

## ArevaEPRDCDocsPEm Resource

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**From:** HOLM Jerald (EXTERNAL AREVA) [Jerald.Holm.ext@areva.com]  
**Sent:** Wednesday, November 05, 2014 2:52 PM  
**To:** Gleaves, Bill  
**Subject:** Slides for November 12 NRC meeting Chapter 4 US EPR  
**Attachments:** Affidavit.pdf; Chapter 4 Closure Plan\_NP.pdf; Chapter 4 Closure Plan\_P.pdf

Billy

A proprietary and a non-proprietary version of the slides for the November 12, 2014 meeting on Chapter 4 of the US EPR is attached. An affidavit is also attached.

Thanks

Jerry Holm

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9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Mark E. Roth

SUBSCRIBED before me this 5<sup>th</sup>  
day of November, 2014.

Danita R. Kidd

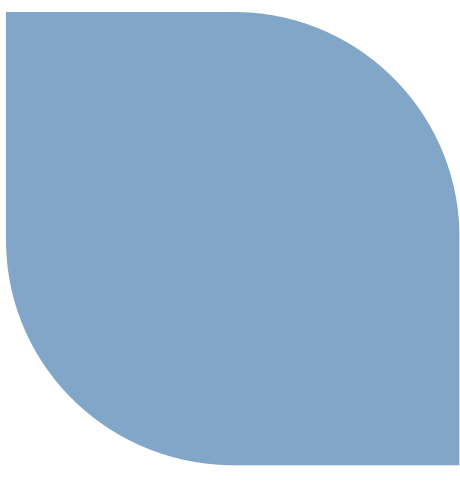
Danita R. Kidd  
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MY COMMISSION EXPIRES: 12/31/2016  
Reg. # 205569

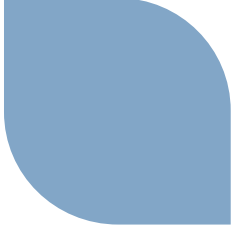


# Chapter 4 Closure Plan

Jerry Holm  
Brett Matthews  
Kevin Segard

November 12, 2014

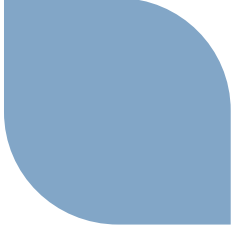




# Agenda

- ▶ **Chapter 4 Remaining items**
- ▶ **Schedule for Remaining Items**
- ▶ **Faulted Analyses (Chapter 4)**
- ▶ **AZI and AO LCOs (Chapters 4 and 16)**

# Chapter 4 RAIs not closed

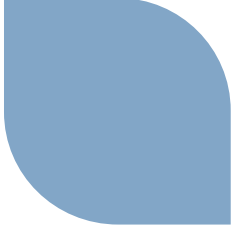


RAI	Question	Topic	Status	Reviewer
339	04.02-17	Track ANP-10285P	Open tracking item	Lu
600	04.02-19	Service level C for faulted analysis	Waiting for response	Schmidt
544	04.04-67	3-loop behavior	Confirmatory action	Lu
367	04.06-14	Implementation ANP-10287P	In evaluation	Budzynski



## **New Items - AZI LCO and AO LCO**

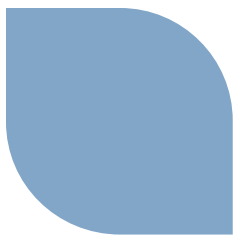
- ▶ **AZI LCO**
  - ◆ This LCO will be removed from the FSAR
- ▶ **AO LCO**
  - ◆ Revised Treatment
  - ◆ A new technical report will be created to document the revised treatment



## Schedule

- ▶ **RAI 600 response and revised faulted analyses**
  - ◆ **May 29, 2015**
- ▶ **AZI LCO and AO LCO**
  - ◆ **February 3, 2015**
- ▶ **FSAR Closure Package**
  - ◆ **August 2015**

# Start of Proprietary Meeting

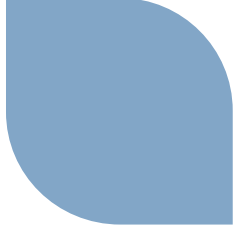




# Faulted Analyses -Agenda

- ▶ **Chapter 4 Open Items - faulted analyses**
- ▶ **Status of Open Items**
  - ◆ **RAI 600**
  - ◆ **Re-analysis**
- ▶ **Deliverables**
- ▶ **Next steps - schedule**

# Chapter 4 Open Items –Faulted Analyses

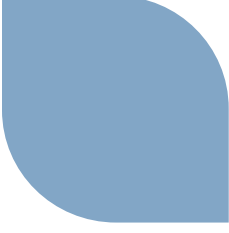


- ▶ **RAI 600**
  - ◆ Question: “Demonstrate through testing or analysis that meeting the ASME Service Level C limits ensures guide tube operability with respect to maintaining control rod insertability. Include the stress/strain distributions along the axial length of the fuel assembly for the limiting U.S. EPR fuel assembly deflection.”
  - ◆ RAI issued from audit of May 2013 submittals
- ▶ **Seismic Re-analysis**
  - ◆ Issue: Re-perform fuel seismic analyses using the latest inputs after resolving “upstream” soil-structure interaction issues
  - ◆ Same scope of work described in ANP-10325P is being re-executed
  - ◆ No change in conclusions are expected

