Enclosure 3
Nuclear Island System Design Update – April (REDACTED)
Revised November 15, 2012 for CCI Content

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Nuclear Island Systems Design Update

April 26, 2012 (Revised November 15, 2012 for CCI Content)

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(Redacted Version)

This is a pre-application document and includes preliminary B&W mPower Reactor design or design supporting information and is subject to further internal review, revision, or verification.

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mPower™ Reactor Nuclear Island (NI) Systems

- Overview of NI Systems Safety Strategy
- Reactor Coolant System (RCS)
- Auxiliary Condenser System (CNX)
- Reactor Coolant Inventory and Purification System (RCI)
- Emergency Core Cooling System (ECC)
- NI Systems Responses to Transients/Design Basis Accidents (DBA)
- Summary

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NI Systems Function Summary

	SAFETY FUNCTION	DEFENSE –IN – DEPTH	NON-SAFETY FUNCTION
RCS	Yes	No	Yes
CNX	Yes*	Yes	No
RCI	Yes*	Yes	Yes
ECC	Yes	No	Yes

* Containment isolation only

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Overall NI Systems Safety Strategy

- RCS design minimizes both the probability and impact of design basis accidents
- Nonsafety systems maintain RCS within safe operating envelope as first line of defense (defense-in-depth)
- A simple, passive safety system protects the reactor core in the event that RCS leaves safe operating envelope
- Simple, passive features protect the lower vessel and containment in the event of a severe accident

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NI Systems Safety Strategy

Strategy	Design
RCS minimizes the probability and impact of design basis accidents	• Large integral NSSS • Small penetrations – [ ]
Promote defense-in-depth	] • RCI provides high and low pressure decay heat removal, [ ]
Rely upon simple, passive safety features and capabilities	• [ ]
Provide protection from severe accidents	]

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Robust Defense-in-Depth Strategy

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Major Enhancements to NI Systems

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Change	Rationale

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Major Enhancements to NI Systems(cont.)

Change	Rationale
Modified RCI to provide HP decay heat removal	• Additional method of decay heat removal provided [ ]
[ ]	

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RCS Features Minimize Design Basis Accident Probability and Consequences

- Large reactor coolant inventory
- Small RCS penetrations [ ]
- Lowest penetration [ ] above the top of the core

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GSI-191 Approach

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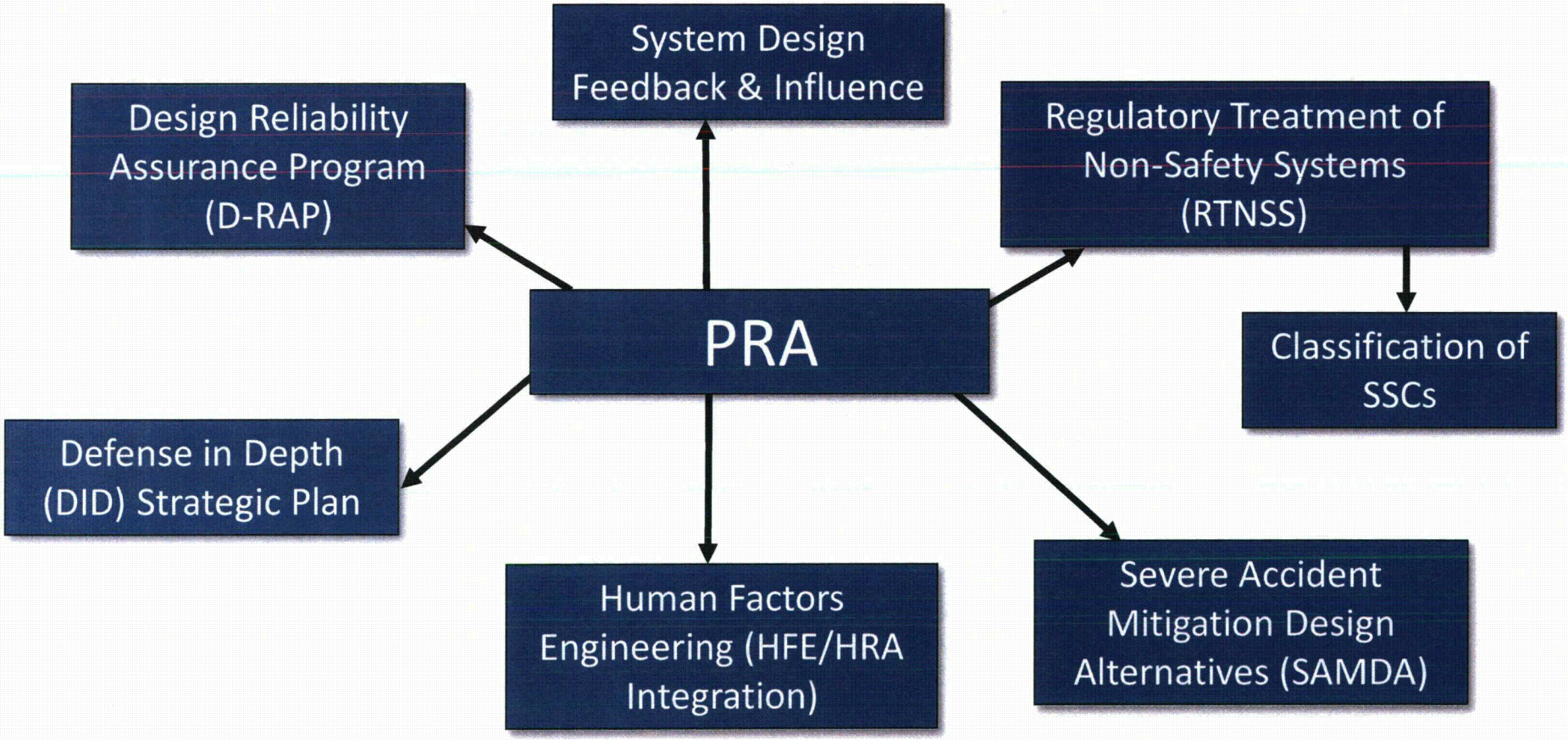
Probabilistic Risk Assessment Design Influence



