Decay Ratio Adder Removal

Option I-D/II Exclusion Region Licensing Methodology

Presentation to NRC – Closed Session

April 18, 2007(scheduled)

Agenda

- Open Questions from Previous Presentations
  - Current Plants and Cycles
  - On-Line Stability Monitor Experience
  - Haling Methodology & Conservatisms
  - Buffer Region (BR)
- ODYSY Methodology Changes
  - Modified Shape Function (MSF)
  - Proposed ODYSY Procedure & FWTR
  - Removal of 0.15 Decay Ratio (DR) Adder
- Summary and Conclusion

Current Plants/Cycles

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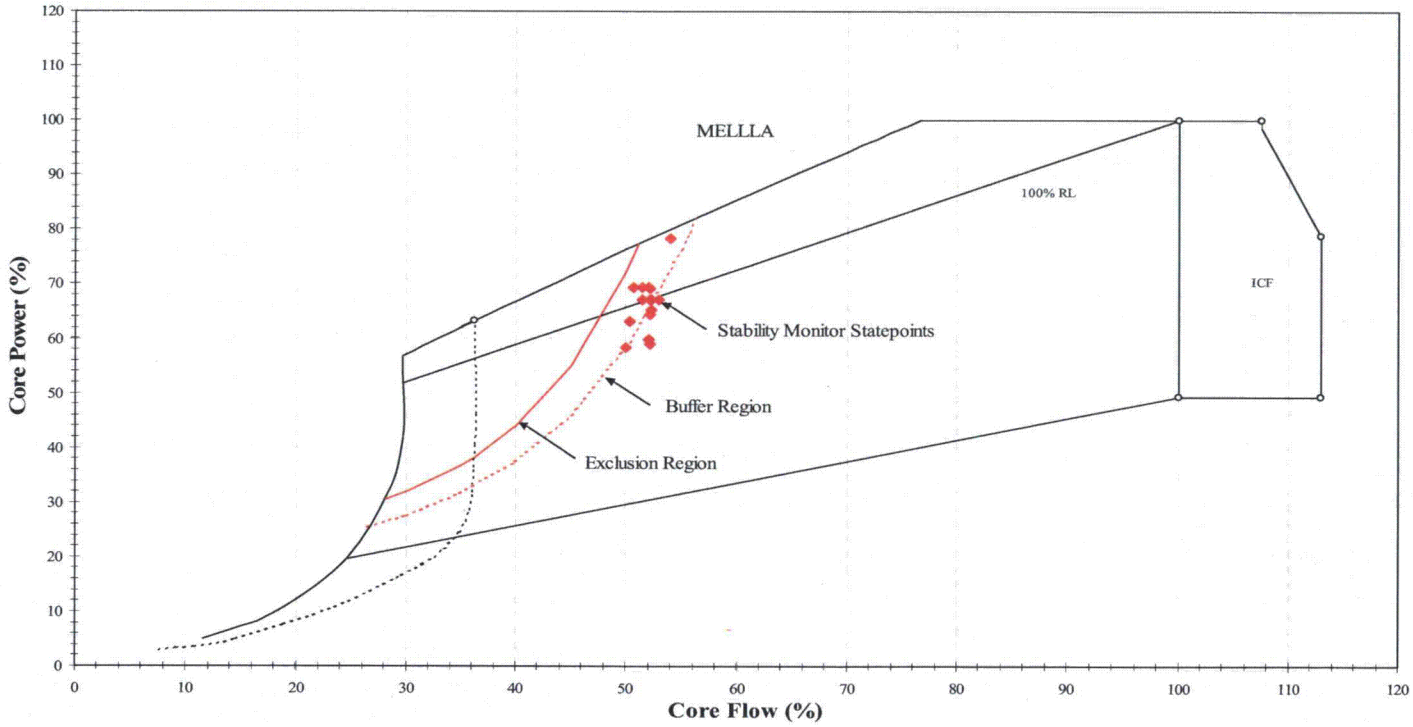
On-Line Stability Monitors

- Option I-D plants are required to have an online stability monitor (SOLOMON/GARDEL)
  - Must be operational to enter Buffer Region
  - Calculated decay ratios must be below specified stability criterion to operate in Buffer Region
  - If decay ratios above criterion, immediate exit from Buffer Region required
  - If inadvertent entry into Buffer Region and stability monitor not operational, immediate exit required
  - Typically used during startups, control rod pattern adjustments at reduced power, EOC shutdown

