ArevaEPRDCPEm Resource

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Sent: Thursday, May 23, 2013 4:46 PM
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Cc: Gleaves, Bill; HOLM Jerald (EXTERNAL AREVA); GUCWA Len (EXTERNAL AREVA); VANCE Brian (AREVA); UYEDA Graydon (AREVA)
Subject: AREVA Presentation for Public Meeting on May 30th to Discuss Single Failed SPND
Attachments: Single Failed SPND Presentation NON-PROPRIETARY.pdf

Attached is AREVA NP's presentation for the public meeting next Thursday, May 30th at 1 pm to provide an update on the status of U.S. EPR Open Item RAI 505 Q 07.01-33 [Undetected Single Failure of a Self-Powered Neutron Detector (SPND)] . AREVA NP considers some of the material contained in the slides to be proprietary information. Attached is the redacted PUBLIC version of the presentation. The Proprietary version and accompanying affidavit will be submitted separately.

Thanks,
Dennis

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Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 4494

Mail Envelope Properties (554210743EFE354B8D5741BEB695E65616A4FE)

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Sent Date: 5/23/2013 4:45:55 PM
Received Date: 5/23/2013 4:46:18 PM
From: WILLIFORD Dennis (AREVA)

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Single Failed SPND Presentation NON-PROPRIETARY.pdf	1125831	

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Public Meeting to Provide Update on U.S. EPR FSAR Open Item on RAI 505 Q 07.01-33 – Single Failure SPND

AREVA/NRC Meeting 5/30/2013

Randy Ellison
Jerry Holm
William Walters

AREVA

Agenda

- Introduction
- Overview of Issue
- Static Setpoints
- Dynamic Compensation
- Summary
- Next Steps

Purpose and Background

Purpose

- Update the NRC on status of U.S. EPR FSAR open items for RAI 505 Q 07.01-33 – undetected single failure of a self powered neutron detector (SPND)
- Provide preliminary results and understanding of the issue

Schedule for Open Items for RAI 505 Q 07.01-33

RAI	Question No.	Topic/Subject	Advance to NRC	Final to NRC
505	07.01-33	Single failure in an SPND	6/28/2013	7/30/2013
		Revised topical report ANP-10287P	6/28/2013*	8/30/2013**
		*markups and inserts		
		** Recommend 7/30/2013 to match RAI		

RAI 505 Q 07.01-33

- Question 07.01-33:
  - OPEN ITEM
  - Provide an evaluation of the most limiting location of the undetected single failure of a self-powered neutron detector (SPND). In addition, identify any changes to the Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) and Combined License (COL) action items associated with the new setpoint method.
  - In Attachment 2 of the letter dated, May 24, 2011, the applicant proposed to revise the Topical Report ANP-10287P, "Incore Trip Setpoint and Transient Methodology For U.S. EPR," Revision 0, to add the method for including the undetected SPND failure and perform necessary Chapter 15 transient analyses taking credit of this SPND-based incore low departure from nucleate boiling ration (LDNBR) and high linear power density (HLPD) trips. In these two new submittals, the staff requests the applicant to (1) include the uncertainty analysis and method taking into account the possible undetected single failure of SPND at the most limiting location; (2) provide an evaluation of the most limiting location of the undetected single failure of SPND; (3) evaluate the impact on the DNBR undershoot due to this new SPND undetected single failure; and (4) identify any changes to the ITAAC and COL action items associated with the new setpoint method.