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PRA Design Influence in Nuclear Island Systems

- Internal Events Initiators – Due to the design simplicity, several PWR typical initiators have been eliminated:

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- PRA risk insights guiding design to maximize reliability

  [

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Reactor Coolant System (RCS) Functions and Key Features

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Safety-Related RCS Functions

- Maintain pressure boundary integrity
- Transfer sufficient decay heat from the core via natural circulation
- Provide overpressure protection
- Vent non-condensable gases following severe accidents
- [ ] [CCI per Affidavit 4(a)-(d)]

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Non-safety-Related RCS Functions

- Maintain forced circulation of reactor coolant
- Maintain a steam-water interface in pressurizer

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Reactor Coolant System Process Flow Diagram

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Pressure Boundary Integrity

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Pressure Boundary Integrity

- ASME Section III Subsection NB (Class 1) & Seismic Category I

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Pressure Boundary Integrity

- ASME Section III Subsection NB (Class 1) & Seismic Category I

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Pressure Boundary Integrity

- ASME Section III Subsection NB (Class 1) & Seismic Category I

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Pressure Boundary Integrity

- ASME Section III Subsection NB (Class 1) & Seismic Category I

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Pressure Boundary Integrity

- ASME Section III Subsection NB (Class 1) & Seismic Category I

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Pressure Boundary Integrity

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Decay Heat Removal via Natural Circulation

- Vertical design
- No primary loop piping

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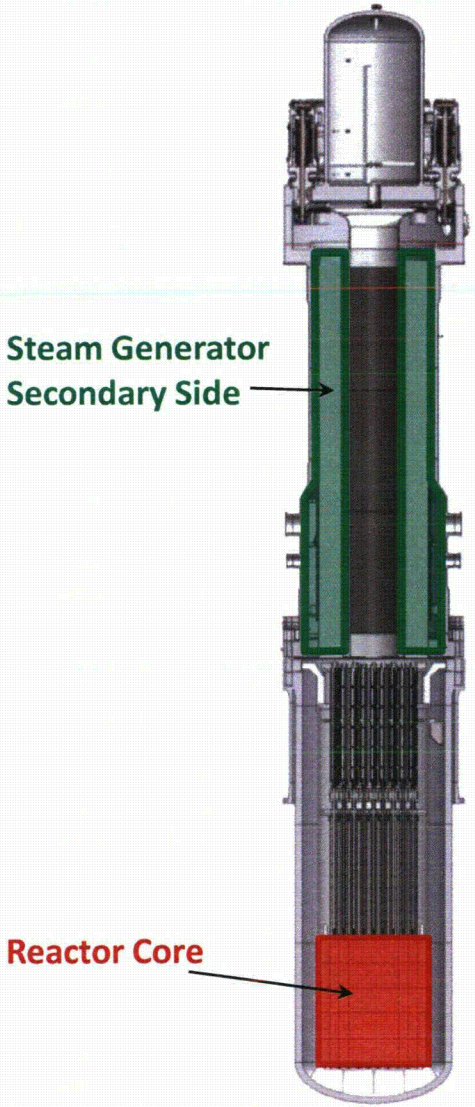
- Inherent natural circulation