# Status of Open Items: RAI 600

- ▶ **RAI has two parts:**
  - 1) Demonstrate acceptability of Level C limits
  - 2) Provide stress/strain distributions for limiting fuel assembly deflection
- ▶ **Status:**
  - ◆ Part 1 is complete
  - ◆ Part 2 is awaiting re-analysis with latest seismic inputs
    - Awaiting final analysis results to submit only a final RAI response

# Status of Open Items: RAI 600



## ► Summary of Part 1 Activities / Conclusions



**NRC Approval Required  
for RAI 600**

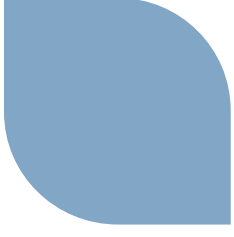


# Status of Open Items: Re-analysis

- ▶ **Previous closure plan from 2012/2013:**
  - ◆ To expedite closure of Chapter 4 issues amid upstream challenges on soil-structure interaction, a “reconciliation” process was agreed upon with the NRC
    - May 2013 document submittals would be final
    - AREVA would re-analyze fuel seismic, post May 2013, and submit a letter to confirm conclusions from May 2013 submittals
- ▶ **Recent needs to revise ANP-10325, ANP-10285, and FSAR have surfaced**
  - ◆ Changes render “reconciliation” approach obsolete
  - ◆ Updated analysis results will be captured directly in a revision to May 2013 submittals



# Status of Open Items: Re-analysis



- ▶ After re-analysis work was partially completed in 2013, analyses were re-started because of a concern with the inputs



# Status of Open Items: Re-analysis – Guide Tube Margins

- ▶ Guide tube stress margins are expected to be further challenged in the updated analysis because of
- ▶ Current methodology conservatively combines worst-case lateral deflections from two directions regardless of core location
  - ◆ Existing method is chosen to simplify the calculation, but is conservative
  - ◆ Alternative, if necessary to manage margins, will be to combine orthogonal lateral deflections for specific core locations

# Status of Open Items: Re-analysis – Stress Indicator

- ▶ **RAI 54 response established justification for use of bending moments as stress indicators to identify limiting stress cases**
  - ◆ Based on BOL as limiting condition
  - ◆ Demonstrated correlation between BOL bending moments and GT stress
- ▶ **Preliminary results from re-analysis have expanded our understanding of the correlation:**
  - ◆ Results behave as expected for BOL cases (confirm RAI 54 response)
  - ◆ For some EOL cases, it is observed that an increase in maximum bending moments result in a decrease in guide tube stress beyond the expected variability in the correlation

# Status of Open Items: Re-analysis – Stress Indicator

- ▶ Internal condition report has been generated to address the observation
- ▶ Evaluation performed to support RAI 54 response is being re-evaluated for the EOL condition with new stress indicators
- ▶ Re-analysis will use expanded set of stress indicators for EOL

**NRC Approval Required  
for expanded set of stress indicators**

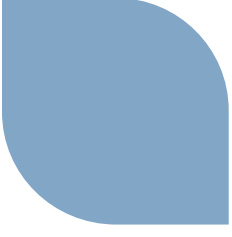
## **Status of Open Items: Re-analysis – Vertical Model**

- ▶ **Internal challenges of the vertical fuel analysis have raised new items that will be addressed in final submittals:**

[

- ▶ **Each issue above has been captured as a condition report within AREVA’s corrective action program**

