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Enhanced Option III
A stability solution for EPU operations

The Stability Protection Challenge

Most BWR operators implementing Extended Power Uprates (EPU) also desire to expand the allowable flow window at full uprated power (e.g., MELLLA+) with higher control rod lines. Operation at such conditions presents a challenge to existing stability solutions. Expected decay ratios can be markedly higher than for traditional MELLLA operation. Further, the possibility of highly unstable conditions can also introduce the phenomenon of mixed mode oscillations where the flow in one or more bundles could undergo diverging oscillations. These factors invalidate the assumptions of the original BWROG Option III Detect & Suppress methodology.

Meeting the Challenge with EO-III

Framatome's EO-III, Enhanced Option III Detect & Suppress Solution, solves all these problems and extends the functionality of the original BWROG solution to all known operational strategies and domains, including MELLLA+. The main feature introduced by Framatome to the BWROG D&S solution is the single channel instability exclusion region. This region is calculated conservatively by approved stability codes, such as STAIF, and is enforced by automatic scram using the stability protection trip (SPT).

Robust Stability Protection

The new SPT restores robustness to the D&S solution by excluding single channel instabilities by hard scram, thus assuring the D&S system remains well behaved and retains the intended functionality. This builds on experience of enforcing exclusion regions similar to that of the original Option IA Long Term Stability Solution. The SPT relies on the proven and robust EPROM approach to trigger a scram if reactor power and flow reach the defined exclusion region.

Retains Existing OPRM System

A key value of Framatome's EO-III solution is that it continues to utilize the existing BWROG solution hardware and software. This preserves the original system with which operators have accumulated extensive experience. Only minimal additional training of the operators and reactor engineers will be needed to adopt the improvements

associated with the new exclusion region. In the EO-III SER, the NRC notes that the *"implementation of the EO-III Long Term Stability Solution is essentially identical to the original Option III."* EO-III simplifies both the implementation of extended flow ranges for EPU operations and the NRC approval process.

