 GWd/MT capsules

Capsule	Irradiation Phase	EFPDs	5	6	12
	I	154.9	19.95	—	—
	II	227.7	23.12	24.98	25.30
	III-Part 1	232.4	17.85	19.00	19.23
	III-Part 2	113.1	13.29	20.81	21.23
	IV-Part 1	289.1	13.58	17.78	17.94
	IV-Part 2	110.2	16.56	19.02	19.25
	IV-Part 3*	337.4	13.04	14.28	14.38

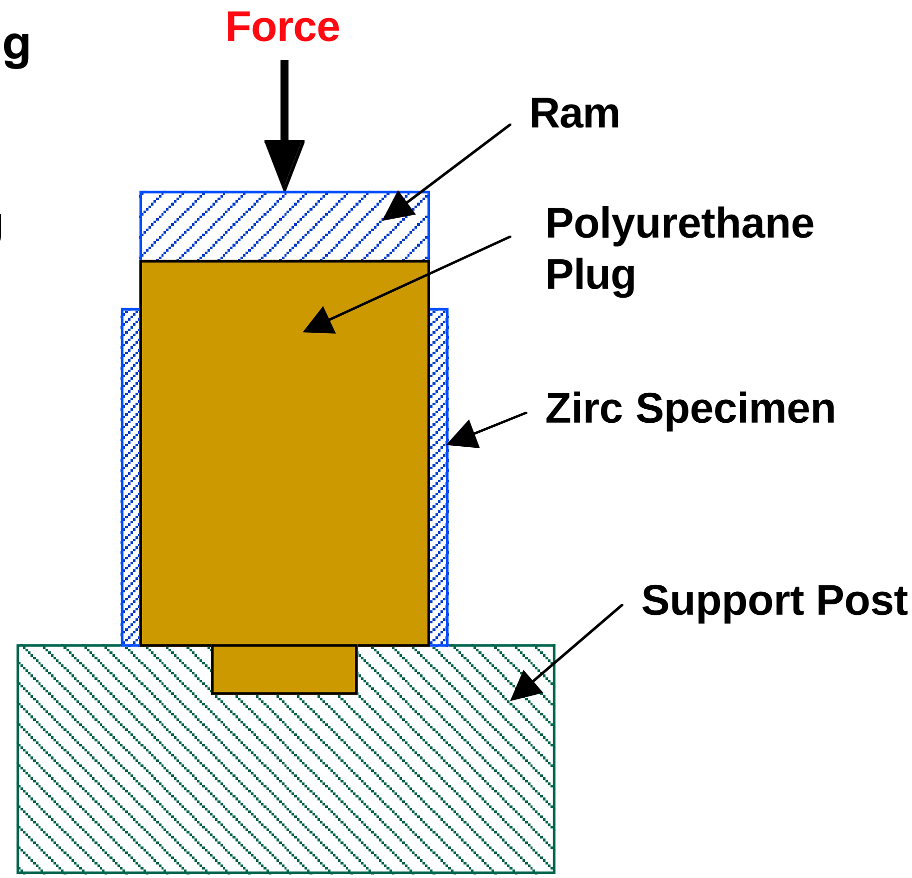
*4 of 8 cycles are based on projected values

The MOX Test Irradiation Is Ideal for Revealing Any Effects of Gallium Because There Is No Masking by Hydride-Induced Clad Damage