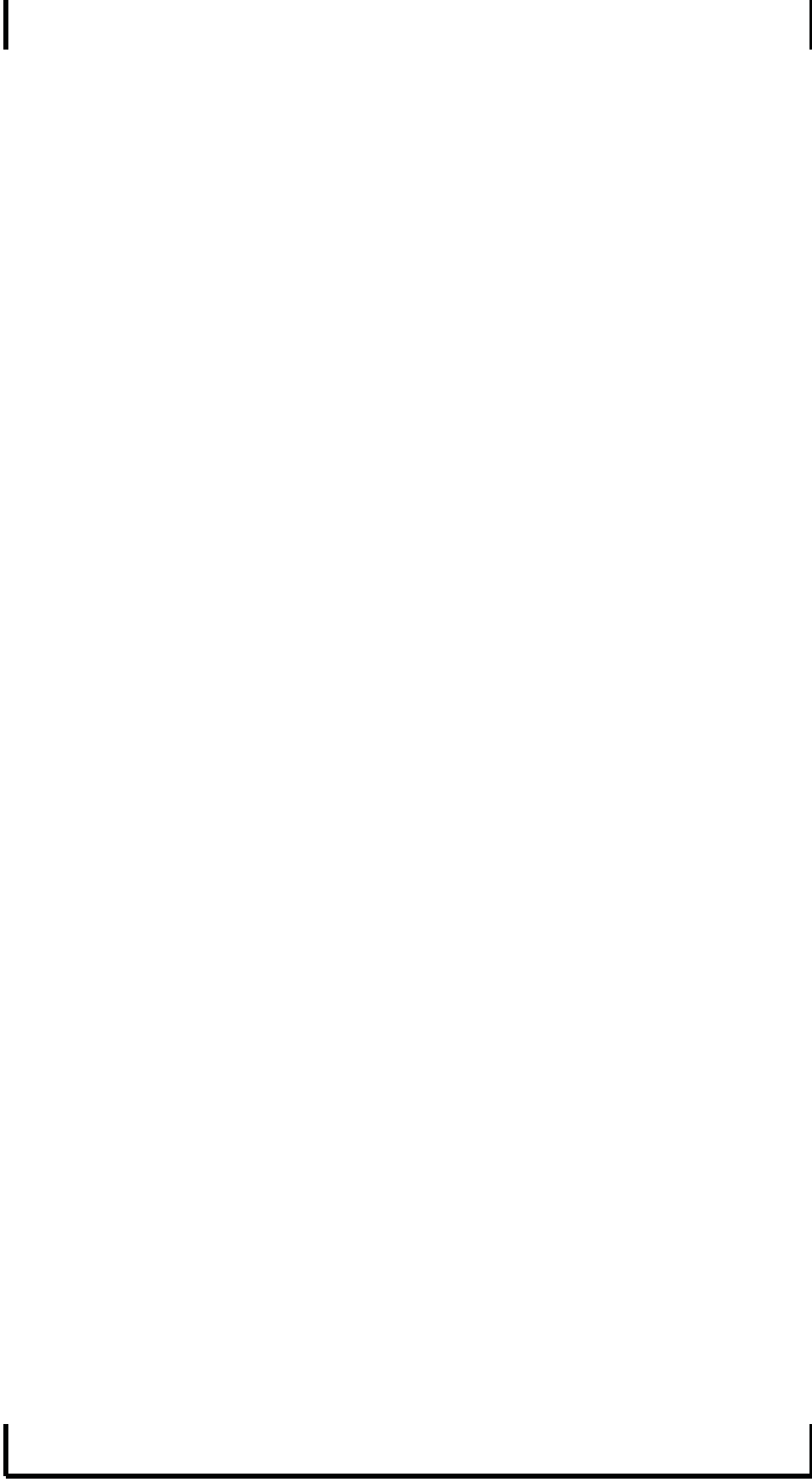
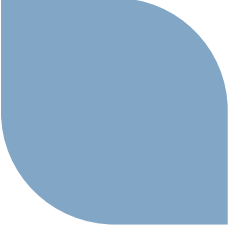
# Status of Open Items: Re-analysis – Vertical Model



**NRC Approval Required  
for use of CASAC on vertical analysis**



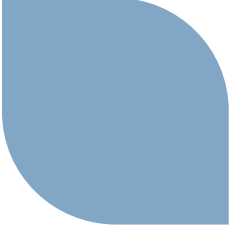
# Status of Open Items: Re-analysis – Vertical Model



# Status of Open Items: Re-analysis – Vertical Analysis

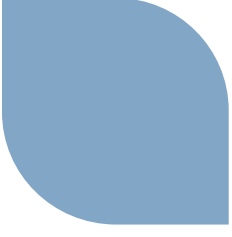
- ▶ **Challenge: Sensitivity study for vertical seismic analysis**
  - ◆ During internal review, the lack of a sensitivity study on the vertical seismic analysis was questioned
  - ◆ Sensitivity study recommended per Section II.3, Appendix A, Chapter 4.2 of the Standard Review Plan
  - ◆ Sensitivity studies performed for lateral analysis
  - ◆ Solution will be to include the sensitivity study as part of the vertical analysis





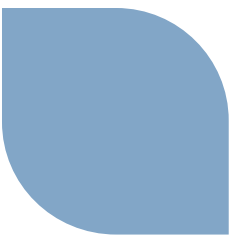
# Deliverables

- ▶ **At the conclusion of the current effort, AREVA will submit four documents as final deliverables:**
  - ◆ RAI 600 response
  - ◆ ANP-10325P Revision
  - ◆ ANP-10285P Revision
  - ◆ FSAR Update
- ▶ **RAI 600 Response Summary**
- ▶ **ANP-10285P Revision Summary**
  - ◆ Update grid impact loads reported in Section 5.1.1.5
  - ◆ Update reference to ANP-10325P



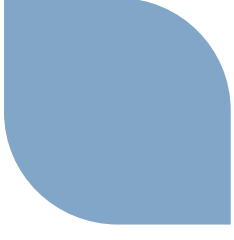
# Deliverables

- ▶ **ANP-10325P Revision Summary**
  - ◆ **Revision to ANP-10325P will eliminate the need for “reconciliation” letter**
  - ◆ **Revision to include:**
    - Updated results/margins (throughout)
    - Update to Vertical Seismic model in CASAC (Section 4.2 and 6.0)
    - Updated discussion of stress indicators (Sections 4.1.5, 4.3.2, 5.2, and 7.0)
  