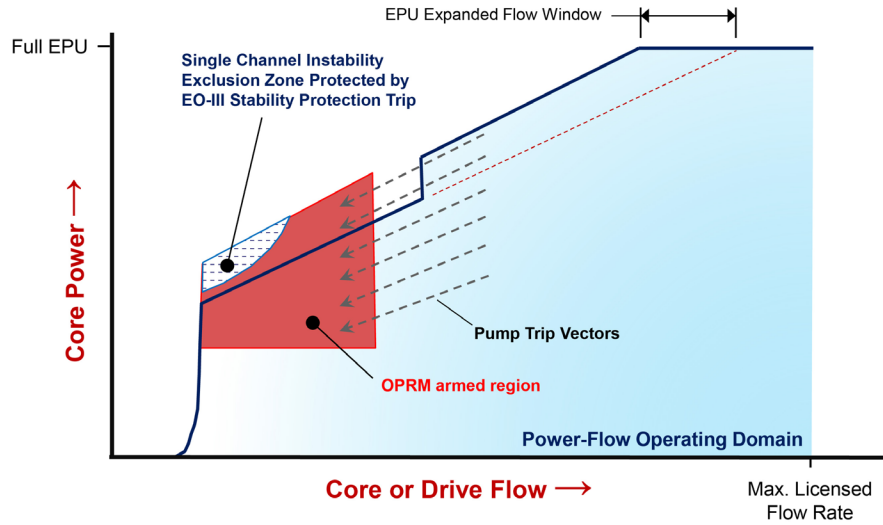## Industry-Best Stability Methodology

Framatome is the recognized industry leader in BWR thermal-hydraulic stability expertise and related methodologies. Framatome's RAMONA5-FA and STAIF tools have the unique capability of evaluating the effects of single channel instabilities and the highly unstable conditions with multiple interacting instability modes associated with extended flow windows at EPU. In the conclusions of the Safety Evaluation Report for Framatome's Enhanced Option III solution, as approved by the NRC in 2008, it is explicitly noted that Framatome *"presents an excellent evaluation of the physical causes of ill-behaved DIVOM correlations"* and accepted that the *"EO-III Long Term Stability Solution addresses these ill-behaved conditions."*
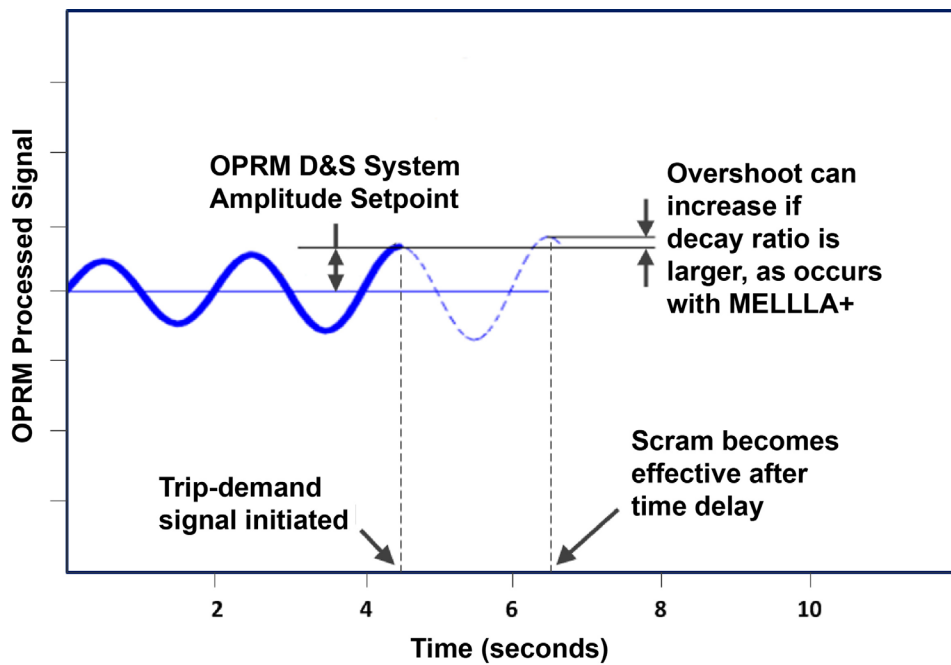
Features and Benefits

NRC-approved solution for EPU operations with extended flow windows (e.g., MELLLA+)

- Extends the original BWROG Option III solution with many years of operational experience
- Introduces a robust single channel instability protection trip to supplement OPRM function
- Minimal channel exclusion region avoids interference with normal operational flexibility
- Assures critical power response to power oscillations (DIVOM correlation) is accurately modeled and well-behaved across allowable power-flow range
- Simplifies implementation for use independent of reload fuel and cycle licensing services suppliers

Your performance
is **our** everyday **commitment**

Full EPU

EPU Expanded Flow Window

**Single Channel Instability
Exclusion Zone Protected by
EO-III Stability Protection Trip**

Core Power ⟶

Pump Trip Vectors

OPRM armed region

Power-Flow Operating Domain

Core or Drive Flow ⟶

Max. Licensed
Flow Rate

A small scram-protected exclusion zone, well out of the normal power-flow operating domain, allows continued use of the original Option III Detect & Suppress stability solution for extended flow window operations at EPU.

OPRM Processed Signal

**OPRM D&S System
Amplitude Setpoint**

**Overshoot can
increase if
decay ratio is
larger, as occurs
with MELLLA+**

**Trip-demand
signal initiated**

**Scram becomes
effective after
time delay**

Time (seconds)

EO-III methodology allows continued use of the OPRM hardware and software without change, addressing more severe instability conditions through a simple power uncertainty factor applied to the Hot Channel Oscillation Magnitude used in the setpoint analyses.

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