Status Update: BWROG Detect & Suppress Stability Solution Methodology

Presentation to USNRC
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Meeting Objective

- **Provide status of BWROG activities to resolve stability (DIVOM) issue**
- **Provide schedule update for licensing review**
- **Obtain NRC feedback on issues/concerns**

Outline

- **Background**
- **Phase 1 Evaluation**
- **Proposed Modifications to Option III Licensing Basis**
- **TRACG Licensing Applicability**
- **Option I-D and Option II Plans**
- **Conclusion/Schedule**

Background - D&S Solutions

- **Three detect & suppress solutions:**
  - **Option III**
    - **Core wide and regional mode oscillations are possible**
    - **SLMCPR protection from Oscillation Power Range Monitor (OPRM) trip**
  - **Option I-D**
    - **Only core wide oscillations are possible**
    - **SLMCPR protection from flow-biased APRM flux trip**
  - **Option II**
    - **Core wide and regional mode oscillations are possible**
    - **SLMCPR protection from quadrant-based flow-biased APRM flux trip**

Background - Methodology

- **Three parts to current Detect & Suppress licensing methodology:**
  - **Hot channel oscillation magnitude (HCOM)**
    - **Statistical method to calculate OM when trip occurs for given hardware configuration**
  - **CPR oscillation response**
    - **Generic DIVOM curve (Delta over Initial CPR Vs. Oscillation Magnitude) based on TRACG analysis**
  - **Pre-oscillation MCPR**
    - **SLMCPR, OLMCPR, CPR change due to 2RPT**

Background – Part 21

- **GE issued Part 21 notifications 6/29 and 8/31/01**
  - **Generic DIVOM curve may be non-conservative for high peak bundle powers in current core designs**
  - **OPRM setpoints based on generic DIVOM may not provide SLMCPR protection for some instability events**
  - **Does <u>not</u> produce a significant safety hazard**
- **Schedule commitments made to NRC**
  - **2Q02 Present revised methodology to NRC**
  - **3Q02 Submit LTR for NRC review**
  - **4Q02 NRC approval requested**

Background - BWROG Activities

- **Reconvened Detect & Suppress Committee in 2001**
- **Phase 1 - Developed initial plan for resolution**
  - **Compile & evaluate existing DIVOM database**
  - **Increase fundamental knowledge of DIVOM phenomena**
  - **Identify key plant/fuel/cycle parameters that affect DIVOM**
  - **Utilize Phenomena Identification & Ranking Table**
  - **Develop correlation to predict plant/fuel/cycle DIVOM curve**
  - **Identify new TRACG cases needed to provide a clear physical understanding of factors that affect DIVOM**
  - **Use conservatisms available in HCOM or pre-oscillation CPR portions of methodology to offset higher DIVOM slope**
  - **Make no basic changes to the approved methodology**

Phase 1 Evaluation Results

- **DIVOM correlation**
  - **Able to identify key parameters affecting DIVOM**
  - **Difficult to develop good DIVOM correlation from regression analysis of TRACG results**
- **Conservatism in HCOM**
  - **Conservative to use high radial peaked oscillation contours**
  - **Oscillation contours based on current flatter radial power distributions provides small benefit (lower HCOM)**
- **Conservatism in pre-oscillation CPR methodology**
  - **Equilibrium feedwater temperature assumption at low power underestimates CPR increase after 2RPT**
  - **Significant benefit to use actual transient feedwater temp**

Phase 1 Evaluation Conclusions

- **Generic DIVOM correlation is <u>not</u> viable approach**
  - **Large uncertainty in DIVOM slope with regression analysis**
  - **Significant work required to develop DIVOM regression equation - completion within defined schedule doubtful**
  - **Bounding DIVOM curve will be very steep**
  - **Combining bounding DIVOM curve with bounding pre-oscillation CPR produces unacceptably low OPRM setpoints for some plants**
- **Plant-specific DIVOM may be possible for use with current methodology**

BWROG Decisions

- **Revise Option III methodology:**
  - **Make use of TRACG integrated transient simulation of oscillation inception and progression for CPR response**
    - **CPR response to oscillations is a function of a number of coupled factors best modeled together rather than separately**
    - **Eliminate excessive conservatisms**
- **Step-wise approach for resolution**
  - **Provide Option III resolution for existing operating domain as first priority**
  - **Evaluate Options I-D and II**
  - **Assess applicability to MELLLA+, future core/fuel designs**

Methodology Objectives

- **Provide SLMCPR protection for anticipated oscillations**
- **No hardware or software changes**
- **Maximize generic elements of solution (less plant specific analysis)**
- **Provide unified approach for Options I-D, II, and III**
- **Define plant/fuel/core design applicability**
- **Applicable to all fuel vendor designs**
- **Minimize reload analysis scope**
- **Low potential for unnecessary scrams**
  - Avoid spurious scrams from noise
  - Survive small oscillation without scram
  - Survive 2RPT without automatic scram
- **Minimize changes to licensing basis**
- **Acceptable to NRC**