- ▶ **FSAR Update**
  - ◆ **Update references to ANP-10285P and ANP-10325P**



## Next Steps

- ▶ **Schedule for Chapter 4 faulted analyses**
  - ◆ **RAI 600 response**                      **May 29, 2015**
  - ◆ **ANP-10325P Revision**                **May 29, 2015**
  - ◆ **ANP-10285P Revision**                **May 29, 2015**
  - ◆ **FSAR Update**                              **May 29, 2015**



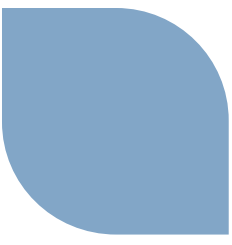
# AZI and AO LCO - Agenda

- ▶ **Objectives**
- ▶ **Background**
- ▶ **Removal of AZI LCO**
- ▶ **Treatment of AO LCO**
- ▶ **Summary**
- ▶ **Next Steps**



## Objectives

- ▶ **Inform the NRC of AREVA's plans regarding the AZI LCO and the AO LCO in the U.S. EPR FSAR (including Generic Technical Specifications (GTS))**
  - ◆ Describe motivation for change
  - ◆ Describe justification for change
  - ◆ Describe schedule and submittals
- ▶ **Remove AZI LCO since it is not used in the U.S. EPR**
- ▶ **Modify AO LCO to be consistent with requirements**



## Background

- ▶ **U.S. EPR Technical Specifications Include:**
  - ◆ An Azimuthal Power Imbalance (AZI) LCO and
  - ◆ An Axial Offset (AO) LCO
- ▶ **The values for these LCOs are specified in the Core Operating Limits Report (COLR)**
- ▶ **All LCOs defined in the COLR are required to be based on NRC approved topical reports which are required to be referenced in the Technical Specifications**
  - ◆ NRC approved topical reports are not referenced in the Technical specifications for the AZI LCO or the AO LCO
  - ◆ A Condition Report was issued that addresses this oversight
  - ◆ The actions we will discuss today are an outcome of the Condition Report evaluation



## Azimuthal Power Imbalance

- ▶ Azimuthal Power Imbalance (AZI) is defined as
  - ◆ maximum power in any core quadrant ( $QN_{\max}$ ) and
  - ◆ minimum power in any core quadrant ( $QN_{\min}$ )

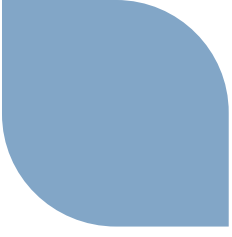
$$AZI(\%) = QN_{\max} - QN_{\min}$$

- ▶ The intent of the AZI LCO is to limit the core power distribution asymmetry to that assumed in the safety analyses.

# Removal of AZI LCO from U.S. EPR GTS

- ▶ **The U.S. EPR uses incore detectors (Aeroball) or SPNDs to measure power distribution**
  - ◆ AZI is inherent in these measurements
  - ◆ FAH LCO and LPD LCO are monitored based on SPNDs
  - ◆ AZI is inherent in these LCOs
  - ◆ AZI was not an input to the U.S. EPR safety analysis
- ▶ **The AZI LCO is redundant and will be removed from the U.S. EPR GTS**





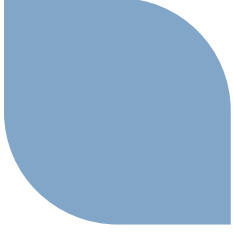
# Axial Offset

► Axial Offset (AO) is defined as:

$$AO(\%) = \frac{P_{\text{top}} - P_{\text{bottom}}}{P_{\text{top}} + P_{\text{bottom}}} \times 100$$

$P_{\text{top}}$  – Power in top half of core

$P_{\text{bottom}}$  – Power in bottom half of core



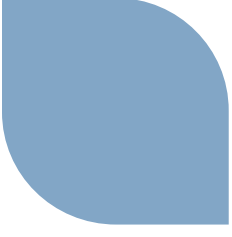
## Axial Offset

- ▶ **The AO LCO is specified in GTS LCO 3.2.4 and the limits are specified in the Core Operating Limits Report**
- ▶ **Reasons for change**
  - ◆ An NRC approved method defining the AO LCO is not referenced in the U.S. EPR GTS
  - ◆ The axial shapes used in safety analyses are not consistent with the currently defined AO limits
- ▶ **Topical Report ANF-88-054PA will be used to update the AO LCO limits**

