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B&W mPower Core and Fuel Design Update Meeting (Redacted)

February 16, 2012

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Meeting Topics

- Introduction
- Overview of Fuel Design Changes
- Mechanical Design Technical Report Feedback
- Core Thermal Hydraulics Update
- Core Design Update
- Benchmarking Status and Plans
- Core Startup and Operation Overview
- Conclusion

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B&W mPower Core Thermal Hydraulics Update

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Core Thermal-Hydraulic Subchannel Analysis

- VIPRE-01 mod 2.4f95 is used to model the core thermal-hydraulics
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Cycle Plot - MDNBR

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DNBR Distribution

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Cycle Plot – Peak Centerline Fuel Temperature

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Axial Plot- Centerline Fuel Temperature

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Fuel Temperature Distribution

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Critical Heat Flux Testing Status

- Testing is being conducted at Stern Laboratories in Hamilton, Ontario, Canada
- Two test series have been completed

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- Three additional tests are planned in 2012 (Tentative plan)

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CHF Test Bundle

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Unit cell test bundle before insertion into the flow channel

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Example of Test Results

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Critical Heat Flux Correlation Development

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B&W mPower Lattice Neutronic Design

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Outline

- Methodology and Computer Codes
- Assembly Lattice Layout
- Lattice Neutronic Design Parameters
- Lattice Analysis Results
- Conclusions

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Methodology and Codes

Code	*Code information*
INTERPIN-4 Version Number: v4.01	*Pin temperature calculation* • Provides data for average fuel pin temperatures as a function of burnup and linear heat generation rate for the Studsvik CMS codes CASMO-5 and SIMULATE-3 • INTERPIN-4 output feeds directly into CASMO-5 and SIMULATE-3 inputs
CASMO-5 Version Number: V2.00.00	*Lattice layout and characterization* • Two dimensional lattice physics (transport) code using the ENDF/B-VII.0 based 586 group cross section library • Neutron energies cover the range from 0 to 20 MeV
CMS-LINK Version Number: v1.26.03	*Cross-section processing* • Processes CASMO-5 Card Image files into a binary formatted nuclear data library for use by SIMULATE-3 • Includes 2-group macroscopic x-sections, discontinuity factors, fission product data, detector data, pin power reconstruction, kinetics, isotopics, etc.
SIMULATE-3 Version Number: v6.09.23	*Reactor core loading and cycle projection simulation* • Advanced three-dimensional, two-group nodal code for reactor core simulation and analysis • The code is based on a neutronics model which employs fourth-order polynomial representations of the intranodal flux distributions in both the fast and thermal groups • One of the key features of SIMULATE-3 is the pin power reconstruction capability

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Assembly Lattice Layout

- Fuel assembly conceptually similar to [a conventional 17x17 square lattice PWR, with the exception that is shorter

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Assembly Layout Summary

Fuel Assembly

Lattice array	**17x17**	–

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Lattice Layout Example

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Lattice Neutronic Design Parameters

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Lattice Neutronic Design Parameters

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Lattice Nomenclature

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Conclusions

- The B&W mPower lattice is based on the industry standard 17x17 fuel assembly
- ***CASMO-5*** has been used to create and analyze lattice cross sections for the construction of fuel assemblies in ***SIMULATE-3*** for the mPower core loading and cycle management design
- Lattice burns provide a window into the behavior of assemblies constructed from the various ***CASMO-5*** cross section sets

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B&W mPower Core Loading and Management

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Outline

- Core Design Parameters
- Core Loading
- Control Rod Patterns and Cycle Management
- ***SIMULATE-3*** Summary Results
- Conclusions

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Core Design parameters

Core Data	
Total number of assemblies	[
Estimated core loading	
Rated thermal power level	
Rated thermal power density	
Rated core flow	
Bypass flow	
Reference dome pressure	
Reference reactor mid-plane pressure	
Reference inlet temperature	
Reference outlet temperature	
Subcooling (outlet)	] **[CCI per Affidavit 4(a)-(d)]**

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Core Design Parameters

Energy Parameters

Cycle length	48 months
Cycle capacity factor	[
Cycle energy (estimated)	
EOC Power Level	
Cycle hot target k-effective	
Cycle cold target k-effective	] [CCI per Affidavit 4(a)-(d)]

Margin Parameters

Minimum cold shutdown margin	[
Maximum nodal peaking	] [CCI per Affidavit 4(a)-(d)]

Control Parameters

Exposure between sequence exchanges	[
Control rod utilization	
Parked control rod positions preferred	] [CCI per Affidavit 4(a)-(d)]

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Simulate-3 Fuel Assembly and Control Rod Assembly Definition

Fuel Assemblies

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Control Rod Assemblies

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Core Loading – Fuel Assembly Types

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Core Loading – Assembly Map

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Control Rod Sequence Definition

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Cycle Management

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Cycle Management (cont.)

