EMF-92-116, Supplement 1: Response to RAI 3 on RODEX2 Rod Internal Pressure Predictions

AREVA/NRC Meeting
NRC Headquarters
April 29, 2014

AREVA

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AREVA

Agenda

- Objectives
- Remaining Request for Additional Information (RAI)
- RAI Response
- Conservatism in RODEX2 code/method/criteria
- GALILEO
- Observations
- Conclusion
- Next Steps

Objectives

- Discuss issues discovered in the RODEX2 predictions of rod internal pressure
- Obtain NRC feedback on the proposed response to RAI 3

Start of Proprietary Information

- Proprietary meeting will begin with next slide

Remaining RAI

▶ RAI #3

SRP 4.2 Acceptance Criteria 1.A.vi – Rod Internal Pressure

Based on knowledge acquired in recent licensing actions utilizing RODEX2, the staff has concerns that the RODEX2 rod internal pressure calculations may be non-conservative. Therefore, the staff performed confirmatory calculations using the NRC fuel thermal-mechanical code FRAPCON-3 as a follow up to the audit that took place July 9-11, 2013. The results of the calculations showed that [

]. When FRAPCON was run using a best-estimate plus uncertainty methodology the upper tolerance limit (95/95) rod internal pressure prediction, for both cases, [

]. The results were discussed with AREVA as a continuation of the audit during several phone conversations held in August 2013.

Please provide additional justification to show that RODEX2's rod internal pressure predictions remain conservative, as used in the framework of AREVA's reload methodology. If additional RODEX2 sample cases are run to support AREVA's response, please provide the input parameters to allow the staff to model the cases using FRAPCON.

Issues

- In the process of developing the response to RAI 3, two [ ] issues were identified in the RODEX2 rod internal pressure predictions
  - [ ]
  - Thermal Conductivity Degradation (TCD)
    - [ ]

Impact on Benchmark Analyses

- Benchmarks to measured fission gas release (FGR) data are not impacted (Figure 3, Supplement 1)
  - [ ]
  - [ ]
  - TCD impact is inherent in the benchmark to measured data
- Benchmarks to cold free volume measurements are not impacted (Figure 4, Supplement 1)
  - [ ]
  - [ ]
  - TCD impact is inherent in the benchmark to measured data
- Comparisons of "at power" measured to predicted rod internal pressure (Figure 5 and Table 4 in Supplement 1) are impacted

FGR Benchmark

[ ]

Free Volume Benchmark Cold Conditions

[ ]

Rod Internal Pressure Benchmark Cold Conditions

Impact on RODEX2 Rod Internal Pressure Predictions

- [ ]
  - Bias was established in the original RODEX2 Topical Report
  - Competing effects must be carefully considered
    - [ ]
    - Conservative selection depends on the rod design and operating conditions
  - Typically increases rod internal pressure by [ ]
- TCD
  - [ ]
  - Typically increases rod internal pressure by [ ]
- Combined impact is [ ] increase in the RODEX2 predicted rod internal pressure

Examples of Impact

Fuel rod design/ plant type	RODEX2 (before)	RODEX2 (after)*
CE 14	[ ]	]
W 15	[ ]	]
W 17	[ ]	]
CE 15	[ ]	]

*** Results from Operability Assessment in AREVA Corrective Action Program**

Revised Methodology for RODEX2 Rod Internal Pressure

- **Current method will be augmented**
  - [ ]
  - [ ]
  - Sensitivity study on [ ] to determine conservative bias (new)
  - Apply penalty for TCD impact (new)
- **Revised method is currently implemented through the AREVA Correction Action Program**

Impact on Supplement 1 Content

- The identified issues change the conclusions for rod internal pressure
- Text, tables, and figures will need to be replaced to reflect the corrected information
  - Conclusions in Section 1.0
  - Section 2.7
  - Section 3.0
  - Table 4
  - Table 5
  - Figure 5

Conservatism in the RODEX2 Criteria

- **Criterion of [ ] above system pressure is conservative**
  - **Contemporary evaluations show conservative hydride re-orientation limits of**
    - [ ] above system pressure for Zr-4 cladding
    - [ ] above system pressure for M5™ cladding
  - **Stable pellet-clad gaps are maintained at the higher limits**

Conservatism in RODEX2 Code and Methodology

- [

  ]
- Approved method for rod internal pressure designed to be more conservative than best-estimate
  - [

    ]
- [ ]
- [

  ]
  - Not required by regulations

GALILEO

- **State-of-the-art design code and methods to license AREVA fuel**
  - Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR)
  - All AREVA cladding and fuel types
  - Address all observed phenomena, including fuel thermal conductivity reduction with burnup
  - Code backed by extensive calibration and validation database
  - Statistical methodology
- **Replace legacy codes RODEX2/2A, TACO3, GDTACO**
- **Provide a means to transition to a single fuel performance code**
- **GALILEO Topical Report (ANP-10323P) submitted to NRC and accepted for review**

Observations

- **A fuel performance code and associated methodology provide a conservative prediction of actual performance**
  - The degree of conservatism can vary greatly from code to code
  - Differences between codes can vary plant to plant and case by case
  - This includes RODEX2, COPERNIC, GALILEO, and FRAPCON
- **The FRAPCON statistical methodology is more conservative than RODEX2**
  - FRAPCON method is 95/95 while RODEX2 method was not designed to be this conservative
  - Unrealistic synergy between some uncertainties can create outliers in the population
  - Overly strong thermal feedback effects in high pressure rods can skew the distribution

Conclusions

- Two [ ] issues were identified in the RODEX2 rod internal pressure predictions
- Revised methodology corrects these issues and is being implemented
- RODEX2 has been benchmarked to modern test data for FGR and cold free volume

The augmented RODEX2 code/methodology provides an adequate and acceptable level of conservatism for rod internal pressure

Next Steps

- Schedule for RAI Response
- GALILEO

Acronyms/Nomenclature

AOO	Anticipated Operational Occurrence
BWR	Boiling Water Reactor
CE	Combustion Engineering
FGR	Fission Gas Release
PWR	Pressurized Water Reactor
RAI	Request for Additional Information
SRP	Standard Review Plan
TCD	Thermal Conductivity Degradation
W	Westinghouse