## **ANF-88-054PA Methodology**

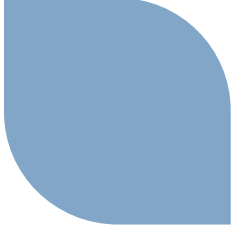
- ▶ Referred to as PDC-3 methodology
- ▶ Developed for Westinghouse plants
- ▶ PDC-3 (or the Westinghouse equivalent RAOC methodology) is used for all but two Westinghouse operating units
- ▶ Key concepts
  - ◆ Used to assure that LOCA limits are satisfied during operation
  - ◆ LOCA axial shapes are chosen to be conservative relative to the PDC-3 axial shapes
  - ◆ AO target + AO range about target
  - ◆ V(Z) function to define change in power distribution within AO range
  - ◆ Surveillance requirements defined to verify that the LOCA limits are met during operation

# ANF-88-054PA Methodology - Changes



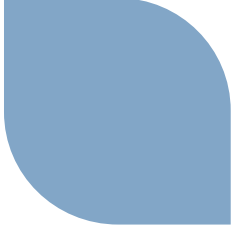
# AO LCO Treatment for U.S. EPR

- ▶ **AO barn selection**
- ◆ **Conservative AO range will be chosen to bound range of axial shapes used in safety analyses**
- ◆ **Confirmation of the AO LCO performed using**
  - ANF-88-054-(P)(A), PDC-3: Advanced Nuclear Fuels Corporation Power Distribution Control for Pressurized Water Reactors and Application of PDC-3 to H.B. Robinson Unit 2
- ◆ **U.S. EPR FSAR and Technical Specifications will be modified consistent with ANF-88-054PA topical report**
- ◆ **An AO range and the PDC-3 V(z) penalty will be included in the COLR**
- ◆ **A Technical Report will be provided establishing the use of the PDC-3 methodology along with modifications required to support the U.S. EPR**



## Summary

- ▶ **The AZI LCO (LCO 3.2.5) will be removed from the GTS**
- ▶ **The NRC approved PDC-3 methodology will be used to define the AO LCO**
- ▶ **The AO LCO will be chosen to be conservative relative to the axial shapes used in safety analyses**
- ▶ **A Technical Report will be provided establishing the applicability of the PDC-3 methodology to the U.S. EPR**
- ▶ **FSAR changes will be made to reflect the PDC-3 methodology**



## Next Steps

- ▶ **Letter to NRC**      **February 3, 2015**
- ◆ **Technical Report**
  - Describe use of ANF-88-054PA
  - Justify applicability of ANF-88-054 and modifications to U.S. EPR
- ◆ **FSAR changes**
  - Chapter 4
  - Chapter 16

# Acronyms/Nomenclature

- ◆ **AFD – Axial Flux Difference**
- ◆ **AMS – Aeroball Measurement System**
- ◆ **AO – AREVA Rod Ejection Analysis Methodology**
- ◆ **AZI – Azimuthal Power Imbalance**
- ◆ **COLR – Core Operating Limits Report**
- ◆ **FSAR – Final Safety Analysis Report**
- ◆ **GTS – Generic Technical Specifications**
- ◆ **LCO – Limiting Condition for Operation**
- ◆ **PDC – Power Distribution Control**
- ◆ **PS – Protection System**
- ◆ **RCSL – Reactor Control Surveillance and Limitation**
- ◆ **SPND – Self Powered Neutron Detector**



Proprietary

# Chapter 4 Closure Plan

Jerry Holm  
Brett Matthews  
Kevin Segard

November 12, 2014



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# Agenda

- ▶ **Chapter 4 Remaining items**
- ▶ **Schedule for Remaining Items**
- ▶ **Faulted Analyses (Chapter 4)**
- ▶ **AZI and AO LCOs (Chapters 4 and 16)**

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## New Items - AZI LCO and AO LCO

- ▶ **AZI LCO**
  - ◆ This LCO will be removed from the FSAR
- ▶ **AO LCO**
  - ◆ Revised Treatment
  - ◆ A new technical report will be created to document the revised treatment

## Schedule

▶ **RAI 600 response and revised faulted analyses**

◆ May 29, 2015

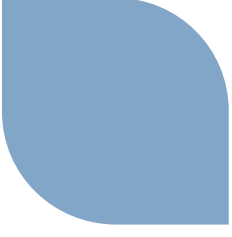
▶ **AZI LCO and AO LCO**

◆ February 3, 2015

▶ **FSAR Closure Package**

◆ August 2015

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# Start of Proprietary Meeting



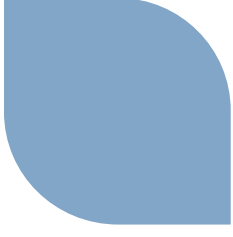
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## Faulted Analyses -Agenda

- ▶ **Chapter 4 Open Items - faulted analyses**
- ▶ **Status of Open Items**
  - ◆ RAI 600
  - ◆ Re-analysis
- ▶ **Deliverables**
- ▶ **Next steps - schedule**

