Next Generation Fuel and MOX

For Nuclear Regulatory Commission Staff

April 23, 2004

Duke Power
A Duke Energy Company

MOX
MIXED OXIDE FUEL PROJECT

Enclosure 2

Agenda

- Introductions and Meeting Purpose Review
- Duke Presentation
- Additional NRC Staff Questions
- Wrap Up

Outline of Duke Presentation

- Introduction
  - Generic Reload Process
  - New Fuel Type Implementation
  - Reload Status for C1C16
- MOX Application Review
  - Review Process
  - Findings
  - Disposition
- Thermal-hydraulic Evaluation
  - Methods
  - Results
- Mechanical Evaluation
  - Methods
  - Results
- Safety Analysis LOCA Evaluation
  - Methods
  - Results
- Safety Analysis Non-LOCA Evaluation
  - Methods
  - Results
- Summary

Generic Reload Design Milestones

- Reload Design Work Governed by Approved Topical Reports
- Generic Set of Milestone Dates for Core Reload
- Generic Dates are Required to be Flexible
- Some Highlighted Generic Milestones

• Cycle Length Target	24 months prior to startup
• Loading Pattern Development	15 months prior to startup
• Final Fuel Cycle Design	13 months prior to startup
• Energy Requirements Notification	12 months prior to startup
• Specifying Number of Feed	
• Specifying Enrichment	
• Specifying Inserts	
• Complete Cycle Specific Physics & Safety Analysis	8 months prior to startup
• Last Fuel Shipment	2 months prior to startup
• Plant Data Book, Core Operating Limits Report	1 month prior to startup

Catawba 1 Cycle 16 and MOX Milestones

• Duke MNS/CNS Application Submitted to NRC	2/27/2003
• Duke limiting MOX Application to Catawba	9/23/2003
• Duke Targeting Catawba 1 Cycle 16 for MOX	September 2003
• NGF Introduced in Catawba 1 Cycle 15	1/2004
• Loading Pattern Development Complete	3/25/2004
• NRC Presentation	Today
• Station PORC Review	4/29/2004
• Energy Requirements Notification	May 2004
• LOCA Limits	September 2004
• Thermal-hydraulics Evaluation	September 2004
• Mechanical Evaluation	September 2004
• Reload Safety Evaluation	May 2005
• Expected Startup Date	June 2005

MOX Application Review

- Conducted a review of application submittal materials
- Used key technical individuals in several disciplines
- Process and results documented in corrective action program
- Results

Fuel Types in Presentation

Fuel Type Designator	Manufacturer	Common Name	Application
NGF	Westinghouse	Next Generation Fuel	8 Assemblies Catawba 1
Mark-BW	Framatome	Mark BW	Limited Reinserts
Mark-BW/MOX1	Framatome	Mark BW MOX	Planned for C1C16
RFA	Westinghouse	Robust Fuel Assembly	In Batch Use MNS and CNS since 2000

Robust Fuel Assembly (RFA) vs. Next Generation Fuel (NGF)

- **Dimensional / Mechanical Comparison**
  - NGF goal is to eliminate grid to rod fretting failure mechanism in 17x17 fuel
  - Basic geometry is 17x17 RFA described in DPC-NE-2009P-A, Westinghouse Transition Core Analyses, with improved features
  - Most components unchanged, following table highlights major items:

Feature	Change
Fuel Assembly Structure	Yes
Fuel Rod Diameter	No
Fuel Pellets	No
Burnable Absorber	No
Active Fuel Length	No
Fuel Assembly Debris Features	No
Fuel Rod Internal Design	Slight
Mixing Vane Grid Design	Yes
Fuel Assembly Nozzles	Slight
Fuel Cladding Materials	Slight