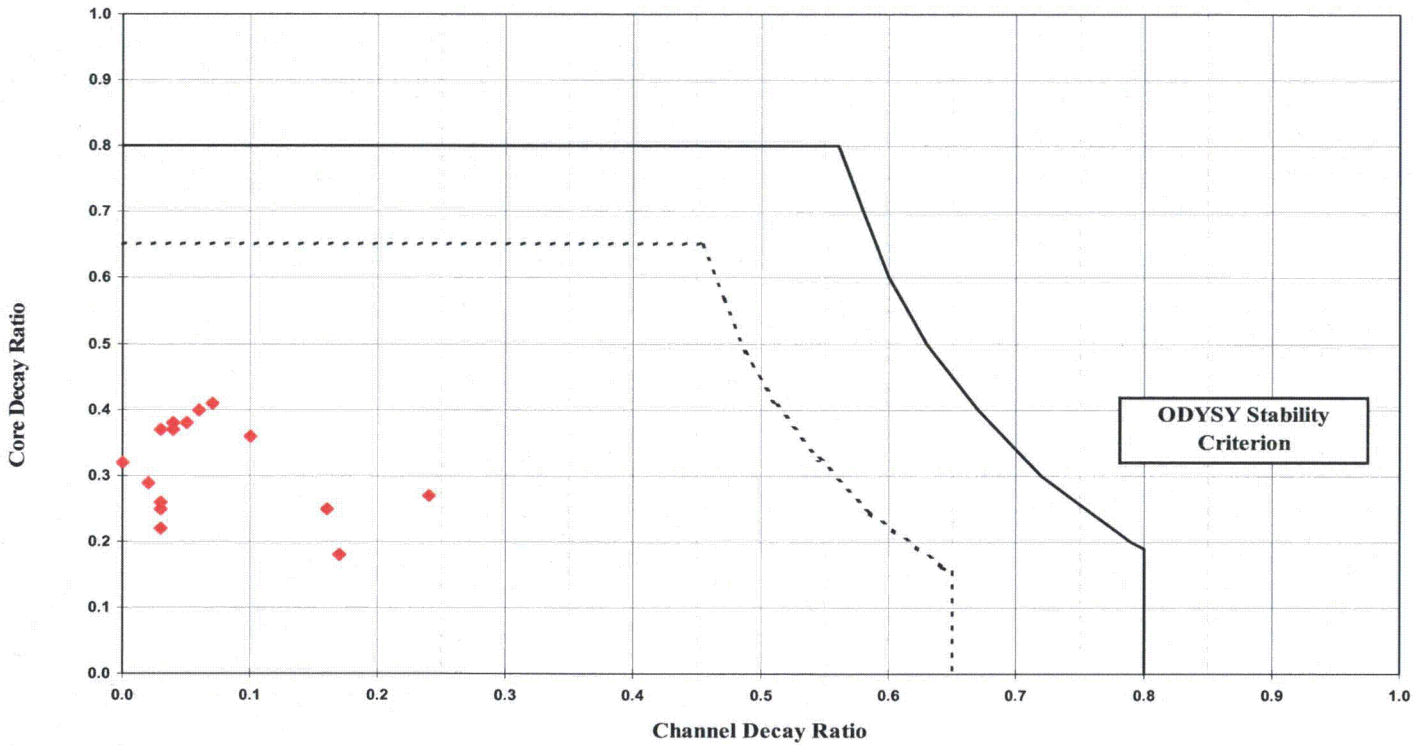
On-Line Stability Monitors

- Example 1 – SOLOMON Data, CRP Adjustment



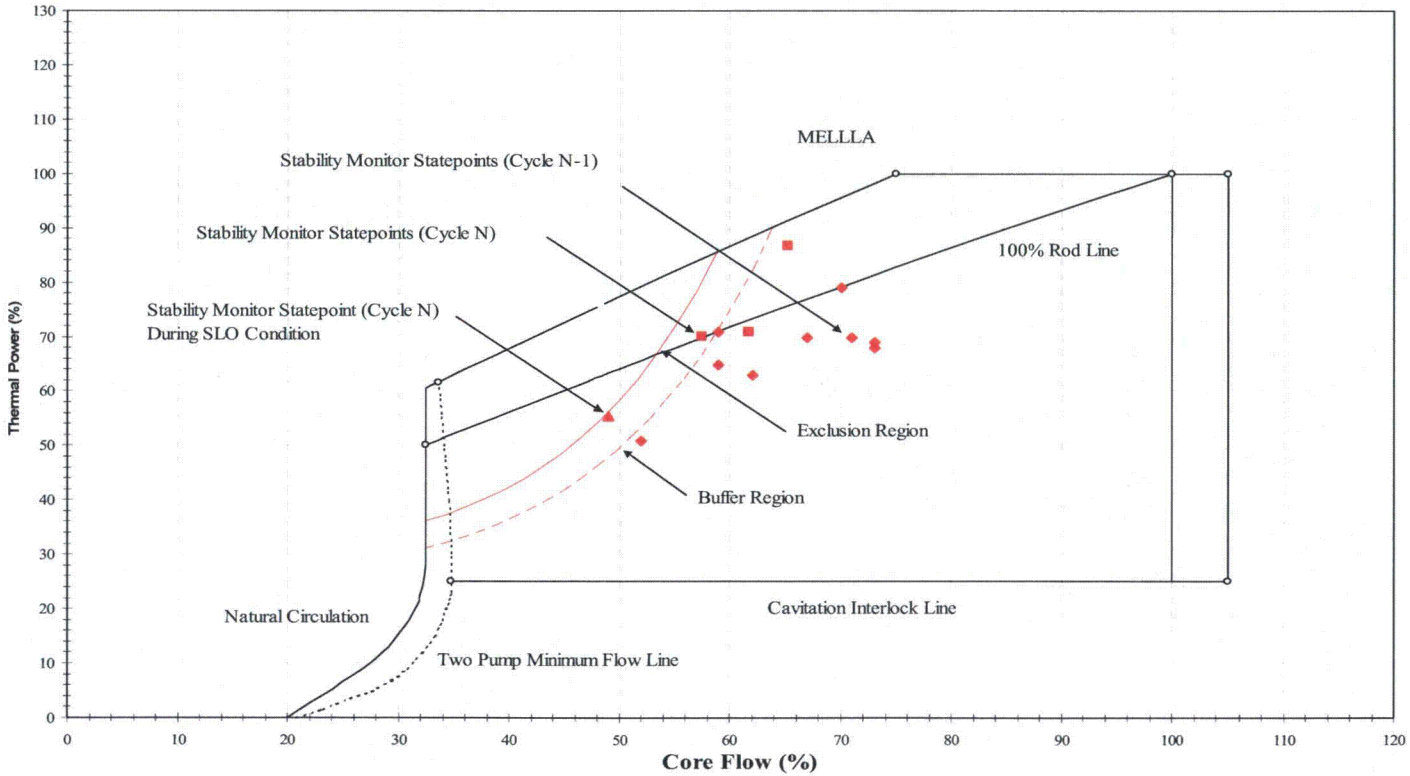
On-Line Stability Monitors

- Example 1 – SOLOMON Data, CRP Adjustment



On-Line Stability Monitors

- Example 2 – GARDEL Data, CRP Adjustment, Single Loop



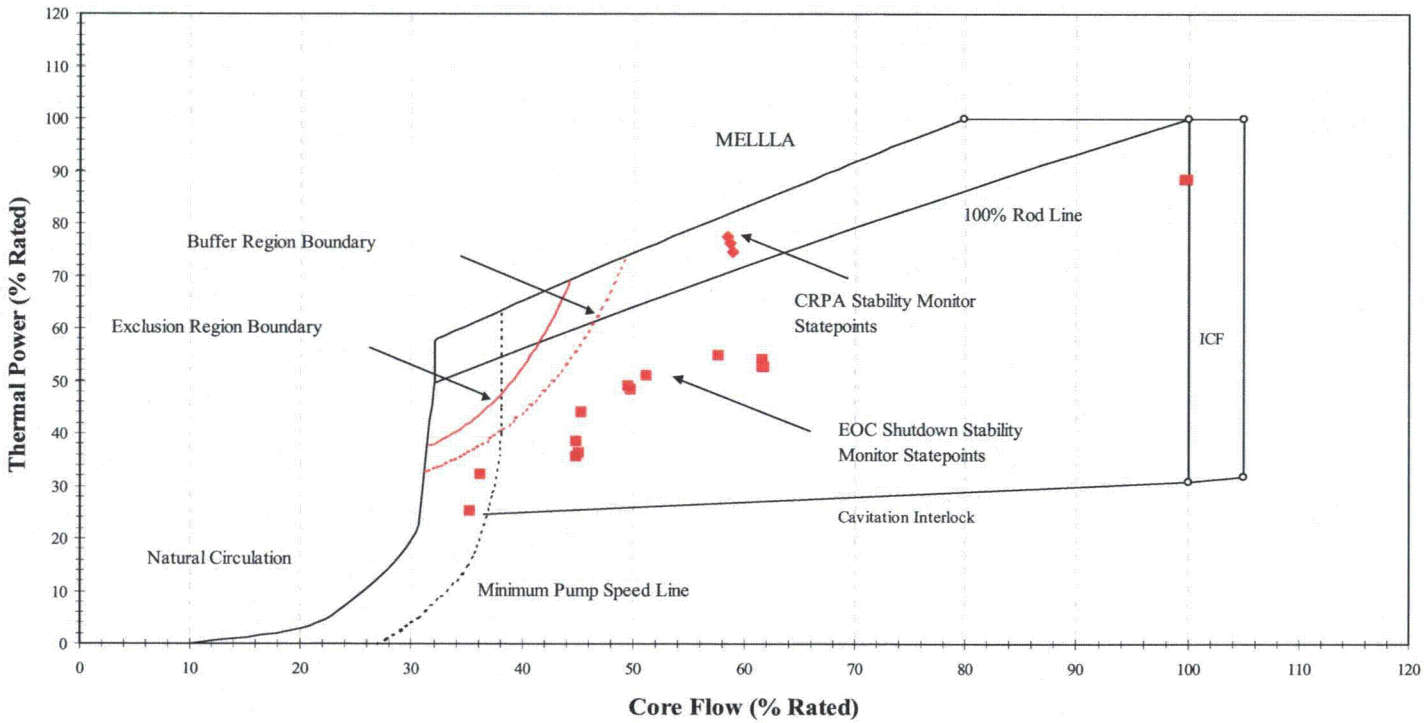
On-Line Stability Monitors

- Example 2 – GARDEL Data, CRP Adjustment, Single Loop

Exposure GWd/MT	Power (%)	Flow (%)	Global DR	Regional DR
Cycle N-1 Statepoints				
0.0	63.0	62.0	0.33	0.041
2.6	51.0	52.0	0.31	0.000
2.6	65.0	59.0	0.46	0.001
2.6	71.0	59.0	0.53	0.000
2.8	70.0	71.0	0.30	0.001
4.8	70.0	67.0	0.42	0.001
5.4	79.0	70.0	0.42	0.000
6.9	68.0	73.0	0.27	0.001
6.9	69.0	73.0	0.27	0.025
Cycle N Statepoints				
0.0	71.0	61.7	0.40	0.037
0.0	70.2	57.5	0.47	0.215
0.0	86.9	65.2	0.46	0.091
1.50	55.5	49.0	0.47	0.25