# Chapter 4 Open Items –Faulted Analyses



- ▶ **RAI 600**
  - ◆ Question: “Demonstrate through testing or analysis that meeting the ASME Service Level C limits ensures guide tube operability with respect to maintaining control rod insertability. Include the stress/strain distributions along the axial length of the fuel assembly for the limiting U.S. EPR fuel assembly deflection.”
  - ◆ RAI issued from audit of May 2013 submittals
- ▶ **Seismic Re-analysis**
  - ◆ Issue: Re-perform fuel seismic analyses using the latest inputs after resolving “upstream” soil-structure interaction issues
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# Status of Open Items: RAI 600

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- ▶ **Status:**
  - ◆ Part 1 is complete
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# Status of Open Items: RAI 600

- ▶ **Summary of Part 1 Activities / Conclusions**
  - ◆ **3-point bending tests performed on guide tubes**
    - Demonstrate that application of Level C limits are sufficient to protect the guide tube (GT) from a localized collapse of the cross-section
    - Demonstrate that Level C limits based on elastically calculated stresses must account for section plastic shape factor
  - ◆ **Elastic-plastic fuel assembly finite element analysis**
    - Model benchmarked to fuel assembly lateral tests (overall stiffness) and 3-point bending tests (material model)
    - Demonstrates that once limit is reached for limiting guide tube, load is redistributed to other components. FA continues to carry increased load and GT deformations are controlled
  - ◆ **Comparison of fuel assembly permanent deformations after reaching Level C limit with previous control rod drop tests**
    - Fuel assembly deformation after reaching Level C is bounded by deflections tested in control rod drop testing

**NRC Approval Required  
for RAI 600**

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# Status of Open Items: Re-analysis

- ▶ **After re-analysis work was partially completed in 2013, analyses were re-started because of a concern with the inputs**
  - ◆ **An internal Software Impact Assessment Condition Report was issued against software used in the processing of input time histories in late 2013**
  - ◆ **Software algorithm was adding high frequency content to core plate time histories**
  - ◆ **Decision was made to re-analyze both vertical and lateral fuel studies with updated time histories**
  - ◆ **Preliminary studies raised two concerns:**
    - 1) Guide tube stress margins may become further challenged in some cases
    - 2) The correlation between bending moments (used as the indicator to identify limiting stress cases) and guide tube stress did not function as expected on some cases (Reference RAI 54 on ANP-10285P).

# Status of Open Items: Re-analysis – Guide Tube Margins

- ▶ **Guide tube stress margins are expected to be further challenged in the updated analysis because of**
  - ◆ Consideration of cross-section plastic shape factor in definition of Service Level C guide tube limit
  - ◆ New time histories may be slightly more severe for guide tube stresses
- ▶ **Current methodology conservatively combines worst-case lateral deflections from two directions regardless of core location**
  - ◆ Existing method is chosen to simplify the calculation, but is conservative
  - ◆ Alternative, if necessary to manage margins, will be to combine orthogonal lateral deflections for specific core locations

# Status of Open Items: Re-analysis – Stress Indicator

- ▶ **RAI 54 response established justification for use of bending moments as stress indicators to identify limiting stress cases**
  - ◆ Based on BOL as limiting condition
  - ◆ Demonstrated correlation between BOL bending moments and GT stress
- ▶ **Preliminary results from re-analysis have expanded our understanding of the correlation:**
  - ◆ Results behave as expected for BOL cases (confirm RAI 54 response)
  - ◆ For some EOL cases, it is observed that an increase in maximum bending moments result in a decrease in guide tube stress beyond the expected variability in the correlation

# Status of Open Items: Re-analysis – Stress Indicator

- ▶ Internal condition report has been generated to address the observation
- ▶ Evaluation performed to support RAI 54 response is being re-evaluated for the EOL condition with new stress indicators
  - ◆ Results indicate that the precision with which limiting stresses are identified can be improved by augmenting bending moments with additional indicators such as strain energy or deflection
- ▶ Re-analysis will use expanded set of stress indicators for EOL

**NRC Approval Required  
for expanded set of stress indicators**

## Status of Open Items: Re-analysis – Vertical Model

► **Internal challenges of the vertical fuel analysis have raised new items that will be addressed in final submittals:**

- 1) Results from vertical seismic analysis performed with ANSYS® were found to be non-repeatable
- 2) The assumption of stationary core plates during the vertical LOCA analysis was challenged
- 3) Sensitivity study on inputs for vertical seismic analysis

► **Each issue above has been captured as a condition report within AREVA’s corrective action program**



# Status of Open Items: Re-analysis – Vertical Model

- ▶ **Challenge: Non-repeatable results with ANSYS**
- ◆ Original U.S. EPR analysis (2007) used CASAC for vertical seismic and ANSYS for vertical LOCA
  - No repeatability issues
- ◆ Updated seismic and LOCA analyses in 2013 standardized to ANSYS
- ◆ During re-analysis work in 2013, it was noticed that previously documented results could only be reproduced within +/- 10%
- ◆ Issue found to be a recently identified problem with the use of ANSYS, with an implicit solver, for non-linear transient analyses
- ◆ Solution has been to perform vertical analyses in CASAC
  - CASAC has an explicit solver and has demonstrated repeatability