Mixed Core Thermal-hydraulic Analyses With NGF - RFA

- Most significant NGF - RFA change is in grid design, location, and performance
  - New grid structural support and revised mixing vane geometry
  - Number of grids increased
- Change affects pressure drop and DNB performance
  - Results in increased ΔP
  - DNB calculated with existing RFA CHF correlation. Acceptable NGF DNB performance verified by CHF testing at Columbia University in 2003
- Modeled in VIPRE-01 as a single NGF assembly surrounded by remaining core of RFA fuel
- Fuel reliability evaluated by analyzing fuel assembly crossflow velocities

Mixed Core Thermal-hydraulic Analyses With MkBW/MOX1 - RFA

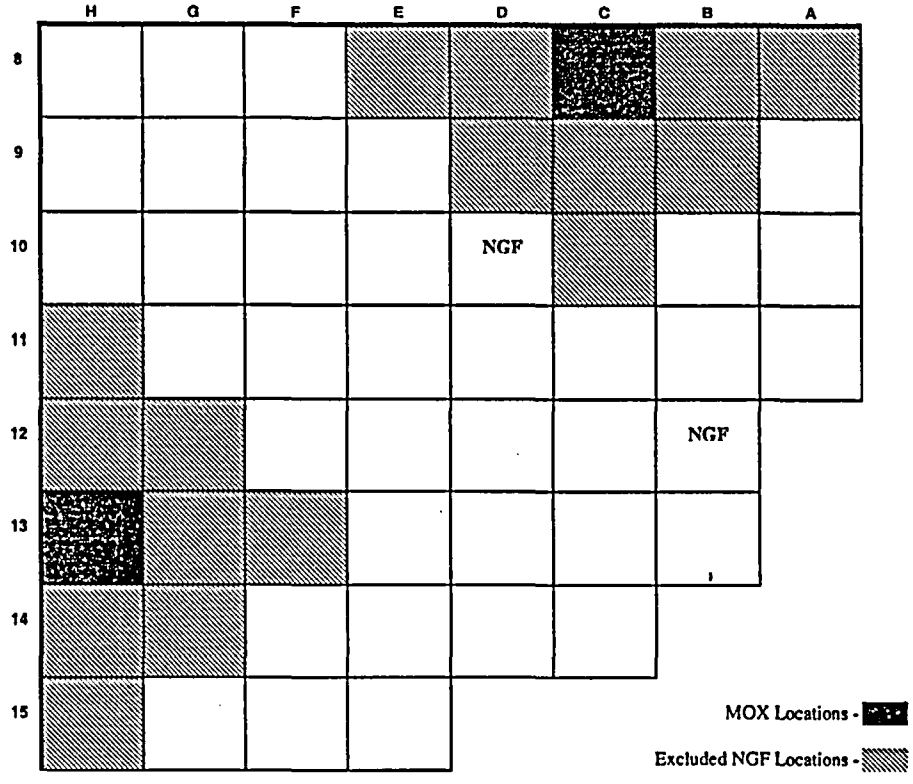
- Most significant MkBW/MOX1 - RFA difference is in grid design and CHF correlation
  - Different grid design between fuel types
- Difference affects pressure drop and DNB performance
  - Similar ΔP
  - DNB calculated with existing licensed CHF correlation for MkBW/MOX1 fuel
- Modeled in VIPRE-01 as a single MkBW/MOX1 assembly surrounded by remaining core of RFA fuel
- Fuel reliability evaluated by analyzing fuel assembly crossflow velocities

Crossflow

- Exclusion area applied to core loading pattern
- Prevents loading NGF assemblies adjacent to MkBW/MOX1 assemblies
- Precludes any local crossflow issues

C1C16 Exclusion Locations

Excluded NGF Core Locations With MkBW/MOX1



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Fuel Rod Mechanical Analysis Methodology

Fuel Design	Topical Report	Analysis	Code
RFA	DPC-NE-2009P-A, Westinghouse Transition Report	Duke	PAD
NGF	DPC-NE-2009P-A, Westinghouse Transition Report	Duke	PAD
MkBW/MOX1	BAW-10231P-A, COPERNIC Fuel Rod Design	AREVA	COPERNIC