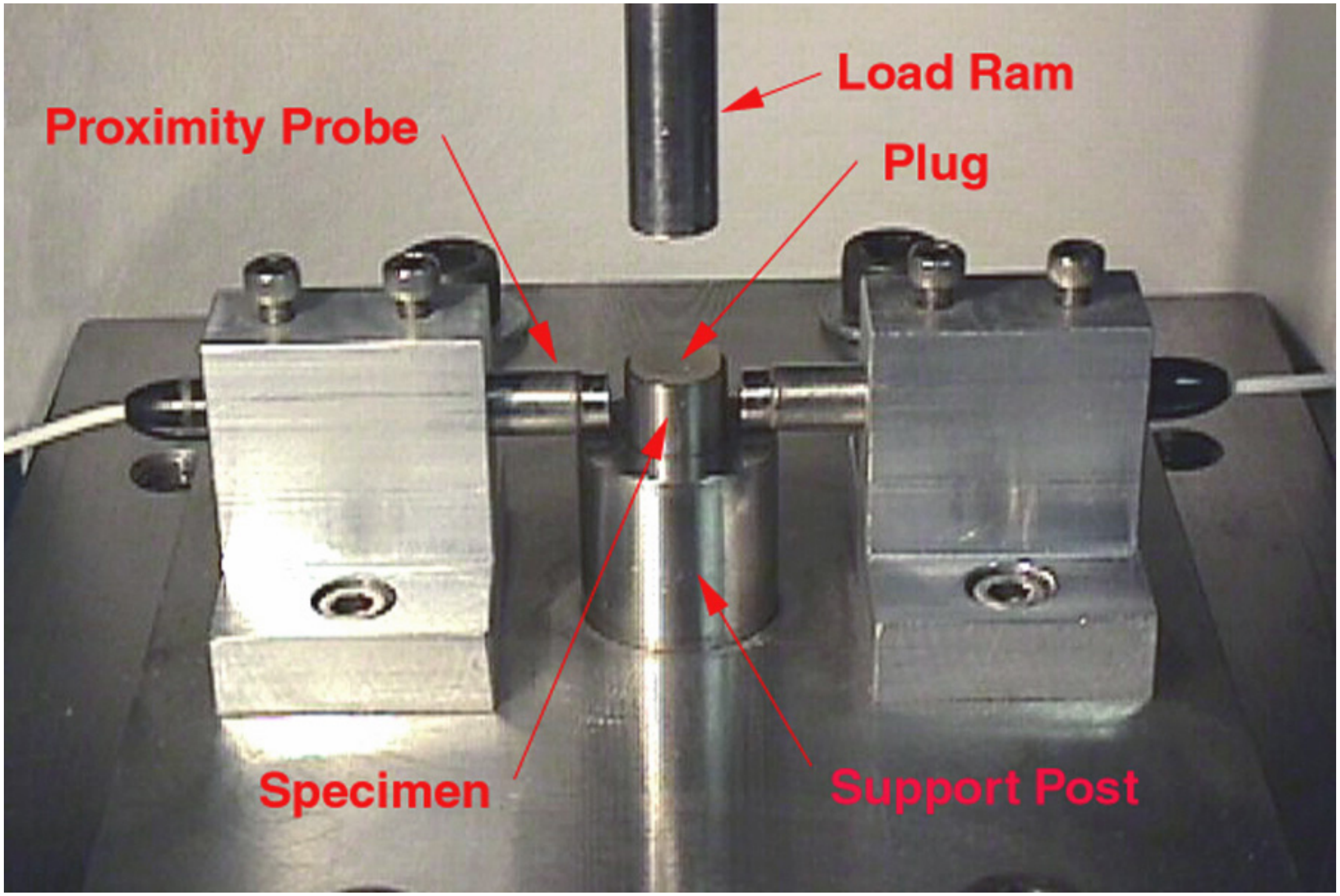
- **Without hydrides, have only effects of fast flux**
  - **Similar to cold-working**
  - **Irradiated clad should withstand uniform strain of 3%–5%**
- **MOX test claddings**
  - **Have no hydrides**
  - **Prototypic integrated fast flux**
  - **0.6 to 4.8 ppm gallium in fuel**
  - **Clad tensile stress (in ORNL hot cells)**

ORNL Has Developed an Improved Loading Concept for Ductility Testing of the MOX Irradiation Cladding Specimens

- Compression of a polyurethane plug fitted inside a short cladding ring specimen
  - Forces expansion similar to swelling of fuel
  - Produces essentially uniform wall stress
- Several specimen prep/testing simplicities
  - No specimen machining
  - Strain is uniform around clad ring
  - Circumferential strain is simply the diameter increase divided by the initial diameter