**NRC Approval Required  
for use of CASAC on vertical analysis**

# Status of Open Items: Re-analysis – Vertical Model

- ▶ **Challenge: Core Plate Motion during LOCA**
- ◆ AREVA’s default practice has been to employ a single-assembly fuel assembly model with stationary core plates for vertical LOCA simulation
  - Primary driver is the transient hydraulic forces applied to the fuel
  - Representing core plates as rigid, stationary boundary conditions is believed to be conservative
- ◆ During re-analysis, it was noted that observable core plate motions in the vertical direction are present during LOCA event
- ◆ Modeling of core plates as rigid structures with motion is believed to be overly conservative and unrealistic, however, ability to perform a full core “bounce” model is not present
- ◆ Preliminary studies show that core plate motions significantly alter the vertical impact loads, but overall these loads are negligible
- ◆ Solution will be to conservatively perform vertical LOCA studies with rigid core plate motions

# Status of Open Items: Re-analysis – Vertical Analysis

- ▶ **Challenge: Sensitivity study for vertical seismic analysis**
  - ◆ During internal review, the lack of a sensitivity study on the vertical seismic analysis was questioned
  - ◆ Sensitivity study recommended per Section II.3, Appendix A, Chapter 4.2 of the Standard Review Plan
  - ◆ Sensitivity studies performed for lateral analysis
  - ◆ Solution will be to include the sensitivity study as part of the vertical analysis

# Deliverables

- ▶ **At the conclusion of the current effort, AREVA will submit four documents as final deliverables:**
  - ◆ RAI 600 response
  - ◆ ANP-10325P Revision
  - ◆ ANP-10285P Revision
  - ◆ FSAR Update
- ▶ **RAI 600 Response Summary**
  - ◆ Summary of 3-point bending tests performed on guide tubes
  - ◆ Summary elastic-plastic fuel assembly finite element analysis
  - ◆ Summary of control rod drop testing used to confirm deformation levels at Level C limits
- ▶ **ANP-10285P Revision Summary**
  - ◆ Update grid impact loads reported in Section 5.1.1.5
  - ◆ Update reference to ANP-10325P

# Deliverables

- ▶ **ANP-10325P Revision Summary**
- ◆ **Revision to ANP-10325P will eliminate the need for “reconciliation” letter**
- ◆ **Revision to include:**
  - Updated results/margins (throughout)
  - Update to Vertical Seismic model in CASAC (Section 4.2 and 6.0)
  - Updated discussion of stress indicators (Sections 4.1.5, 4.3.2, 5.2, and 7.0)
  - Update definition of Level C stress limit to include plastic shape factor (Section 4.3.3)
  - Discussion of sensitivity study for vertical analysis (Section 6.2)
  - Discussion of combination of lateral deflections for stress calculation, if necessary (Section 4.3 and 7.0)
- ▶ **FSAR Update**
  - ◆ **Update Level C definition in Section 4.2.1.5.3 to include plastic shape factor**
  - ◆ **Update references to ANP-10285P and ANP-10325P**

## Next Steps

- ▶ **Schedule for Chapter 4 faulted analyses**
  - ◆ RAI 600 response May 29, 2015
  - ◆ ANP-10325P Revision May 29, 2015
  - ◆ ANP-10285P Revision May 29, 2015
  - ◆ FSAR Update May 29, 2015

Proprietary

# AZI and AO LCO - Agenda

- ▶ **Objectives**
- ▶ **Background**
- ▶ **Removal of AZI LCO**
- ▶ **Treatment of AO LCO**
- ▶ **Summary**
- ▶ **Next Steps**

## Objectives

- ▶ **Inform the NRC of AREVA's plans regarding the AZI LCO and the AO LCO in the U.S. EPR FSAR (including Generic Technical Specifications (GTS))**
  - ◆ Describe motivation for change
  - ◆ Describe justification for change
  - ◆ Describe schedule and submittals
- ▶ **Remove AZI LCO since it is not used in the U.S. EPR**
- ▶ **Modify AO LCO to be consistent with requirements**



## Background

- ▶ **U.S. EPR Technical Specifications Include:**
  - ◆ An Azimuthal Power Imbalance (AZI) LCO and
  - ◆ An Axial Offset (AO) LCO
- ▶ **The values for these LCOs are specified in the Core Operating Limits Report (COLR)**
- ▶ **All LCOs defined in the COLR are required to be based on NRC approved topical reports which are required to be referenced in the Technical Specifications**
  - ◆ NRC approved topical reports are not referenced in the Technical specifications for the AZI LCO or the AO LCO
  - ◆ A Condition Report was issued that addresses this oversight
  - ◆ The actions we will discuss today are an outcome of the Condition Report evaluation

## Azimuthal Power Imbalance

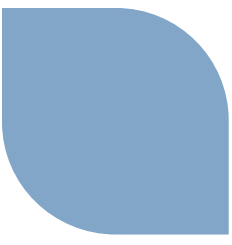
- ▶ Azimuthal Power Imbalance (AZI) is defined as
  - ◆ maximum power in any core quadrant ( $QN_{\max}$ ) and
  - ◆ minimum power in any core quadrant ( $QN_{\min}$ )

$$AZI(\%) = QN_{\max} - QN_{\min}$$

- ▶ The intent of the AZI LCO is to limit the core power distribution asymmetry to that assumed in the safety analyses.