Proposed Methodology

- **Define generic setpoints based on transient TRACG analysis and apply to all plants**
  - **Generic OPRM amplitude and period count setpoints provide SLMCPR protection for all anticipated events**
- **Run TRACG simulation of transient events**
  - **Able to simulate oscillation inception and progression**
  - **Directly calculate CPR response to events**
  - **Model reasonably limiting oscillation events (2RPT, LOFWH)**
  - **Use TRACG-predicted transient feedwater temperature**
  - **Use HCOM to determine time of oscillation suppression**
  - **Determine CPR margin of limiting channel**

Proposed Methodology

- **Solution elements that do not change**
  - **Trip system (HW)**
  - **Detection algorithms (SW)**
  - **Hot channel oscillation magnitude**
  - **CPR response calculation tool (TRACG)**
- **Methodology elements that change**
  - **Initial core conditions – start transient w/ actual plant conditions**
  - **Pre-oscillation MCPR – use integral TRACG simulation**
  - **Bundle CPR response – use integral TRACG simulation**
  - **Reload analysis – simplified by use of generic setpoints**

Proposed Methodology Changes

- **Initial core conditions – change**
  - ➢ **Current: Non-realistic initial condition – oscillation starts at NC with off-rated equilibrium feedwater temperature**
  - ➢ **Proposed: Realistic event simulation including core flow and feedwater temperature transient**
- **Pre-oscillation MCPR – change**
  - ➢ **Current: 3D BWR Simulator calculation of CPR change from rated core flow/rated feedwater temperature to NC with off-rated equilibrium feedwater temperature**
  - ➢ **Proposed: TRACG models CPR change during flow runback with calculated transient feedwater temperature**

Proposed Methodology Changes

- **Bundle CPR response – change**
  - **Current: DIVOM curve**
  - **Proposed: TRACG simulation of CPR response of limiting bundle during power oscillations**
- **Reload analysis – changes**
  - **Current: Confirm DIVOM applicable for fuel and calculate cycle-specific OPRM setpoint**
  - **Proposed: Confirm plant/fuel/cycle parameters within basis for generic OPRM setpoint**

Proposed Licensing Basis for Option III

- **Use the current statistical methodology to determine relationship between amplitude trip setpoint and hot channel oscillation magnitude (HCOM)**
- **From TRACG transient calculations, demonstrate that the oscillation will be suppressed before the SLMCPR is violated**
- **A generic amplitude setpoint is adequate if:**
  - **For a representative population of plants, conditions, core designs, fuels, and events, SLMCPR protection is demonstrated**

TRACG Licensing Applicability

- **Significant TRACG analysis experience exists**
- **NRC review of specific elements**
  - **AOOs – TRACG AOOs LTR**
  - **DIVOM – Stability D&S LTR**
  - **ATWS instability event – ATWS Instability LTR**
- **Use of TRACG in proposed methodology**
  - **Consistent with approved methodology**
  - **Models CPR response during oscillations**
  - **Application limited to demonstrating adequacy of stability setpoints**

TRACG model review not necessary for this application

Summary of Advantages

- **Generic approach for all Option III plants**
- **Makes use of existing robust OPRM**
  - **No OPRM hardware changes**
  - **No OPRM software changes**
- **Simplified and more direct approach**
- **Makes use of existing approved methodology**
- **TRACG already approved to calculate change in CPR for an instability**
- **Simple reload evaluation process**
- **Low potential for spurious scrams**
- **Can survive small oscillation without scram**
- **Do not need a DIVOM curve correlation**

Options I-D and II Plan

- **Assess applicability of proposed Option III methodology changes to Options I-D and II**
  - **I-D: Use TRACG transient simulation of core-wide mode oscillations to confirm SLMCPR protection with existing flow-biased APRM flux trip**
  - **II: Use TRACG transient simulation of regional mode oscillations to confirm SLMCPR protection with existing quadrant-based APRM flux trip**

Open Items

- **Analysis in progress**
- **More than one setpoint may be needed to address all plants and conditions**
- **MELLLA+ to be assessed**
- **Developing applicability to other (non-GE) fuel vendors**
- **Developing applicability for Option I-D and Option II**

Conclusion/Schedule

- **Initial plan needed to be modified**
- **Proposed approach shows promise**
- **Some impact on committed schedule**

Date	Milestone
5/1/02	Update NRC on planned approach
~7/31/02	Review proposed methodology and results with NRC
9/30/02	Submit LTR for NRC review
[?]	NRC approval expected