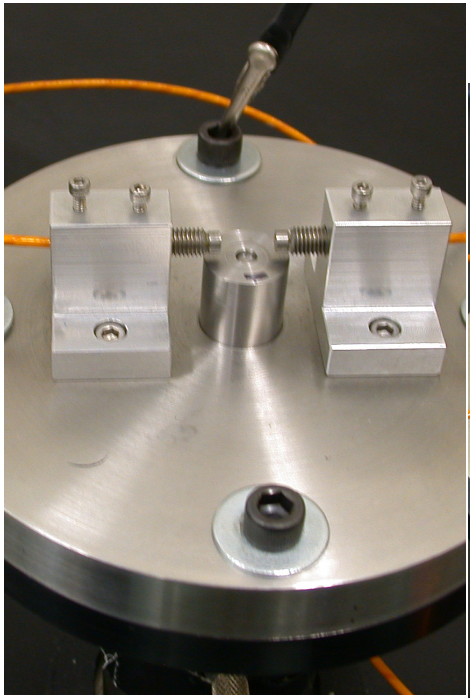


Strain Is Measured Continuously Via Proximity Probes that Do Not Touch the Specimen

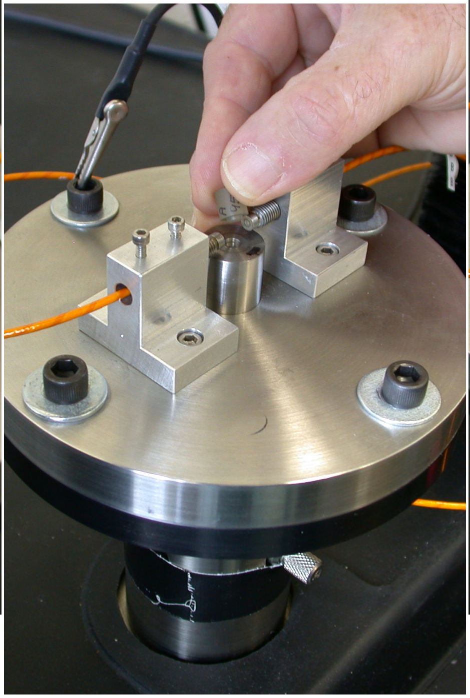


Component Assembly Is Straightforward and Readily Adaptable for Use With Hot-Cell Manipulators