Overview of Issue

Randy Ellison

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Objective

- **Provide an overview of the approach to incorporate the undetected failure of an SPND in the U.S. EPR™ safety analysis bases.**
  - **Highlight how the failure is implemented in methods**
  - **Discuss the setpoint method (ANP-10287P) in conjunction with the SPND failure**
  - **Describe the manner in which the method of trip threshold generation provides the same level of protection for the safety limits**

Background

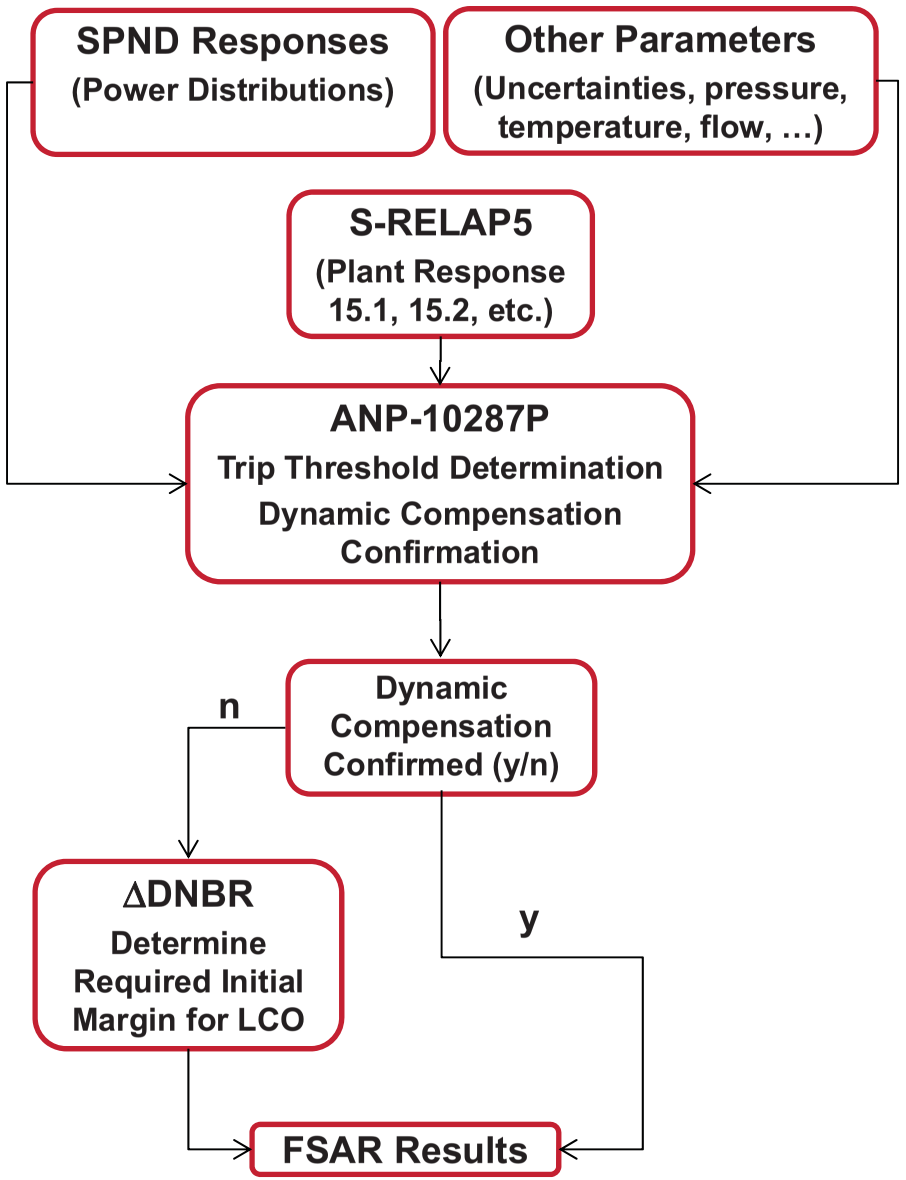
Redundancy, single failure and the SPNDs

