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NRC MOX Fuel Qualification Program Update Meeting

2nd Cycle PIE Results

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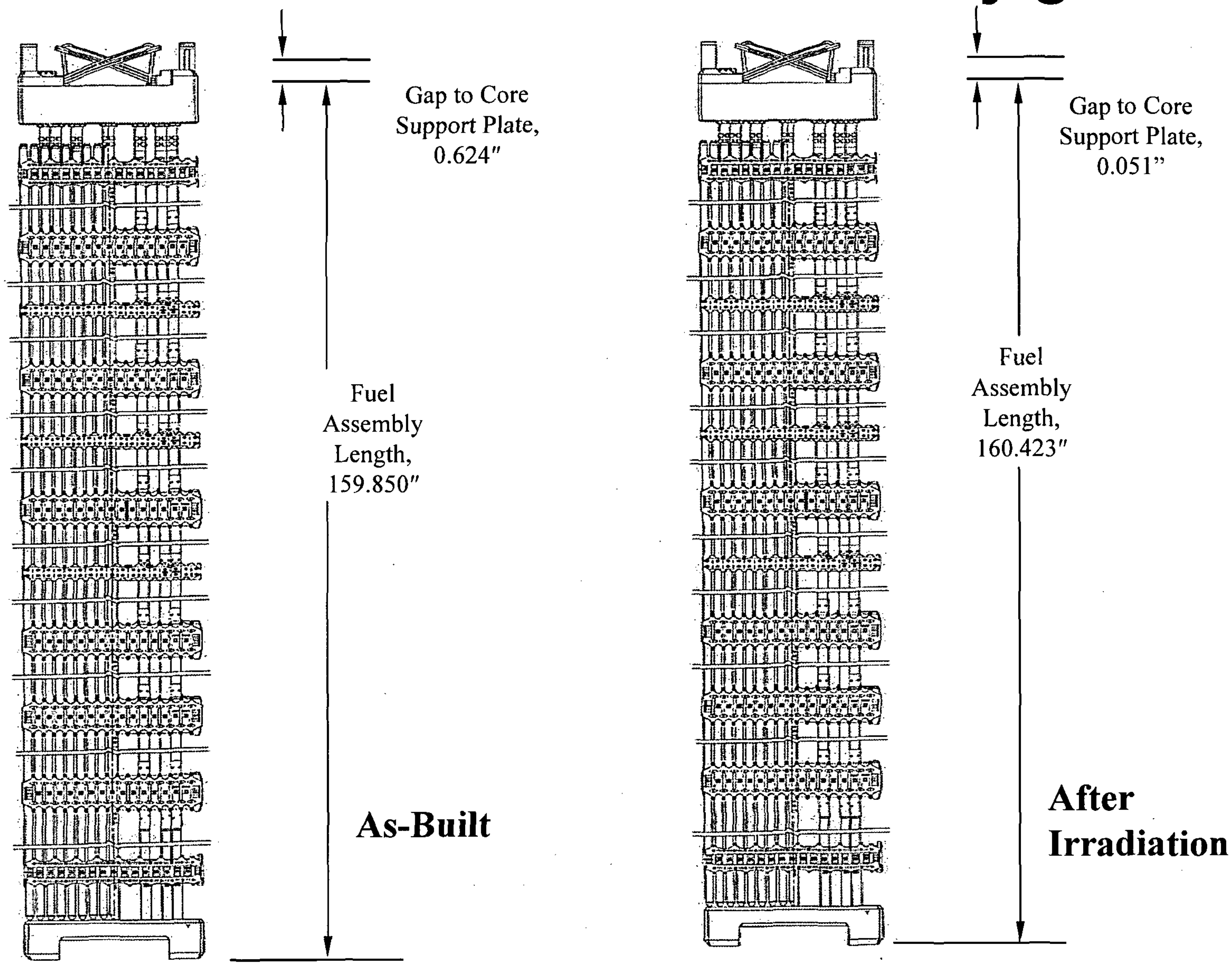
MOX Exams completed

- Assembly Length
- Visuals
- Shoulder Gap
- Fuel Rod Growth
- Fuel Assembly Distortion
- Fuel Rod Distortion (Water Channel)
- Holddown Spring Rate
- Holddown Spring Free Height
- Peripheral Fuel Rod Oxide
- Transverse Grid Growth
- Internal Guide Tube Oxide

MOX Results: Assembly growth



MOX Results: Assembly growth

- Measured growth at end of 2nd cycle was higher than expected at the established burnup
- Dipstick measurements confirmed with measuring tape
- Fuel did not experience hard contact during operation
- Fuel was discharged pending disposition

MOX Results: Visuals

MOX Preliminary Results – Fuel Assembly Length

MOX Results: Shoulder gap

MOX Results: Fuel Rod Growth

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MOX Results: Assembly distortion

MOX Results: Rod bow

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MOX Results – Fuel Rod Distortion

MOX Fuel rod images

MOX Results: Holddown spring rate and free height

MOX Results: Peripheral Fuel Rod Oxide

MOX Results: Grid Transverse Width

MOX Results: Internal guide tube oxide

MOX Results: Summary

Upcoming Hot Cell Exam

Dry Route DUO_2

29 October 2008

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Background

- **MFFF needs 820 MT of DUO_2 powder from 2016 to 2030 to produce MOX fuel.**
- **MOX Services baseline is Wet Route (WR) processed Uranium from depleted UF_6.**
- **But today, the standard route for producing UO_2 Powder is now Dry Route (from DUF_6 [gas] to UO_2 by pyrohydrolysis).**

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Wet Route

- Historical technology.
- Due to the dissolution process in nitric acid uranium conversion, the plants would have to handle liquid effluents containing ammonium nitrate.
- High number of chemical contaminated solid waste (HEPA filters).
- Plants have or will shut down (Pierrelate France).

