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Framatome ANP Methodology for DIVOM Analysis

Presentation to the Nuclear Regulatory Commission

March 14, 2006

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Agenda

- Introduce DIVOM in the context of Detect & Suppress stability solution
- DIVOM using RAMONA5-FA
- Calculation Description

Introduction to Stability Solutions

> Two categories of stability protection systems

- Region Exclusion
  - Automatic scram initiated upon entering pre-defined potentially unstable region on the power/flow map
  - Administrative controls on buffer regions
- Detect and Suppress
  - OPRM signals analyzed to detect oscillations and initiate scram prior to violation of the SLMCPR
  - Option I-D for small plants (global mode only)
  - Option III for large plants (protection for global & regional modes)

Introduction to D&S and DIVOM

> **Elements of Option III Detect and Suppress**

- OPRM cells (closely spaced LPRMs)
- OPRM signals conditioned and filtered for oscillation detection (Period-Based Algorithm)
- Setpoints:
  - Number of PBDA counts (N_P)
  - Amplitude setpoint (S_P)
- Plant-specific relationship between S_P and Oscillation Magnitude (OM)
- Generic (now cycle-specific) relationship between relative OM and relative CPR response (DIVOM Curve)

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DIVOM Basis

- Density waves result in coherent power and flow oscillations
- CPR response can be "correlated" to power signals
- Based on correlating relative, not absolute, parameters
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- Regional mode is limiting
  - Nearly twice the global mode DIVOM slope
- Use a time-domain system code to generate this correlation
- Delta over Initial CPR Versus Oscillation Magnitude (DIVOM)

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Recent DIVOM Challenges

- Part 21 Report: Generic DIVOM curve nonconservative
- Resolution:
  - Figure Of Merit (FOM) DIVOM slope multiplier (GE)
    - FOM Correlated with hot channel Power/Flow ratio
    - Produces high DIVOM slope and consequently low S_P setpoint
  - Cycle-Specific DIVOM calculation
    - Elevated DIVOM slopes less likely for current cycle designs
- Now DIVOM is no longer generic, FANP developed DIVOM capability
  - RAMONA5-FA time-domain code

RAMONA5-FA Benchmarks

- RAMONA5-FA is used to generate the DIVOM correlation
  - RAMONA5-FA was benchmarked to assure that the theoretical models and solution scheme accurately predict the CPR response under oscillatory conditions
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    -]

Transient System Code

- Goal: Perform Well-Defined Numerical Analyses to Provide Data for DIVOM Relationship
- Studsvik-Scandpower RAMONA5-2.4 ⟶ RAMONA5-FA
  - New Modules
  - Updated Closing Relations & Correlations
  - Automation
  - Miscellaneous Improvements
  - Benchmarking & Sensitivity

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    - CPR Correlations (ANFB-10 and SPCB)
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Benchmark Analyses

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Reactor [ ] Benchmarks

Reactor Benchmarks and Sensitivities

> [

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Framatome ANP Cycle-Specific DIVOM Methodology

- **BWROG Cycle Specific Guidelines**
  - Plant-Specific Regional Mode DIVOM Procedure Guideline
    - GE-NE-0000-0028-9714-R0
    - Issued June 15, 2004, Revision 1 issued June 2005
    - Outlines procedure to be used to generate plant/cycle specific DIVOM points
- **Framatome ANP Cycle Specific Analysis Guideline**
  - Issued August, 2004
  - Implements Framatome ANP methodology with the procedure outlined in the BWROG procedure
  - DIVOM results are reviewed to check for the existence of hydraulically unstable channels

Calculation Flow

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Conclusions

- RAMONA5-FA is used to generate the DIVOM correlation at FANP
- RAMONA5-FA was benchmarked to assure that the theoretical models and solution scheme accurately predict the CPR response under oscillatory conditions
- RAMONA5-FA has been streamlined with FANP methods and codes
- DIVOM calculation procedures in place for cycle-specific applications
- Challenge to generic DIVOM has been determined to be interference from possible unstable hydraulic mode in individual hot bundles