- **All 72 SPND signals are distributed to each of the four redundant protection system divisions**
- **The SPNDs themselves are not redundant to each other**
- **The alternative request, acceptable level of protection, and conservative setpoint selection**
  - Detected failure
    - Trip threshold shift to more restrictive value
    - Threshold is calculated through application of the statistical methods to a series of random failed sensor calculations
  - Undetected failure
    - Low probability, non-self announcing failures may be postulated in the SPND amplification and signal multiplication equipment
    - Include failure of the most limiting SPND response as an initial condition in the trip threshold determination and transient compensation confirmation in addition to any detected failures

Background (Continued)

- **U.S. EPR™ FSAR Chapter 15**
  - **Original submission did not include an undetected SPND failure as a credible single failure**
  - **Non self-announcing failure within signal conditioning modules can be incorporated as proposed in the alternative request**
- **Alternative request approach**
  - **Utilize the existing ANP-10287P methodology**
  - **Modify inputs and methods to explicitly account for the undetected failure of the most limiting SPND response**
    - Remove most limiting string (DNBR/Quality) or SPND (HLPD) when determining the static setpoints or verifying the dynamic compensation
  - **DCR approved to restrict the failures to a single undetected SPND failure per amplifier module**

Conceptual Path Overview



ANP-10287P

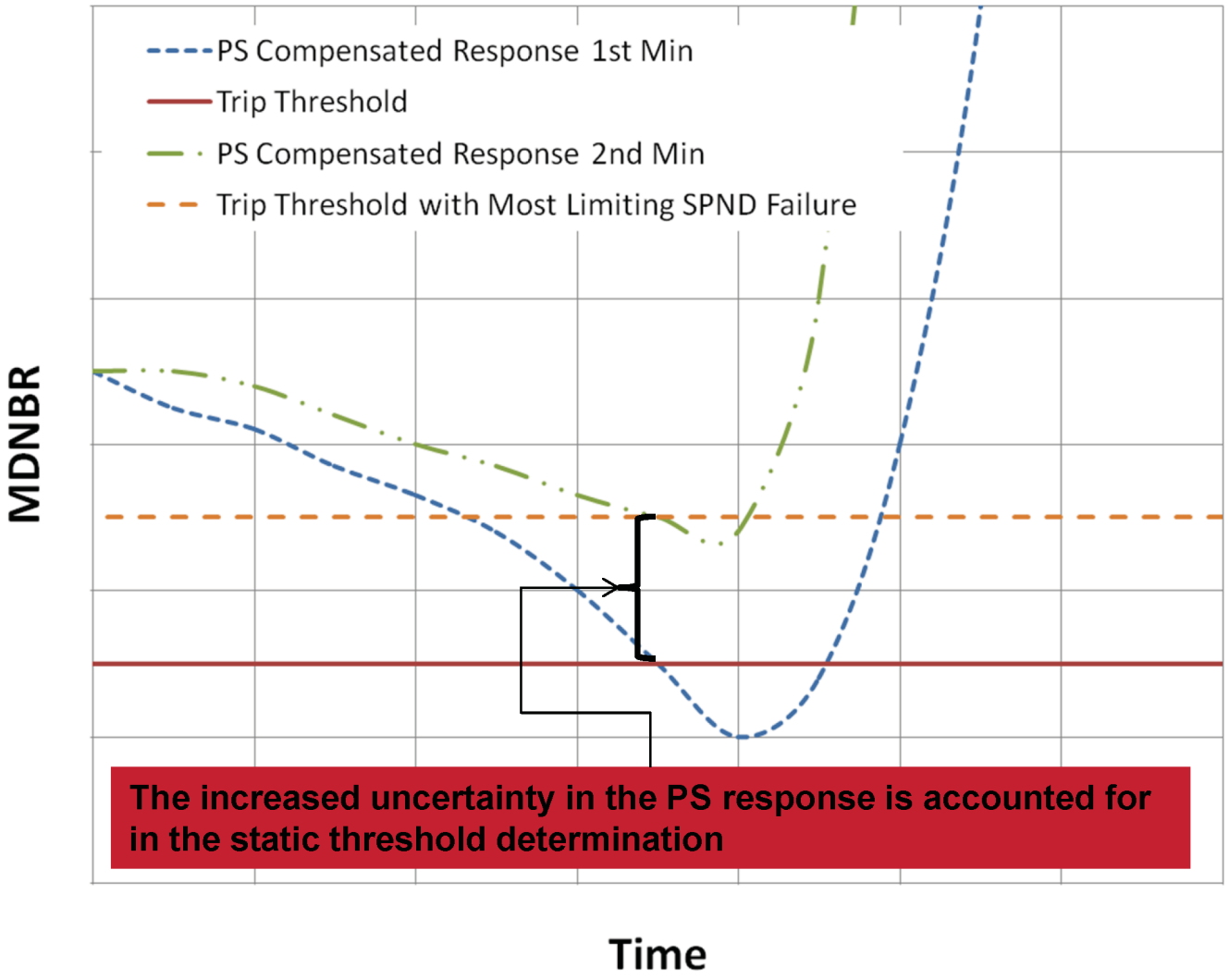
- **Sensed vs. Reference (LPD & DNBR)**
  - Fundamental concept of the methodology
  - Desire to quantify the difference between what the PS senses and the real core condition
- **Core power distribution is provided to the methodology as simulated SPND responses**
  - Facilitates simulation of the reference core condition and the sensed core condition with the requisite uncertainties