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Overpressure Protection

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Overpressure Protection

- Pressurizer Safety Valves

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Overpressure Protection

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Overpressure Protection

- LTOPs

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Venting Non-Condensables Following Severe Accidents

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Venting Non-Condensables Following Severe Accidents

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Forced Circulation of Reactor Coolant

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Forced Circulation of Reactor Coolant

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- Reactor Coolant Pumps
  - 8 RCPs located around pressurizer

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RCS Pressure Control

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RCS Pressure Control

- Pressurizer Heaters

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- Pressurizer Spray

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Auxiliary Condenser System (CNX) Functions and Key Features

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Safety-Related CNX Functions

- Containment Isolation

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Auxiliary Condenser System Process Flow Diagram

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Defense-In-Depth CNX Functions

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CNX - Standby

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CNX - Operation

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Reactor Coolant Inventory and Purification System (RCI) Functions and Key Features

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RCI Safety Function

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RCI Safety Function Containment Isolation

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RCI Defense-in-Depth Functions

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RCI Defense-in-Depth Functions
HPI

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RCI Defense-in-Depth Functions
HPI

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RCI Defense-in-Depth Functions HPDHR

- High pressure decay heat removal (HPDHR)

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RCI Defense-in-Depth Functions
HPDHR

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RCI Defense-in-Depth Functions
HPDHR

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RCI Defense-in-Depth Functions
LPRHR

- Low pressure residual heat removal (LPRHR)
  - Normal residual heat removal & post-72 hour residual heat removal after accident

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RCI Defense-in-Depth Functions
LPRHR

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RCI Defense-in-Depth Functions
LPRHR

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RCI Defense-in-Depth Functions

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RCI Defense-in-Depth Functions

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RCI Defense-in-Depth Functions

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RCI Nonsafety Functions

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Emergency Core Cooling System (ECC) Functions and Key Features

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ECC Approach to Safety

- Enhanced capability of defense-in-depth systems
- Reduced number of safety-related components

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- Reduced quantity of high-pressure safety-related piping susceptible to pipe breaks

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- Simplifies safety analysis

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ECC Safety Functions

1) RCS Automatic Depressurization	3) Emergency Decay Heat Removal
2) Passive Core Cooling Injection	4) Long-Term Core Cooling

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Safety Functions
RCS Automatic Depressurization

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Safety Functions
RCS Automatic Depressurization

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Safety Functions
Passive Core Cooling Injection

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Safety Functions
Passive Core Cooling Injection

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Safety Functions
Passive Core Cooling Injection

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Safety Functions
Passive Core Cooling Injection

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- Refueling Water Storage Tank (RWST)

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Safety Functions
Emergency Decay Heat Removal

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Safety Functions
Long-Term Core Cooling

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Beyond Design Basis Refueling Cavity Long-Term Recirculation

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Nuclear Island Responses to Transients/Accidents

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NI Responses to Transients/Accidents

- Loss of heat sink
  - Loss of feedwater
  - Station blackout
- Loss of coolant
  - Very small breaks
  - Break of makeup or letdown line with isolation
  - Break of a vent line (high break)
  - Break of a makeup or letdown line (low break)
- Backup shutdown capability

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Loss of Feedwater – [ ]

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Loss of Feedwater – [ ]

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Loss of Feedwater – [ ]

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Station Blackout – [ ]

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Station Blackout – [ ]

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Leak/Very Small Break – [ ]

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Low Break – [ ] [CCI per Affidavit 4(a)-(d)]

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High Break – [ ] [CCI per Affidavit 4(a)-(d)]

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Low Break – Beyond Design Basis

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Backup Core Shutdown Capability Defense-in-Depth

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B&W mPower™ Changes LWR Safety Paradigm

Before: Passive safety systems

- RCS failure paths (large break LOCAs) overwhelm safety system response
- Complex safety systems
- Core uncovered in design basis accidents
- Water recirculation in containment generates GSI 191 concerns
- RCS vented to containment in station blackout

After: Integrated safety

- RCS designed to minimize accidents
- Non-safety systems maintain plant within safe operating envelope (multiple layers reduce probability of accidents)
- Single, simplified safety system keeps the core covered and cooled (no radioactive release)
- Large coolant inventory provides core/containment cooling for up to 14 days

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