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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



B&W mPower Core Thermal Hydraulics Update



Core Thermal-Hydraulic Subchannel Analysis

VIPRE-01 mod 2.4f95 is used to model the core thermalhydraulics

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Cycle Plot - MDNBR

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DNBR Distribution

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Cycle Plot – Peak Centerline Fuel Temperature





Axial Plot- Centerline Fuel Temperature

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Fuel Temperature Distribution





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)



CHF Test Bundle

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



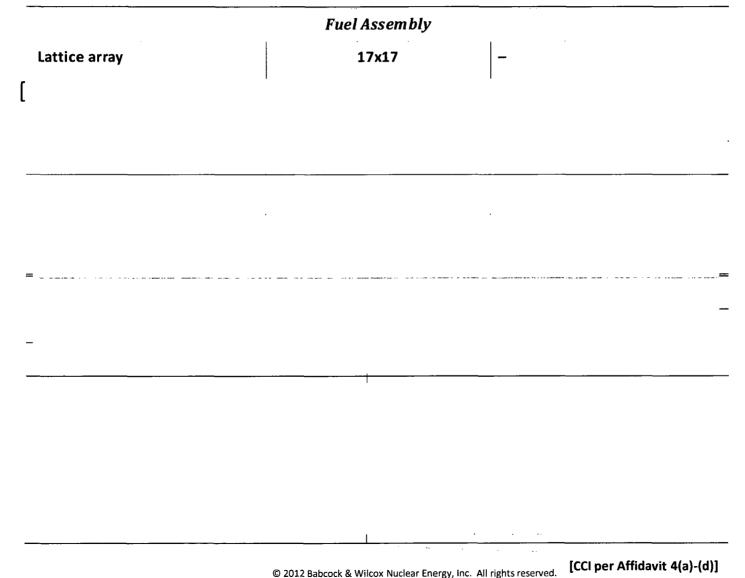
 Fuel assembly conceptually similar to [a conventional 17x17 square lattice PWR, with the exception that is shorter

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mPower Assembly Layout Summary



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Lattice Layout Example

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mPower Lattice Neutronic Design Parameters

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Lattice Neutronic Design Parameters

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- 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



B&W mPower Core Loading and Management



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



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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generation *mPower* Core Design Parameters

Energ	y 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)]
Margi	n Parameters
Minimum cold shutdown margin	[
Maximum nodal peaking	[CCI per Affidavit 4(a)-(d)]
Contro	ol Parameters
Exposure between sequence exchanges	
Control rod utilization	
Parked control rod positions preferred][CCI per Affidavit 4(a)-(d)]



Simulate-3 Fuel Assembly and Control Rod Assembly Definition

Fuel Assemblies

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Control Rod Assemblies

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Control Rod Sequence Definition







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EOC Radial Exposure Distribution

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 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.



MCNPX Benchmark Lattice Physics Analyses



- 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



- 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



Approach To Critical - Strategy

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- 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 ToCritical



Approach To Critical – Neutron Flux Monitoring

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Approach To Critical – Neutron Flux Monitoring

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

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Approach To Critical – Startup Neutron Sources



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 Strategy
- Approach To Critical Neutron Flux Monitoring
- Approach To Critical Startup Neutron Sources
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Presentation Topics

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



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



Reactor Heatup - Strategy

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



Reactor Heatup – Power/Flux Monitoring

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Reactor Heatup – Power/Flux Monitoring

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



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



Reactor Core Heatup – Simulated Reactor Heatup

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Presentation Topics

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



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



Power Ascension - Strategy

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



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

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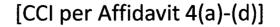
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Power Ascension - Strategy

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Presentation Topics

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



- Cycle Operation Strategy
- Cycle Operation Simulated Sequence Exchange



Cycle Operation - Strategy

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- Cycle Operation Strategy
- Cycle Operation Simulated Sequence Exchange



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Core Outlet Temperature Variations During Sequence Exchange

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