Closed meeting

Static Trip Threshold Determination

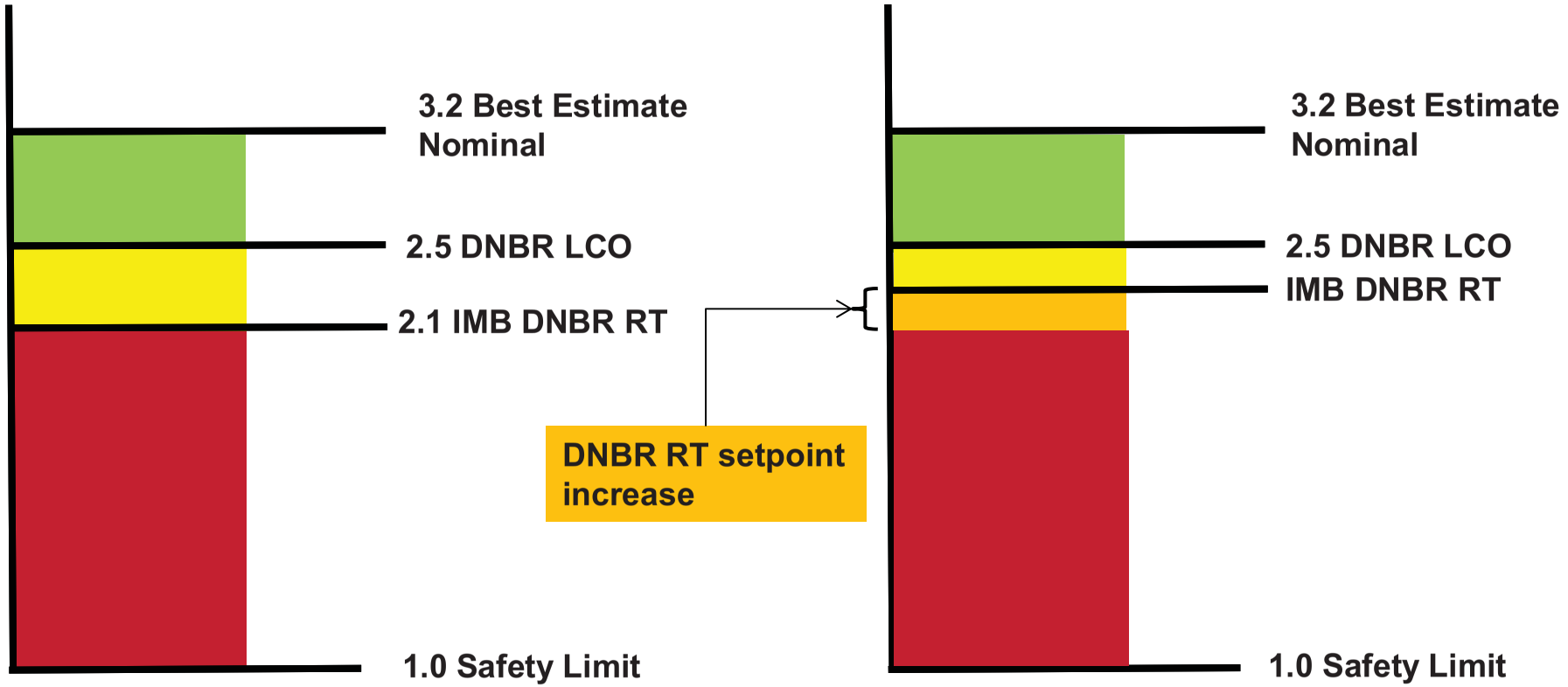
Conceptual Illustration of Monitored DNBR Distribution