## Removal of AZI LCO from U.S. EPR GTS

- ▶ **The U.S. EPR uses incore detectors (Aeroball) or SPNDs to measure power distribution**
  - ◆ AZI is inherent in these measurements
  - ◆ FAH LCO and LPD LCO are monitored based on SPNDs
  - ◆ AZI is inherent in these LCOs
  - ◆ AZI was not an input to the U.S. EPR safety analysis
- ▶ **The AZI LCO is redundant and will be removed from the U.S. EPR GTS**



# Axial Offset

► Axial Offset (AO) is defined as:

$$AO(\%) = \frac{P_{top} - P_{bottom}}{P_{top} + P_{bottom}} \times 100$$

$P_{top}$  – Power in top half of core  
 $P_{bottom}$  – Power in bottom half of core

## Axial Offset

- ▶ **The AO LCO is specified in GTS LCO 3.2.4 and the limits are specified in the Core Operating Limits Report**
- ▶ **Reasons for change**
  - ◆ An NRC approved method defining the AO LCO is not referenced in the U.S. EPR GTS
  - ◆ The axial shapes used in safety analyses are not consistent with the currently defined AO limits
- ▶ **Topical Report ANF-88-054PA will be used to update the AO LCO limits**

## **ANF-88-054PA Methodology**

- ▶ Referred to as PDC-3 methodology
- ▶ Developed for Westinghouse plants
- ▶ PDC-3 (or the Westinghouse equivalent RAOC methodology) is used for all but two Westinghouse operating units
- ▶ Key concepts
  - ◆ Used to assure that LOCA limits are satisfied during operation
  - ◆ LOCA axial shapes are chosen to be conservative relative to the PDC-3 axial shapes
  - ◆ AO target + AO range about target
  - ◆ V(Z) function to define change in power distribution within AO range
  - ◆ Surveillance requirements defined to verify that the LOCA limits are met during operation

# ANF-88-054PA Methodology - Changes

- ▶ **Use of PRISM versus XTGWR for neutronics calculations**
- ▶ **+/-10% target range versus +/-5%**
- ▶ **Target band defined in terms of AO not axial flux difference (AFD)**
- ▶ **Operation within of target band will be handled by**
  - ◆ **A 1% reduction in the AO bands for each percent the FQ limit is exceeded**
  - ◆ **Operation outside of target band at reduced power is not allowed**
  - ◆ **No penalty minutes will be accumulated**

## AO LCO Treatment for U.S. EPR

- ▶ **AO barn selection**
- ◆ **Conservative AO range will be chosen to bound range of axial shapes used in safety analyses**
- ◆ **Confirmation of the AO LCO performed using**
  - ANF-88-054-(P)(A), PDC-3: Advanced Nuclear Fuels Corporation Power Distribution Control for Pressurized Water Reactors and Application of PDC-3 to H.B. Robinson Unit 2
- ◆ **U.S. EPR FSAR and Technical Specifications will be modified consistent with ANF-88-054PA topical report**
- ◆ **An AO range and the PDC-3 V(z) penalty will be included in the COLR**
- ◆ **A Technical Report will be provided establishing the use of the PDC-3 methodology along with modifications required to support the U.S. EPR**



## Summary

- ▶ **The AZI LCO (LCO 3.2.5) will be removed from the GTS**
- ▶ **The NRC approved PDC-3 methodology will be used to define the AO LCO**
- ▶ **The AO LCO will be chosen to be conservative relative to the axial shapes used in safety analyses**
- ▶ **A Technical Report will be provided establishing the applicability of the PDC-3 methodology to the U.S. EPR**
- ▶ **FSAR changes will be made to reflect the PDC-3 methodology**

## Next Steps

- ▶ **Letter to NRC**      **February 3, 2015**
- ◆ **Technical Report**
  - Describe use of ANF-88-054PA
  - Justify applicability of ANF-88-054 and modifications to U.S. EPR
- ◆ **FSAR changes**
  - Chapter 4
  - Chapter 16

## Acronyms/Nomenclature

- ◆ **AFD – Axial Flux Difference**
- ◆ **AMS – Aeroball Measurement System**
- ◆ **AO – AREVA Rod Ejection Analysis Methodology**
- ◆ **AZI – Azimuthal Power Imbalance**
- ◆ **COLR – Core Operating Limits Report**
- ◆ **FSAR – Final Safety Analysis Report**
- ◆ **GTS – Generic Technical Specifications**
- ◆ **LCO – Limiting Condition for Operation**
- ◆ **PDC – Power Distribution Control**
- ◆ **PS – Protection System**
- ◆ **RCSL – Reactor Control Surveillance and Limitation**
- ◆ **SPND – Self Powered Neutron Detector**