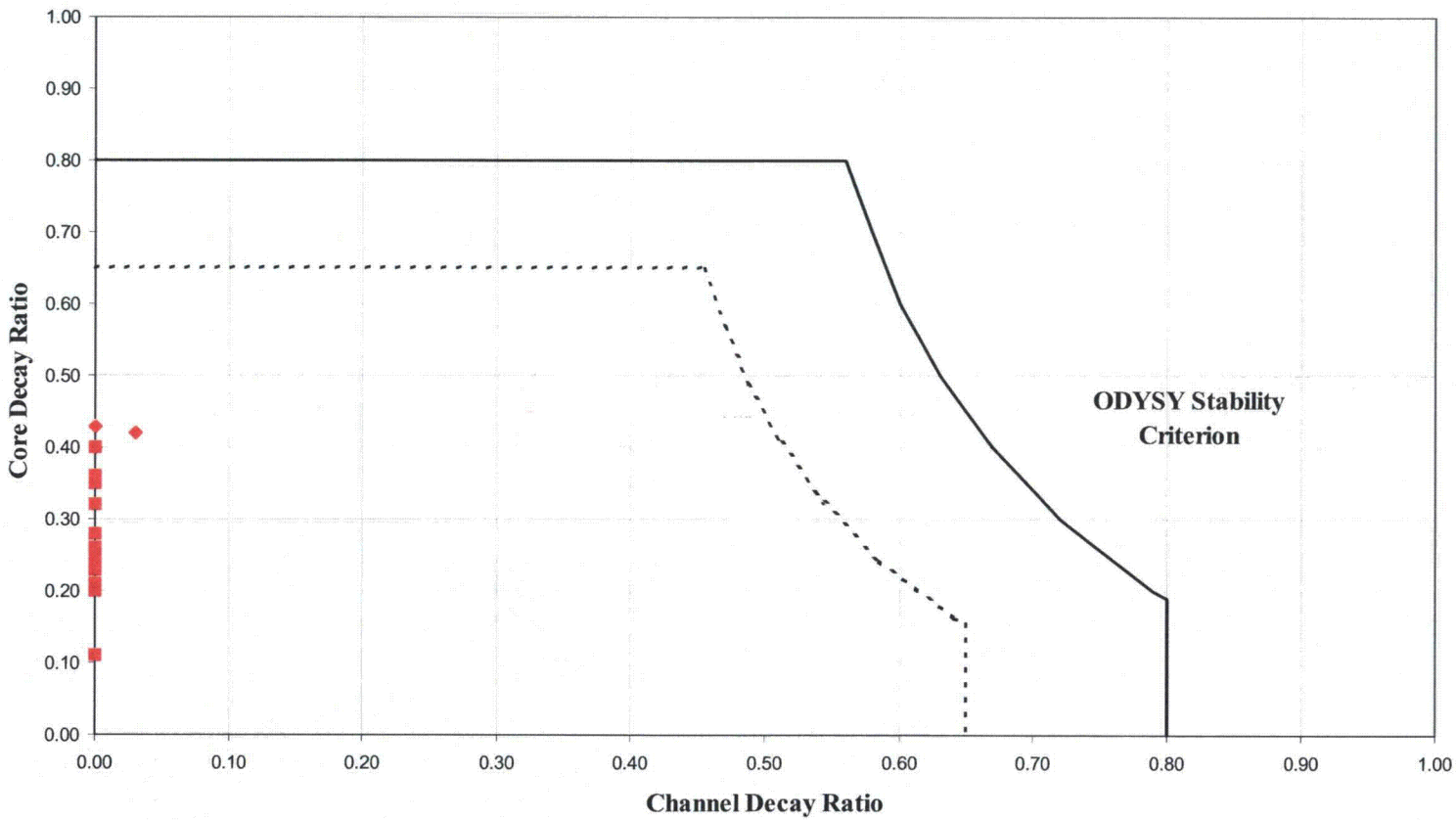
On-Line Stability Monitors

- Example 3 – SOLOMON, CRP Adjustment, EOC Shutdown



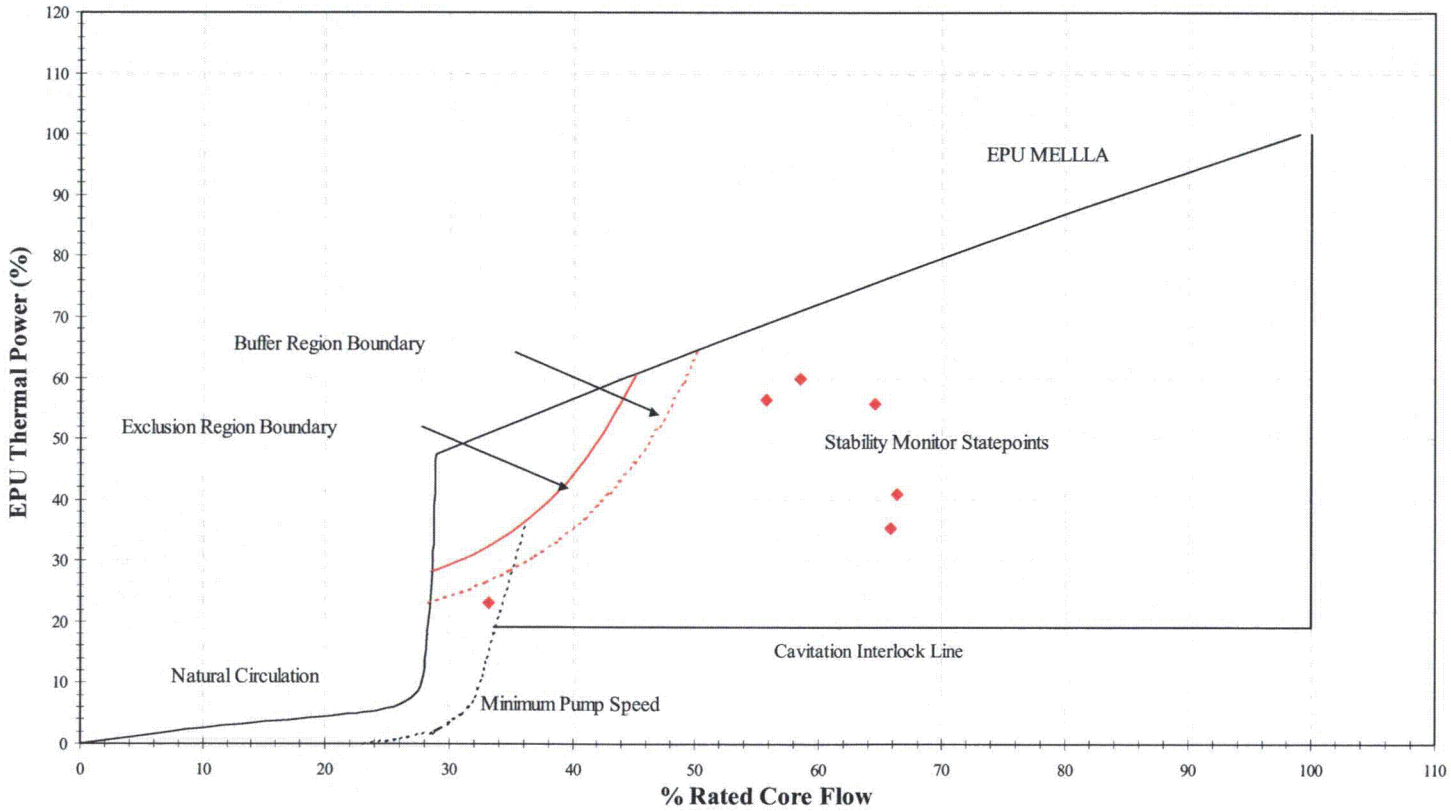
On-Line Stability Monitors

- Example 3 – SOLOMON, CRP Adjustment, EOC Shutdown



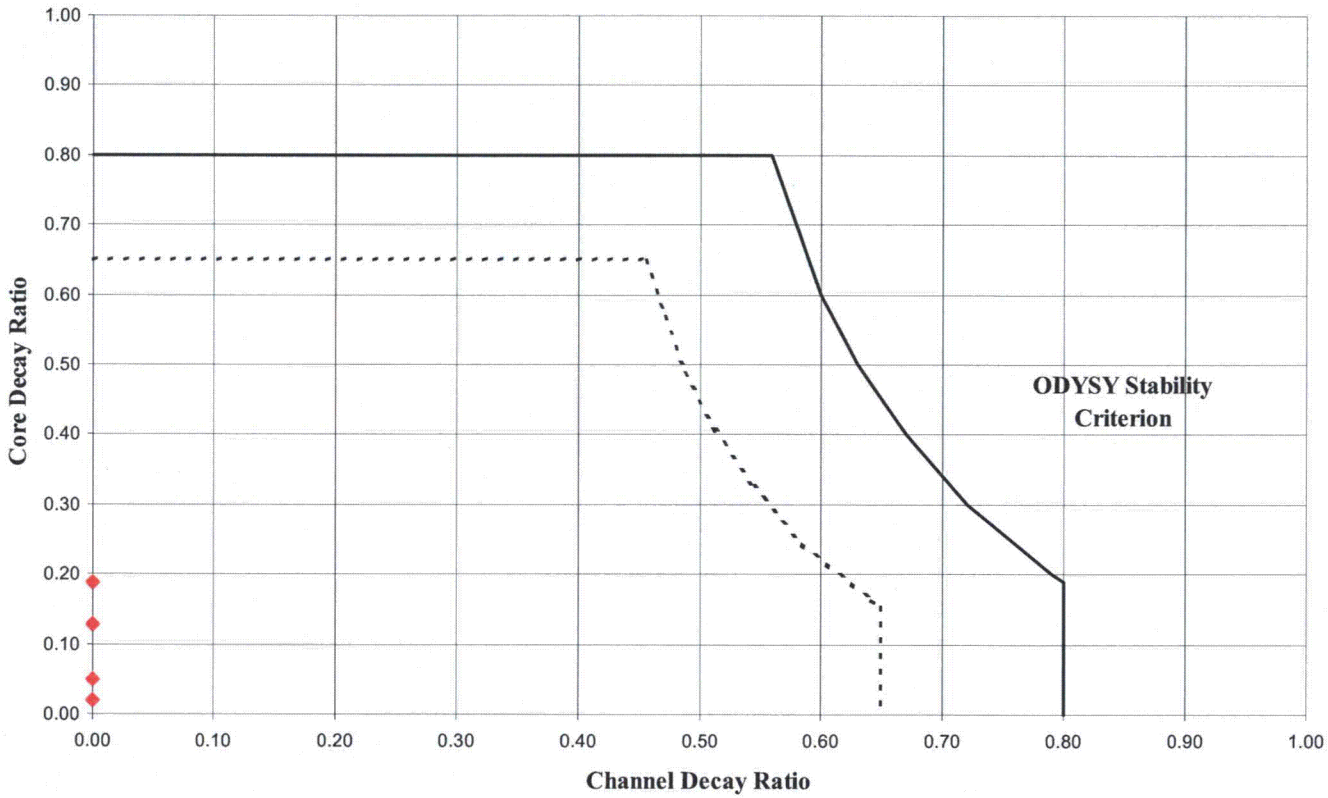