Example - Transient PS Response and RT Threshold



- The reference DNBR remains the same
- The evaluation of the dynamic compensation accounts for detected failures and the undetected failure
- The safety limit is respected with the same coverage and confidence

Example Illustration – Imbalance / Rod Drop 1 of 4 Trip Threshold Modification



- Level of protection of the safety limit is unchanged.
- The impact is seen as a reduction in operating margin

Summary

- The undetected failure of the most limiting SPND is implemented as a modification of the existing ANP-10287P methodology
  - ANP-10287P describes the statistical techniques utilized in U.S. EPR setpoint methods, as well as the design basis for the incore trip and LCO functions
  - The statistical techniques and design basis are not altered by consideration of an undetected failure
  - The incore trip thresholds will be decreased (HLPD) and increased (Low DNBR) as dictated by the ANP-10287P methodology to provide the required safety limit protection.
  - Discussion of the treatment of the undetected SPND failure will be added
- Changes to the FSAR
  - Update of the modified trip thresholds
  - Inclusion of an additional section in Chapter 15 to describe the manner in which the undetected SPND failure is addressed in the safety analyses.
  - Updates to the affected transients discussion and plots

Process

- Reviewed calculations and reports for the time of DC submittal and previous RAI responses
- Examined methodology for compliance with topical reports
- Performed fresh review of the issues to define workscope and identify any potential errors/omissions in the method
- Divided workscope into three major efforts
  - Static setpoint analysis
  - Transient setpoint application (dynamic compensation)
  - Transient assessment
- Condition Reports were identified and resolutions included

Summary of Condition Reports

- Imbalance calculation in the static setpoint assessment over predicted imbalance by factor of two
- Compliance with topical reports
  - CHF uncertainty application
- Inconsistent inputs at various stages
  - Uncertainties and distribution of uncertainties used
- Conditions in the transient analysis evaluation
  - Transient analysis did not consider detected SPND failures
  - Unverified assumptions used
  - Core shape scaling methods incomplete or inappropriate
  - Conditions found in the calculations supporting the asymmetric events

Summary of Condition Reports

- Incorrect text in topical report ANP-10287P (not related to SPND failures)

- Due to number of issues found, a higher level Condition Report was written
  - Root cause analysis

Static Setpoints

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Static Setpoints

- Code and inputs modified to address the inclusion of an undetected failure
- [

]

- Undetected failure assumed in the most conservative location in the core for the given monitored parameter
  - DNBR/Quality – worst string location
  - HLPD/SPND Imbalance – worst sensor location
- Relatively small differences due to the inclusion of the undetected failure for symmetric cases
  - All detectors are close in their sensed reading, resulting in similar thresholds

