FRAMATOME ANP

Revisions to "MOX Fuel Design Report"

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Revisions to Report

- NRC concerns with Rev. 0
- Highlights of technical changes to report, chapter by chapter
- General changes in response to concerns

Concerns with Rev. 0

- Needed clearer focus on what specific approvals were being requested
- Needed to better identify relationship to other submittals
- Needed to include more specific data to support the application

Chapter 1: Introduction and Summary

- *Provided a clear statement of what is being submitted for approval:*
  - *Approval of MOX lead assemblies for two cycles*
  - *Approval of fuel design for batch implementation (maximum rod burnup 50 GWd/MThm)*
  - *Approval of lead assembly for a 3rd cycle (beyond 50 GWd/MThm but not beyond 60 GWd/MThm)*
- *Identified related topical reports*

Chapter 2: MOX Design Considerations

- > Added section on mixed cores
  - Details of methodology are in Duke reports on neutronics and thermal-hydraulics
- > Updated typical isotopics for consistency

Chapter 3: Weapons-Grade Plutonium

- Provided better explanation and justification for using nuclear analysis methods for RG and LEU fuel to model WG MOX
- Expanded discussion of U/Pu ratio in master mix
- Updated tables and figures to reflect current calculations

Chapter 3: Weapons-Grade Plutonium

- ***Provided additional discussion on WG MOX pellet microstructure***
  - ***UO_2 matrix establishes pellet microstructure***
  - ***Grain size, particle size, and particle distribution same since same process parameters used (blending, sieving, pressing, and sintering)***
  - ***Local heating in agglomerates same (or less severe in WG MOX) because:***
    - ***Particle size same***
    - ***Master mix adjustment maintains or reduces density of fissile nuclei in the Pu-rich agglomerates***

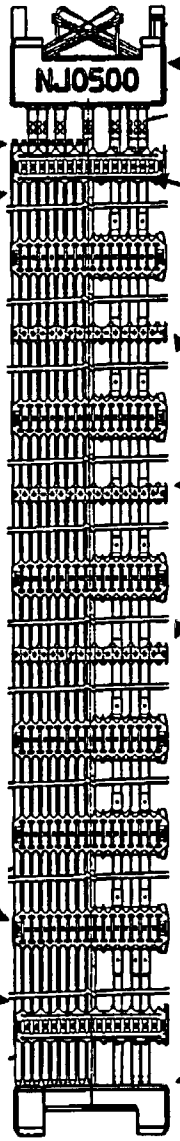
Chapter 4: Manufacturing Processes

- MIMAS (MIcronized MASter mix) process
  - Is proven and established
  - Is used in European MOX plants
  - Will be used for the lead assemblies
  - Will be used in the MFFF

Chapter 5: Assembly Description

- MOX fuel assembly design is the Advanced Mark-BW design with WG MOX pellets
- Changes to report are minor:
  - Corrected terminology for mid-span spacer grids
  - Increased burnup limit for Advanced Mark-BW (not Mark-BW/MOX1) to reflect recent submissions
  - Adjusted precision of some values
  - Moved discussions of Pu isotopics to Chapter 3

Advanced Mark-BW Design Features



Top Nozzle
Inconel 718 Leaf Springs & Spring Screws

Inconel Top
End Grid

M5™ Structural Tubing

M5™ Fuel Rod
Cladding

M5™ Mixing-Vane
Intermediate Grids

M5™ Mid-Span Mixing Grids

M5™ Vaneless
Intermediate Grid

Inconel Bottom
End Grid

TRAPPER™
Bottom Nozzle

Chapter 6: Design Evaluation

- Provided linear heat rate for 1% transient cladding strain
  - [28.9 kW/ft at 20,000 MWd/MThm]
  - [16.2 kW/ft at 50,000 MWd/MThm]
- Provided fatigue utilization factor: [ ]
- Provided limit on cross-flow velocity, 2 ft/s, and predicted maximum, [ ]

Chapter 6: Design Evaluation

- Provided more detail on M5™ parameters for hydrogen
  - Pick-up rate, [ ]
  - Allowable hydrogen content, [ ]
  - Predicted content at end of life, [ ]
- Provided additional clarification and discussion on
  - Fuel rod bow
  - Fuel rod axial growth and end-of-life pressure
  - Assembly liftoff

Chapter 6: Design Evaluation

- Provided minimum linear heat rate for centerline fuel melt
  - [ ]
  - [ ] at end of life
- Revised discussion of fuel coolability for consistency with Duke's License Amendment Request
- Provided proprietary figure on oxide thickness

Chapter 7: Experience Base

- **Strengthened discussion of U.S. experience, added discussion of Saxton reactor MOX**
  - **94 ± 2 % dense**
  - **6.6% PuO_2**
  - **90.5% ^{239}Pu**
  - **51,000 MWd/MThm**
  - **No failures attributed to use of MOX**

Chapter 7: Experience Base

> **Updated discussion of the European experience base**

- **German experience now includes**
  - **Philippsburg 2: [ ]**
  - **Neckar 2: [ ]**
  - **Grafenrheinfeld: [ ]**
  - **Brokdorf: [ ]**
- **New information on European MOX failures: [ ],**

  no failures attributed to MOX

Chapter 7: Experience Base

- Over 500,000 MOX rods irradiated
- Updated
  - List of plants using MIMAS MOX
  - Information on discharge burnups
  - Information on Mark-BW and MOX burnup experience

Chapter 8: Lead Assembly Program

- Clarified and updated discussion of fabrication
- Expanded discussion of examinations, classified into 3 levels
  - Required poolside PIE each cycle
  - Additional poolside PIE, to be performed as needed (based on results of required PIE)
  - Updated scope of hot cell examination
- Clarified application of updated PIE acceptance criteria

General Changes

- Clarified and better focused on what specific approvals were being requested
- Clarified relationships to other topical reports
- Improved traceability to supporting data
  - Increased number of references from 15 to 38
  - Tripled number of citations
- Added proprietary supporting data

Summary

- Rev. 0 of report was reviewed and revised in light of NRC concerns
- Changes were made to
  - Focus the review
  - Improve / clarify relationship with other submittals
  - Provide better traceability to data sources

As a result, Rev. 1 is stronger, more detailed, and more traceable, to facilitate review and approval