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Cycle Management (cont.)

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Nodal Peaking

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Core Axial Offset

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Cold Shutdown Margin

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Hot Excess Reactivity

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Control Rod Movement

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EOFP Axial Power and Exposure Profile

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EOC Radial Exposure Distribution

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Core Design Results

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Conclusions

- ***SIMULATE-3*** supports the design and analysis of the steady state operation of the B&W mPower Reactor reference design.

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- Optimization studies are continuing.

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MCNPX Benchmark Lattice Physics Analyses

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Outline

- Introduction
- Lattice Studies
- Reflector Analyses
- Conclusions

Lattice Studies – MCNPX vs. CASMO-5

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Lattice Benchmark Cold BOC k_∞ Results

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Lattice Benchmark Hot BOC k_∞ Results

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MCNPX Radial Reflector Benchmark Results

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Radial Reflector Thermal Flux Profile

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Radial Reflector Total Flux Profile

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Radial Reflector Thermal Current Profile

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MCNPX Lattice Physics Benchmark Conclusions

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MCNPX Model of the B&W mPower Reactor Reference Core Design

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Core Model Description

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Cross Section of mPower Reactor Model at Core Mid-Plane

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Core Model Description: Former, Basket, Vessel Wall, Air

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Reactor Core Startup and Operation

Presentation Topics

- Approach To Critical
- Reactor Heatup
- Power Ascension
- Cycle Operation

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Contents

- Approach To Critical – Strategy
- Approach To Critical – Neutron Flux Monitoring
- Approach To Critical – Startup Neutron Sources
- Approach To Critical – CRA Sequences
- Approach To Critical – Simulated Approach To Critical

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Approach To Critical - Strategy

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Approach To Critical – Neutron Flux Monitoring

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Approach To Critical – Neutron Flux Monitoring

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Approach To Critical – Startup Neutron Sources

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Approach To Critical – Startup Neutron Sources

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Approach To Critical – Startup Neutron Sources

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Approach To Critical – Startup Neutron Sources

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Approach To Critical – CRA Sequences

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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[CCI per Affidavit 4(a)-(d)]

Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Approach To Critical – Simulated Approach To Critical

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Presentation Topics

- Approach To Critical
- Reactor Heatup
- Power Ascension
- Cycle Operation

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Contents

- **Reactor Heatup – Strategy**
- **Reactor Heatup – Flux/Power Monitoring**
- **Reactor Heatup – Reactivity Insertion/Feedback**
- **Reactor Heatup – Simulated Reactor Heatup**

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Reactor Heatup - Strategy

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- Reactor Heatup – Strategy
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Reactor Heatup – Power/Flux Monitoring

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Reactor Heatup – Power/Flux Monitoring

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Reactor Heatup – Reactivity Insertion/Feedback

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Reactor Heatup – Reactivity Insertion/Feedback

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Reactor Heatup – Reactivity Insertion/Feedback

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Reactor Core Heatup – Simulated Reactor Heatup

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Presentation Topics

- Approach To Critical
- Reactor Heatup
- Power Ascension
- Cycle Operation

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Contents

- Power Ascension – Strategy
- Power Ascension – In-Core Power/Flux Monitoring
- Power Ascension – Ex-Core Power/Flux Monitoring
- Power Ascension – Simulated Power Ascension

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Power Ascension - Strategy

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Power Ascension – In-Core Flux/Power Monitoring

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Power Ascension – In-Core Flux/Power Monitoring

In-Core Detector Axial Locations

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- **Power Ascension – Strategy**
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- **Power Ascension – Simulated Power Ascension**

Power Ascension – Ex-Core Flux/Power Monitoring

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Power Ascension – Ex-Core Flux/Power Monitoring

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- **Power Ascension – Simulated Power Ascension**

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension – Simulated Power Ascension

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Power Ascension - Strategy

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Presentation Topics

- Approach To Critical
- Reactor Heatup
- Power Ascension
- Cycle Operation

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Contents

- **Cycle Operation – Strategy**
- **Cycle Operation – Simulated Sequence Exchange**

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Cycle Operation - Strategy

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- Cycle Operation – Strategy
- Cycle Operation – Simulated Sequence Exchange

Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

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Cycle Operation – Simulated Sequence Exchange

Core Outlet Temperature Variations During Sequence Exchange

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