Fuel Rod Mechanical Analysis Methodology - Continued

- For each design, generic analyses demonstrate that the performance of the limiting rod is within the fuel rod design limits (i.e., rod internal pressure, centerline fuel melt, clad stress)
- These generic analyses have conservative RCS boundary conditions that envelope the effects of a mixed core
- Generic analyses are based on bounding power history envelope which are verified for each reload cycle
- A mixed core of NGF – RFA – MKBW/MOX1 has no impact on the generic fuel rod analyses

Safety Analysis (LOCA)

- Robust Fuel Assembly
- Next Generation Fuel
- Mixed Oxide Fuel
- Cycle Specific Evaluation of C1C16

Robust Fuel Assembly

- Best-estimate large break LOCA analysis (WCOBRA/TRAC)
- Appendix K – small break LOCA analysis (NOTRUMP)
- Sensitivity performed to address mixed core (Mark-BW fuel) (similar trends, negligible PCT impact)

Next Generation Fuel

- LBLOCA sensitivity calculations performed to address the NGF design differences compared to RFA design (higher ΔP and grid design)

- Peaking penalty developed (for NGF fuel) to ensure NGF assemblies non-limiting with respect to the LOCA analysis

Mixed Oxide Fuel

- MOX analysis performed with Framatome Appendix K method
- Analysis performed assuming average core region comprised of RFA fuel
- Fuel difference alone (MOX for LEU) showed little difference
- Sensitivity performed for different SG types, various power shapes, and cycle burnup
- Lower peaking limits established for the MOX assemblies and will be used in the reload design

MOX / RFA

- MOX/RFA Evaluation
  - No impact of MOX fuel on RFA analysis
    - Pressure drop less than 4 percent difference
    - Previous sensitivities performed for mixed core of RFA and Mark-BW
    - MOX fuel more similar hydraulically to RFA than Mark-BW

Cycle Specific LOCA Evaluation of C1C16

- Impact of MOX on NGF evaluation
  - No direct interaction between MOX and NGF
  - Presence of MOX will not alter NGF evaluation (minor difference in resistance between MOX and RFA)

- Impact of NGF fuel on MOX evaluation
  - No direct interaction between MOX and NGF fuel
  - Minor change in average core resistance
  - No significant impact expected

Safety Analysis (Non-LOCA)

- Safety Analysis Reload Process
- Catawba 1 C15 – RFA & Co-resident NGF Assemblies
- Catawba 1 C16 – RFA & Co-resident MOX & NGF Assemblies

Safety Analysis Reload Process

- Safety Analysis updates Reload Design Safety Analysis Review (REDSAR) Checklist reference analysis values
- Safety Analysis provides updated REDSAR checklist to Nuclear Design
- Nuclear Design provides cycle specific reload values for the REDSAR parameters and identifies any discrepancies
- Discrepancies are dispositioned by
  - Performing cycle specific evaluations/calculations
  - Restricting operating limits
  - Core redesign

Catawba 1 C15 – RFA & Co-resident NGF Assemblies

- Followed the standard reload process
- Conservatively applied approved methods to analyze NGF fuel
- DNB transients were analyzed with NGF specific VIPRE model

Catawba 1 C16 - RFA & Co-resident MOX & NGF Assemblies

- All three fuel types will be explicitly evaluated in the standard reload process

- VIPRE models
  - RFA modeled as all RFA
  - NGF modeled as 1 NGF surrounded by RFA
  - MOX modeled as 1 MOX surrounded by RFA

Summary

- C1C16 core design contains
  - Four MOX assemblies
  - Eight NGF assemblies
  - 181 RFA assemblies
- The eight NGF assemblies are hydraulically different from RFA
- Cycle specific reload analysis will explicitly confirm acceptable performance of all three fuel types prior to completion of the reload safety evaluation

Staff Questions