On-Line Stability Monitors

- Example 4 – SOLOMON, Startup



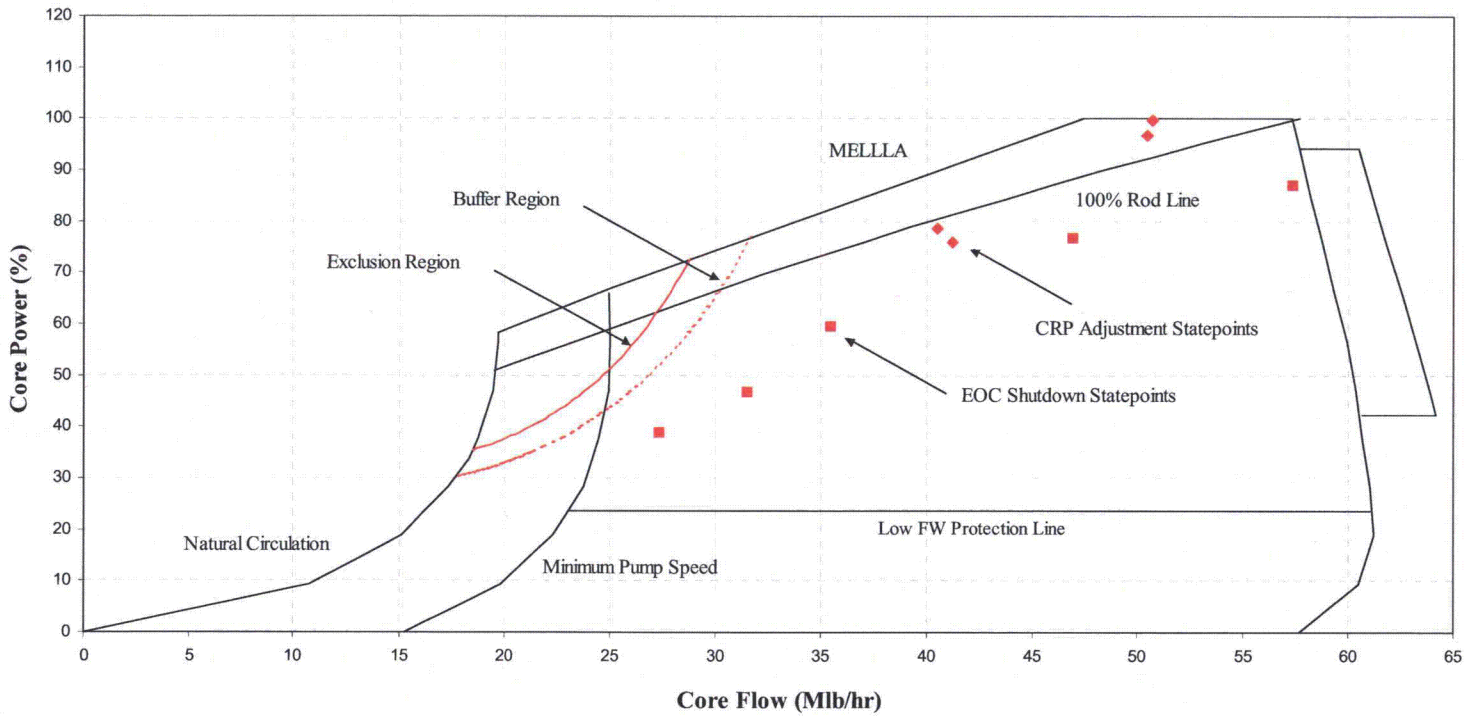
On-Line Stability Monitors

- Example 4 – SOLOMON, Startup



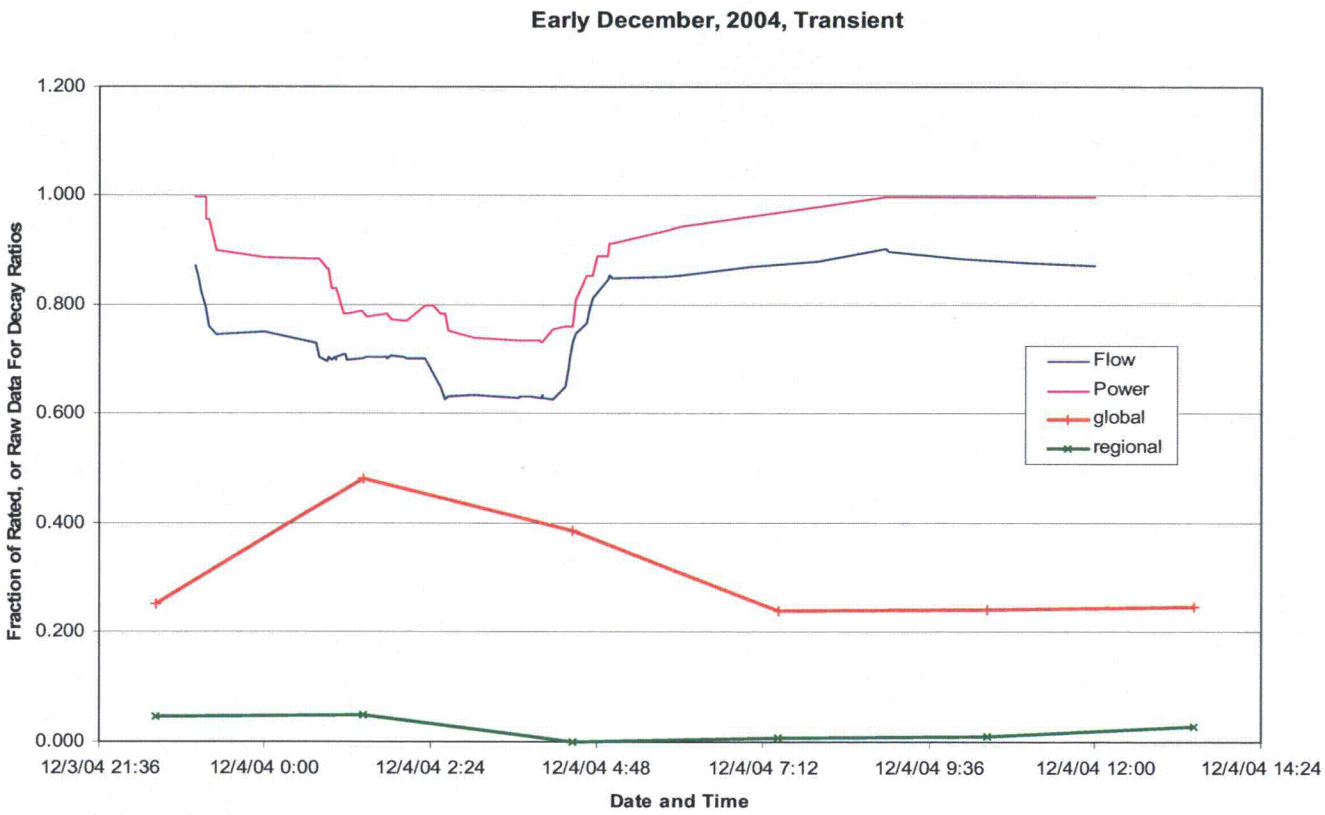
On-Line Stability Monitors

- Example 5 – GARDEL, CRP Adjustment & EOC Shutdown



