generation

mPower

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

February 16, 2012

generation mPower

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

generation
mPower

B&W mPower Core Thermal Hydraulics Update

generation
mPower

Core Thermal-Hydraulic Subchannel Analysis

- VIPRE-01 mod 2.4f95 is used to model the core thermal-hydraulics
- [

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

generation mPower

Cycle Plot - MDNBR

[

]

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

generation
mPower

DNBR Distribution

[

]

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

generation mPower

Cycle Plot – Peak Centerline Fuel Temperature

[

]

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

generation
mPower

Axial Plot- Centerline Fuel Temperature

[

]

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

generation
mPower

Fuel Temperature Distribution

[

]

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

generation mPower

Critical Heat Flux Testing Status

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

  [

  ]

  [CCI per Affidavit 4(a)-(d)]
- Three additional tests are planned in 2012 (Tentative plan)

  [

  ]

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

generation
mPower

CHF Test Bundle

[

Unit cell test bundle before insertion into the flow channel

]

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

generation
mPower

Example of Test Results

[

]

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

generation mPower

Critical Heat Flux Correlation Development

[

]

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

generation
mPower

B&W mPower Lattice Neutronic Design

generation mPower

Outline

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

generation mPower

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**

generation
mPower

Assembly Lattice Layout

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

[

]

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

]

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

generation mPower

Assembly Layout Summary

Fuel Assembly

Lattice array	**17x17**	–

[

]

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

generation
mPower

Lattice Layout Example

[

]

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

generation
mPower

Lattice Neutronic Design Parameters

[

]

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

generation mPower

Lattice Neutronic Design Parameters

[

]

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

generation
mPower

Lattice Nomenclature

[

]

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

generation
mPower

[

]23

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

generation
mPower

[

]

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

generation
mPower

[

]

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

generation mPower

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

generation
mPower

B&W mPower Core Loading and Management

generation mPower

Outline

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

generation mPower

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)]**

[

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

generation mPower

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)]**

generation
mPower

Simulate-3 Fuel Assembly and Control Rod Assembly Definition

Fuel Assemblies

[

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

Control Rod Assemblies

[

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

generation
mPower

Core Loading – Fuel Assembly Types

[

]

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

generation
mPower

Core Loading – Assembly Map

[

]

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

generation mPower

Control Rod Sequence Definition

[

]

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

generation
mPower

Cycle Management

[

]

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

generation
mPower

Cycle Management (cont.)

[

]

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

generation mPower

Cycle Management (cont.)

[

]

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

generation mPower

Nodal Peaking

[

]

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

generation mPower

Core Axial Offset

[

]

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

generation
mPower

Cold Shutdown Margin

[

]

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

generation
mPower

Hot Excess Reactivity

[

]

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

generation mPower

Control Rod Movement

[

]

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

generation mPower

EOFP Axial Power and Exposure Profile

[

]

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

generation mPower

EOC Radial Exposure Distribution

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

generation
mPower

Core Design Results

[

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

generation mPower

Conclusions

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

[

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

- Optimization studies are continuing.

generation mPower

MCNPX Benchmark Lattice Physics Analyses

generation mPower

Outline

- Introduction
- Lattice Studies
- Reflector Analyses
- Conclusions

generation mPower

Lattice Studies – MCNPX vs. CASMO-5

[

]

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

generation mPower

Lattice Benchmark Cold BOC k_∞ Results

[

]

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

generation mPower

Lattice Benchmark Hot BOC k_∞ Results

[

]

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

generation
mPower

MCNPX Radial Reflector Benchmark Results

[

]

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

generation mPower

Radial Reflector Thermal Flux Profile

[

]

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

generation mPower

Radial Reflector Total Flux Profile

[

]

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

generation
mPower

Radial Reflector Thermal Current Profile

[

]

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

generation mPower

MCNPX Lattice Physics Benchmark Conclusions

[

]

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

generation mPower

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

generation
mPower

[

]

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

generation
mPower

[

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

generation
mPower

Core Model Description

[

]

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

generation
mPower

Cross Section of mPower Reactor Model at Core Mid-Plane

[

]

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

generation
mPower

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

[

]

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

generation
mPower

[

]

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

generation
mPower

[

]

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

generation mPower

[

]

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

generation
mPower

Reactor Core Startup and Operation

generation mPower

Presentation Topics

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

generation mPower

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

generation mPower

Approach To Critical - Strategy

[

]

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

generation mPower

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 ToCritical

generation mPower

Approach To Critical – Neutron Flux Monitoring

[

]

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

generation mPower

Approach To Critical – Neutron Flux Monitoring

[

]

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

generation mPower

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

generation mPower

Approach To Critical – Startup Neutron Sources

[

]

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

generation
mPower

Approach To Critical – Startup Neutron Sources

[

]

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

generation
mPower

Approach To Critical – Startup Neutron Sources

[

]

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

generation mPower

Approach To Critical – Startup Neutron Sources

[

]

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

generation mPower

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

generation mPower

Approach To Critical – CRA Sequences

[

]

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

generation mPower

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation
mPower

Approach To Critical – Simulated Approach To Critical

[

]

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

generation mPower

Approach To Critical – Simulated Approach To Critical

[

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

]

generation mPower

Presentation Topics

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

generation mPower

Contents

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

generation mPower

Reactor Heatup - Strategy

[

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

generation mPower

Contents

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

generation
mPower

Reactor Heatup – Power/Flux Monitoring

[

]

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

generation
mPower

Reactor Heatup – Power/Flux Monitoring

[

]

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

generation mPower

Contents

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

generation mPower

Reactor Heatup – Reactivity Insertion/Feedback

[

]

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

generation mPower

Reactor Heatup – Reactivity Insertion/Feedback

[➢

]

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

generation
mPower

Reactor Heatup – Reactivity Insertion/Feedback

[➢

]

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

generation mPower

Contents

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation
mPower

Reactor Core Heatup – Simulated Reactor Heatup

[

]

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

generation mPower

Presentation Topics

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

generation mPower

Contents

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

generation
mPower

Power Ascension - Strategy

[

]

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

generation mPower

Contents

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

generation mPower

Power Ascension – In-Core Flux/Power Monitoring

[

]

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

generation
mPower

Power Ascension – In-Core Flux/Power Monitoring

In-Core Detector Axial Locations

[

]

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

generation mPower

Contents

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

generation
mPower

Power Ascension – Ex-Core Flux/Power Monitoring

[

]

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

generation
mPower

Power Ascension – Ex-Core Flux/Power Monitoring

[

]

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

generation mPower

Contents

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension – Simulated Power Ascension

[

]

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

generation
mPower

Power Ascension - Strategy

[

]

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

generation mPower

Presentation Topics

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

generation mPower

Contents

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

generation
mPower

Cycle Operation - Strategy

[

]

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

generation mPower

Contents

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

generation
mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation mPower

Cycle Operation – Simulated Sequence Exchange

[

]

generation mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation
mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation mPower

Cycle Operation – Simulated Sequence Exchange

[

]

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

generation
mPower

Cycle Operation – Simulated Sequence Exchange

Core Outlet Temperature Variations During Sequence Exchange

[

]

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