Static Setpoints

- **Asymmetric cases show greater impact**
  - **As expected, a larger number of failures will lead to more conservative thresholds (higher DNBR and lower HLPD) due to less accurate sensing of the core power**
    - Most limiting location always assumed for the undetected failure
    - The effect on the threshold is greater than the statistical treatment of detected failures since it deterministically removes the most limiting condition from the threshold determination
  - **Threshold used for binning symmetric and asymmetric cases important for assessing the impact**
    - An error in the calculation of the imbalance led to more cases ending up in the asymmetric bin than should have been placed there (Condition Report issued)
    - Corrected the error and the symmetric threshold was affected
  - **Threshold values increase as a result of the combination of the undetected failure and the error in the imbalance calculation**
- **Overly conservative asymmetric temperature profiles have been removed**
    - 90° F quadrant-to-quadrant ΔT cases removed with benefit to the imbalance threshold

Static Setpoints

- **Determination of the worst SPND location ensures the worst location is chosen for each trip function**
  - **For DNBR, the assumed undetected failure is always placed in the most limiting string, that being the one which would lead to a greater setpoint**
    - If the trip threshold would be based upon the 2nd minimum, the undetected failure results in a threshold based upon the 3rd minimum (raises the required threshold)
  - **For Quality, the assumed undetected failure is always placed in the most limiting string, that being the one which would lead to a lower setpoint**
    - If the trip threshold would be based upon the 2nd maximum, the undetected failure results in a threshold based upon the 3rd maximum (lowers the threshold)
  - **For HLPD, the assumed undetected failure is always placed in the most limiting SPND location , that being the one which would lead to a lower setpoint**
    - If the trip threshold would be based upon the 2nd maximum, the undetected failure results in the threshold based upon the 3rd maximum (lowers the threshold)

Static Setpoints

Observations

- **Very conservative asymmetric temperature shapes are driving setpoint thresholds**
- **Removed some shapes representing very high quadrant-to-quadrant temperature differences based upon verification of transient behaviors**
  - Improved threshold values in some cases

Static Setpoints

- **Observations of the undetected failure effects**
  - **Increases the likelihood of an entire quadrant (three SPND strings) being removed for consideration in DNBR/quality**
    - Previous analysis assumed failures in strings independent of the locations when randomly sampling which led to more cases with all quadrants represented
  - **Loss of an entire quadrant of strings has a significant impact on asymmetric core power shapes**
    - The worst power peaking may not be measured
  - **Without preventing the loss of a full quadrant, allowing for the undetected failure results in noticeable loss of operating margin**
- **To prevent loss of a full quadrant, analysis rules are used to ensure protection and reduce chance of spurious trips**
  - **Rules to be implemented by Technical Specification and COLR**

Rules for Detected Failures

- **Number of SPND strings with detected failures limited to one string per quadrant**
  - A string is considered failed if one or more SPNDs in the string are failed
  - With undetected failure, each quadrant will have at least one string available
  - Limits the total number of strings allowed to be failed to four (4)
- **Number of SPND failures limited to five**
  - Evaluated coincident with rule on strings
  - Five SPND failures requires that at least two of the failures have to be in the same string

Rules for Detected Failures

Static Setpoints

Recommended DNBR Setpoints				
Number of Detected SPND String Failures	Original RT Setpoint	RT Setpoint	$RT_{RD/IMB}$ Setpoint	LCO
0	1.95	2.30	2.35	2.50
1	Not calculated	2.35	2.40	2.50
2	Not calculated	2.40	2.50	2.55
3	Not calculated	2.45	2.55	2.60
4	Not calculated	2.50	2.60	2.65
5	2.10	N/A	N/A	N/A

Static Setpoints

Recommended Quality Thresholds			
Number of Detected SPND String Failures	Original RT Setpoint	RT Setpoint	$RT_{IMB/RD}$
0	0.25	0.25	0.20
1	Not calculated	0.25	0.20
2	Not calculated	0.25	0.20
3	Not calculated	0.25	0.20
4	Not calculated	0.25	0.20
5	0.25	N/A	N/A