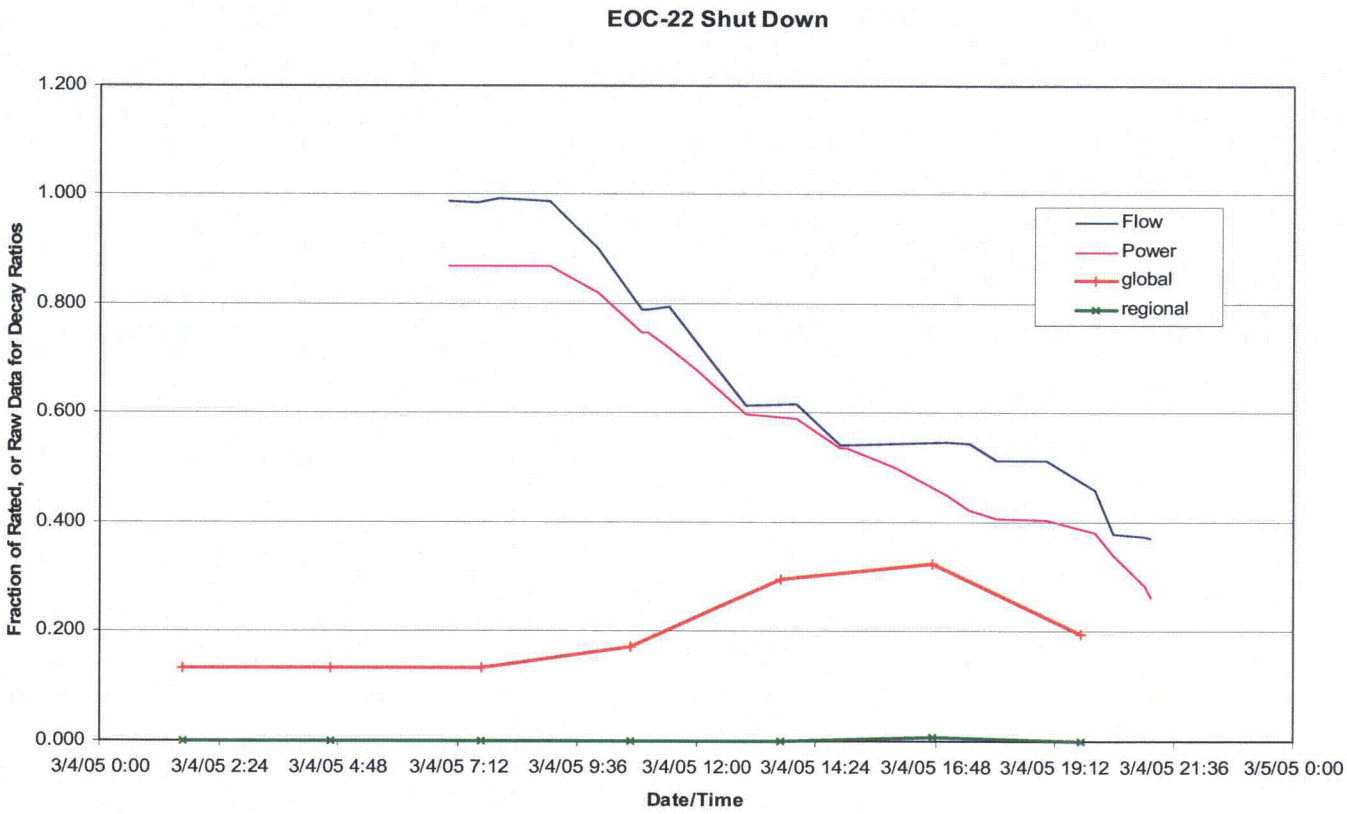
On-Line Stability Monitors

- Example 5 – GARDEL, CRP Adjustment



On-Line Stability Monitors

- Example 5 – GARDEL, EOC Shutdown



On-Line Stability Monitors – Key Points

- On-Line Stability Monitors provide an additional level of protection for Option I-D plants
- Monitors must be operational and calculations are performed prior to planned entry into the Buffer Region
- DRs based on actual operating history, plant conditions and control rod patterns show no surprises relative to the licensing basis calculations