Dry Route

- New reference technology worldwide.
- Generate much less effluents with typically far fewer chemical constituents.
- LEU fuel business has almost entirely switched to Dry Route (DR).

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AREVA NP Dry Conversion Process

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AREVA NP Dry Conversion History

UO_2	1981-1983	Pilot plant operation
	1984-1986	Development in prototype system
	1993-1997	Prototype in production (100 MTU/yr)
	1993-	400 MTU/yr plant on-line in Germany
	1997-	1200 MTU/yr plant on-line in U.S.
MOX	2003-	First MOX fuels in 900 MW, 3 loop reactor

All UF_6 Conversion in AREVA NP is Dry Route.

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Qualification of Dry-Process Uranium in LEU fuels

U.S. Experience – early 1990's

– AREVA purchased pellets from Siemens (Richland)

- Transition to dry-process UO_2 was qualified extensively
  - Physical examinations of pellets, including microstructure
  - Qualification was completely "internal" – between purchaser and supplier
  - No changes relative to fuel design or performance

Qualification of Dry-Process Uranium for MOX

- At the beginning of 2009 MELOX Reference Plant will use DR powder for producing MOX batches and to qualify the process.

- The completed switch to DR is expected in about three years.

DR Performance

- MELOX produced MOX fuel with DR powder in 2003.
- The fuel was irradiated in a 3-loop 900 MW reactor.
  - Rods have been extracted after 3 cycles : 45 Gwd/MT
  - Rods have been extracted after 4 cycles : 52 Gwd/MT
- Those rods will be shipped this year to "hot cells" and results will be available in mid-2009.

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Use and Qualification of DR UO_2 Powder for MOX

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Use and Qualification of DR UO_2 Powder for MOX

- In 2009, the following PIEs are planned:
  - 3-cycle: Non-destructive examinations on one DR and on one ADU, three punctures and gas analysis.
  - 4-cycle: Non-destructive examinations on one DR and on one ADU, five punctures and gas analysis, destructive examinations (metallographies and density measurements) on one DR rod.
- Those hot cell examinations are comparable with Oak Ridge U.S. MOX examination program.

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Microstructure of the standard non-irradiated MOX MIMAS

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X-Ray maps Frewitt sieved fuels

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Cumulated Surface Fraction of Pu Rich Agglomerates

Effect on Fission Gas Release

- MOX DR microstructure is characterized by larger UO_2 spots, but it is a technical non-issue and the surface fraction occupied by these UO_2 spots is similar to the reference fuels.
- Similar distribution of the PuO_2 rich and coating phase areas.
- Fission product distribution simulation gives similar results to the reference fuels (mainly due to the fact that the size and distribution of the Pu rich agglomerates are similar).

[Same FGR behavior is expected]

Dry Route Changes for MELOX

- DR will only affect the uranium feeding hoppers.
- DR will not affect the Primary Blend characteristics which are determined by the performances of the Ball Mill and Sieving Processes.
- Previous mixing results in MELOX are showing that DR U does not affect the Pu rich particles size.

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Impact for MFFF ?

- Switch to DR is a natural evolution.
- The European database (i.e., demonstration program with 'hot cells' results) will be large and comprehensive.
- MFFF changes would be consistent with existing licensing basis
- May be minor editorials in process description
- Not switching would make MFFF diverge from future European fuel performance database.

Qualification of Dry-Process Uranium for MOX

Expectations for MFFF and Fuel Designer in US

- ♦ Follow MELOX – adopt same type of Uranium
  - Qualify product by comparison to MELOX product
    - Physical examinations of pellets, including microstructure and resintering data
  - Use hot cell PIE data from MELOX-produced lead rods to benchmark Fuel Performance Code Models

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Potential Schedule

- Base Plan
  - Demonstration using existing and future data
- 2009: Hot Cell Results
  - Benchmark Fuel Performance Codes
- 2010: New reload in European Reactor
- Starting 2010: Operating experience

- 2016: MFFF start-up

Documents Impacted

- **MOX Fuel Qualification Plan (information document) will be revised to incorporate all changes.**
- **MOX Fuel Design Report (BAW-10238) will be updated to identify all changes relative to the MOX LTA design.**

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Conclusion

- **MFFF must be attentive to Ref-plants and industry evolutions.**
- **Expectations that the fuel performances are not affected by the conversion route chosen for uranium.**
- **Data to confirm this is expected mid 2009.**