Static Setpoints

Recommended HLPD Setpoints (W/cm)				
Number of Detected SPND Failures	Original RT Setpoint	RT Setpoint	$RT_{RD/IMB}$ Setpoint	LCO
0	460	460	385	350
1	Not calculated	460	385	350
2	Not calculated	445	385	350
3	Not calculated	445	385	350
4	Not calculated	440	385	350
5	460	440	385	350

Planned Topical Report Changes

- Updates for description of undetected SPND failures in methods
- Description of allowed SPND failure rules
- Changes to Appendices F and G (not related to SPND failures)

Dynamic Compensation with an Undetected SPND Failure

William F. Walters
Principal Engineer

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Agenda

- Effect of an undetected SPND failure on the incore transient analysis
- SPND failure location determination
- Examples with an undetected SPND failure
  - Increase in Feedwater Flow (IFF) Event (SRP 15.1.2)
- Summary
- Status Update

Incore Transient Analysis Review

Compensated Trip Model

Uncompensated Trip Model

SPND Imbalance by Axial Level

Determining Limiting Failure Location

Limiting Failure Location for DNBR

Limiting Failure Location for HLPD

Limiting Failure Location for SPND Imbalance

DNBR for a Symmetric Event

Symmetric DNBR Trip with no SPND Failures

Symmetric DNBR Trip with an Undetected SPND Failure

Compensated DNBR for IFF Event

IFF Trip without SPND Failures

IFF Uncompensated Trip Model

IFF with Undetected SPND Failure

IFF with 1 Undetected + 1 Detected SPND String Failure

IFF with 1 Undetected + 2 Detected SPND String Failures

Transient Analysis Summary

- Asymmetric events are more sensitive to SPND failures than symmetric events.

Status Update

- **The Chapter 15 transient analyses have been reviewed to determine which events must be re-evaluated with an undetected SPND failure.**
  - **Most symmetric events remain representative.**
    - The control rod bank drop event is being re-evaluated.
  - **The asymmetric events are being re-evaluated.**
- **The transient evaluations for incore trip with an undetected SPND failure are prepared and are under review.**

Expected FSAR Changes

- The overall conclusions to the transient analyses in Chapter 15 of the FSAR are expected to remain unchanged.
  - Figure 15.1-58 – Increase in Main Feedwater Flow – Representative Plot of Normalized Minimum DNBR and Maximum LPD to SAFDL will be updated
- Changes are needed to discuss the undetected SPND failure and update the setpoints
  - Table 4.4-1 – DNB LCO setpoint
  - Chapter 15.0 (including Table 15.0-7 – Trip Setpoints)
  - Section 7.2.1.2.1 and 7.2.1.2.2 – Describe the incore trips

Summary

- This presentation has explained the analysis and method used to calculate the static trip setpoints while accounting for the undetected single failure of an SPND at the most limiting location.
- This presentation has explained how the most limiting location of an undetected single failure of an SPND is determined.
- Finally, this presentation has demonstrated the impact of the undetected SPND failure on the DNBR undershoot analysis.

Next Steps

- **Advanced Response to RAI 505** — **6/28/2013**
  - Response to Q07.01-33
  - Updates to ANP-10287P
- **Audit** — **July 2013**
- **Final Response to RAI 505** — **7/30/2013**
  - Response to Q07.01-33
  - Updates to ANP-10287P

Acronyms

COL	Combined License
DCR	Design Change Request
DNBR	Departure from Nucleate Boiling Ratio
HLPD	High Linear Power Density
IFF	Increase in Feedwater Flow
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
PS	Protection System
RT	Reactor Trip
RT_{IMB}	Reactor Trip for Imbalance Condition
RT_{RD}	Reactor trip for Rod Drop Condition
SPND	Self-Powered Neutron Detector