Boundary Shape Functions

- Option I-D/II boundary shape functions establish conservative stability regions
- The Generic Shape Function (GSF) is defined in the current LTR
- The Modified Shape Function (MSF) is new
- Both functions are conservative
- When MSF is selected, procedure includes additional cycle specific confirmation analysis

Boundary Shape Functions

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Boundary Shape Functions – Key Point

- Both boundary shape functions – GSF/MSF – are conservative relative to a line of constant DR

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Haling Methodology

- Demonstrations were performed to show the ODYSY procedure produces a reasonably bounding Exclusion Region
- Exclusion Regions generated with proposed ODYSY procedure (DR=0.80, MSF)
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- Current operating strategies and the latest fuel designs were captured

Haling Methodology

- The scenario assumptions are follows
  - a flow reduction event occurs from the initial state point along the rod line established by the initial point
  - an ODYSY calculation is performed at the intersection of the rod line and ER boundary line
  - the analysis state point calculation follows the proposed procedure and captures the rated initial conditions and control rod pattern
  - Best estimate results are compared to the Haling based results and conservatism is demonstrated

Haling Methodology Demonstration

- Plant A Cycle (N) – EPU MELLLA, 72% 10x10, ~2 Yr Cycle

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Haling Methodology – Key Points

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The Buffer Region

- Buffer Region – the Exclusion Region is expanded by 5% in core flow along the High Flow Control Line (HFCL) and 5% in core power along the Natural Circulation Line (NCL)
- A 5% expansion of the ER can be 10% or greater in core DR depending on rod line
- Online stability monitor must be operational prior to entry and predicted DRs are known based on operating conditions – no surprises

The Buffer Region

- Plant A – EPU, MELLLA, 100% 10x10 Fuel, 2 Yr Cycle

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The Buffer Region

- Plant B – MELLLA, 66% 10x10 Fuel, 18 Month Cycle

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The Buffer Region

- Plant C – 5% PU, MELLLA, 100% 10x10 Fuel, ~2 Year Cycle

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The Buffer Region

- Plant D – MELLLA, 70% 10x10 Fuel, ~18 Month Cycle

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The Buffer Region – Key Points

- The currently defined Buffer Region size –

  5% in core flow along the HFCL & 5% in core power

- Along with the online stability monitor

- Provides adequate margin to the Exclusion Region

Proposed Procedure - FWTR

- The Exclusion Region is expanded for reduced feedwater temperature operation
- Plants implementing FWTR as a cycle extension option will apply an expanded Exclusion Region
- FWT demonstration assuming 50°F & 100°F reductions were performed

Proposed Procedure - FWTR

- Example 1 – Plant A Cycle N+1 – EPU, MELLLA, 2 Year Cycle

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Proposed Procedure - FWTR

- Example 2 – Plant B Cycle N+1 – MELLLA, 18 Month Cycle

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Proposed Procedure - FWTR

- Example 3 – Plant C Cycle N+1 – MELLLA, ~2 Year Cycle

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Proposed Procedure - FWTR

- Example 4 – Plant D Cycle N+1 – MELLLA, ~18 Month Cycle

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Proposed Procedure – Key Points

- The proposed procedure explicitly accounts for reduced FW temperature operating conditions
- The Exclusion Region is expanded appropriately for FWTR operation
- Cycle specific analysis is performed based on the maximum licensed FWTR

Justifications to Remove Adder

- Current ODYSY LTR took no credit for methodology improvements :
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- Significant theoretical improvement over FABLE

Justifications to Remove Adder

- ER provides defense-in-depth protection for the APRM based protection system
- ER is determined based on conservative methodology (Haling depletion to an extended cycle exposure, limiting cycle exposure used)
- Standard ODYSY uncertainty (20%) applied to evaluation is appropriate and sufficient
- Expanded ER generated for reduced feedwater temperature operation
- Online stability monitor required and operating at all Option I-D plants for added protection

Key ODYSY LTR Changes

- Introduce the revised ODYSY Stability Criterion Curve based on DR of 0.80

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Key ODYSY LTR Changes

- Remove comparisons to FABLE
- Expanded Exclusion Region for FWTR operation
- Addition of recent instability event analysis experience
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- Demonstration of procedure based on modern core designs
- Stability online monitor experience included in new appendix
- The Modified Shape Function

Summary & Conclusions

- Online stability monitor data showed no surprises
- Using [[ ]] Haling Methodology shown to be sound
- Modified Shape Function provides sufficient conservatism
- 0.80 DR basis using ODYSY methodology sufficient for defining the Exclusion Region
- Exclusion Region are expanded for FWTR
- Buffer Region is adequately sized to provide conservatism and maintain operator stability awareness

Summary & Conclusions

- The current LTR,

  NEDC-32992P, "ODYSY Application for Stability Licensing Calculations"

  will be replaced with the revised LTR,

  NEDC-33213P, "ODYSY Application for Option I-D and II Stability Licensing Calculations"

  following NRC review and approval

NRC Feedback

- Questions?
- Comments?