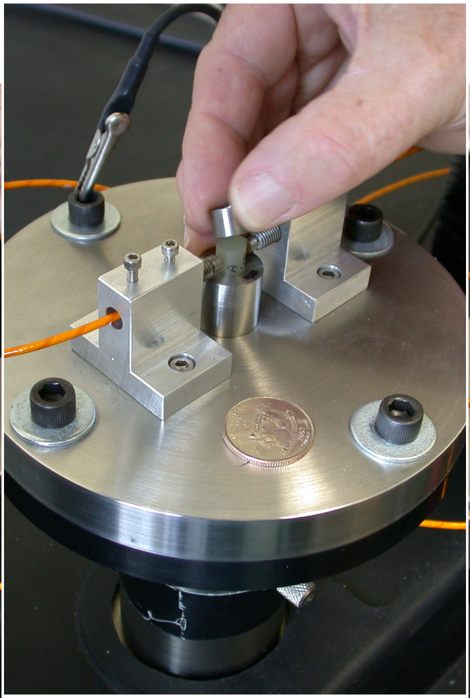
Test fixture



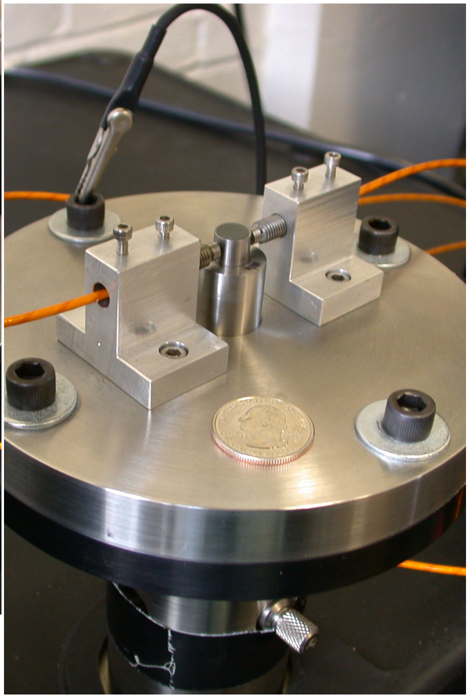
Mount plug



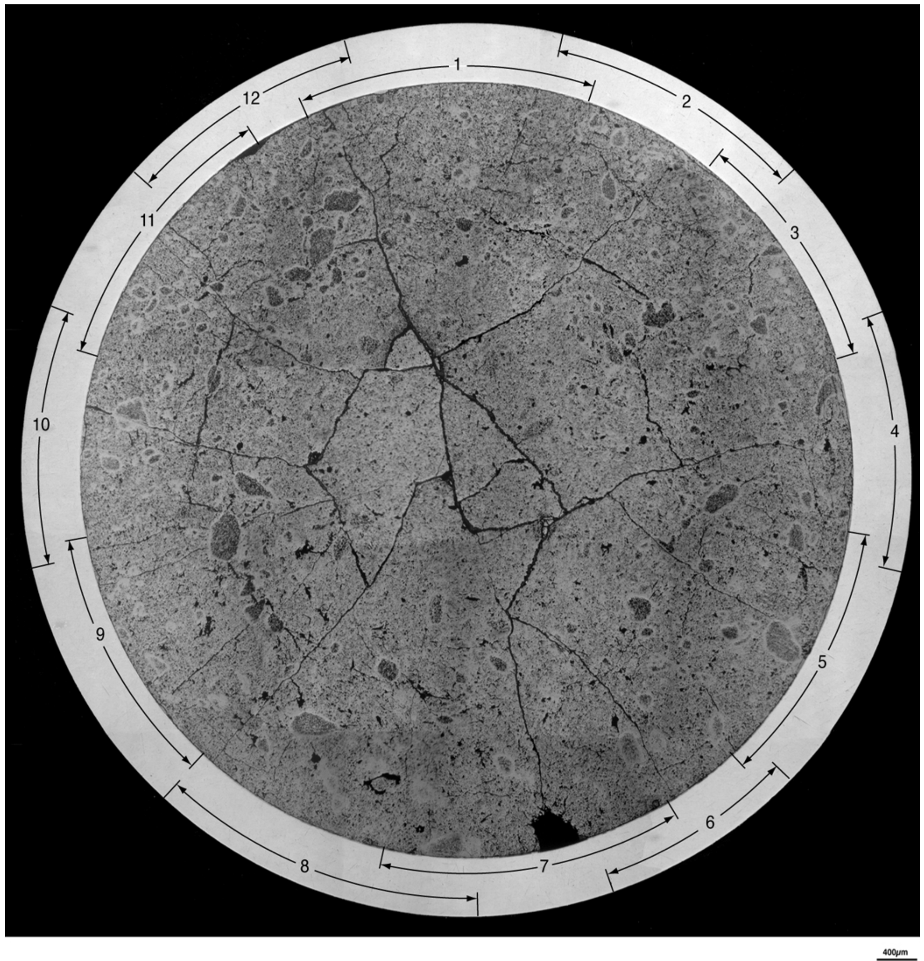
Slip specimen over plug



Specimen ready for test

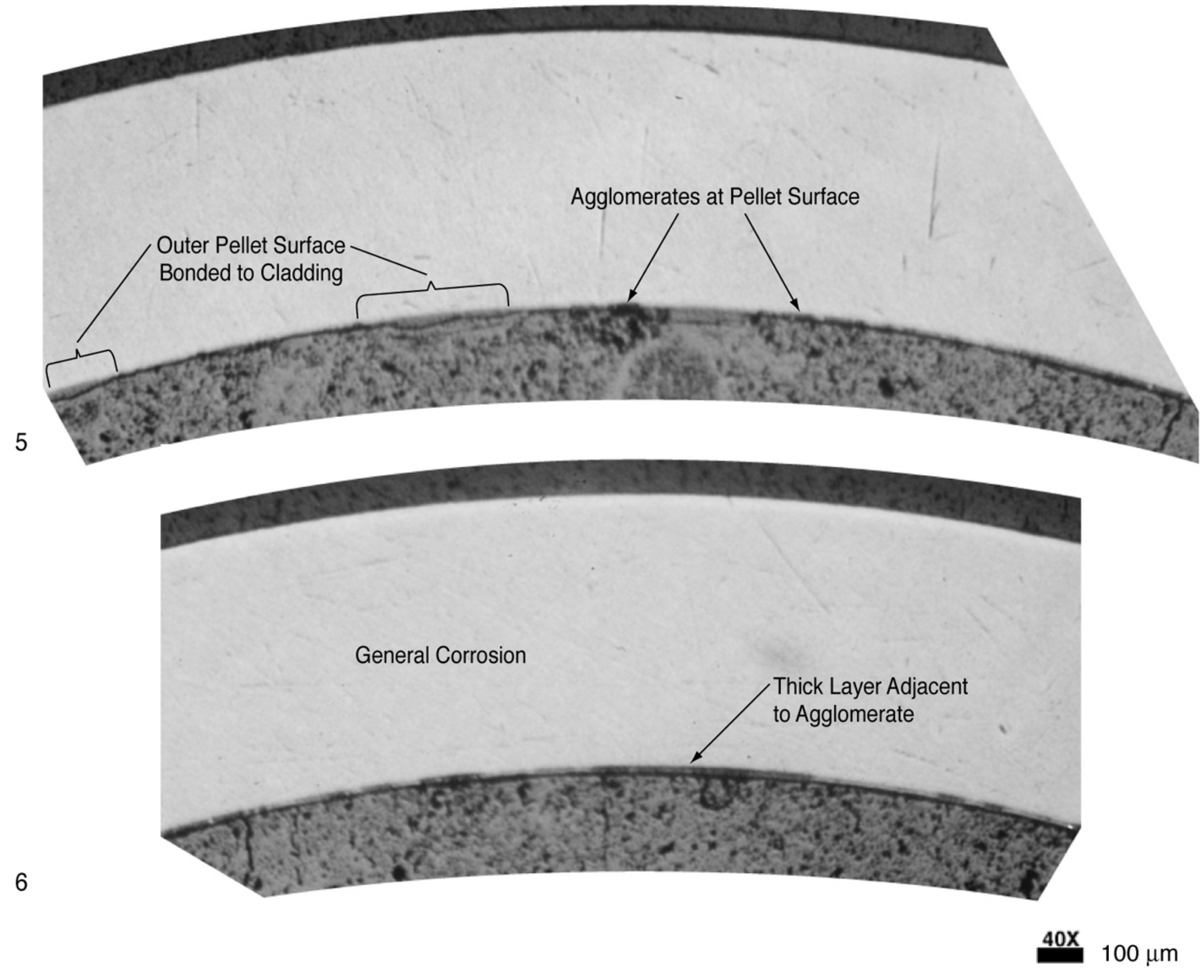


Conditions at the Pellet-Clad Interface Are of Interest for the 40 GWd/MT PIE



Fuel Pin 16 – Pellet 15 – Upper Surface – Mount 6225

Pellet-Clad Interface
4:00 ↔ 5:30



Fuel Pin 16 – Pellet 15 – Upper Surface – Mount 6225

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. Slight difference between TIGR-treated and non-TIGR-treated MOX fuel performances. (clad creep and FGR)
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 slightly below 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.