Enclosure 3
ATWS Rule Slides (Redacted)

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mPower Reactor Design and the ATWS Rule 10 CFR 50.62

(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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Agenda

- Overview of ATWS Rule (10 CFR 50.62) and Staff Guidance
- mPower Reactor Design Features – Conformance with ATWS Rule
  - Reliability of RTS
  - Diverse Actuation System
  - Breaker Voltage
  - Operator Actions
  - Moderator Temperature Coefficient
  - Temperature and Pressure Responses
  - Pressure Relief Capability
  - Auxiliary Feedwater Initiation (Alternative)
  - Turbine Generator Trip
- Summary

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

§ 50.62 Requirements for reduction of risk from anticipated transients without scram (ATWS) events for light-water-cooled nuclear power plants

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

(b) *Definition. For purposes of this section, Anticipated Transient Without Scram (ATWS)* means an anticipated operational occurrence followed by the failure of the reactor trip portion of the protection system specified in General Design Criterion (GDC) 20

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

Criterion 20 – Protection system functions. The protection system shall be designed

- (1) to initiate **automatically** the operation of appropriate systems including the **reactivity control systems**, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and
- (2) to **sense accident conditions** and to initiate the operation of systems and components important to safety

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

(c) *Requirements*. (1) Each pressurized water reactor must have equipment from sensor output to final actuation device, that is **diverse** from the reactor trip system (RTS), to automatically initiate the auxiliary **feedwater system** (AFW) and initiate a **turbine trip** under conditions indicative of an ATWS.

This equipment must be designed to perform its function in a **reliable** manner and be **independent** (from sensor output to the final actuation device) from the existing reactor trip system.

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

(2) Each pressurized water reactor manufactured by Babcock and Wilcox must have a **diverse scram system** from the sensor output to interruption of power to the control rods. This scram system must be designed to perform its function in a reliable manner and be **independent** from the existing reactor trip system (from sensor output to interruption of power to the control rods).

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

- ATWS rule was originally issued in 1984
- NUREG-0800, Standard Review Plan (SRP) 15.8, Revision 2 was issued in March 2007
- SRP 15.8 provides updated criteria for evolutionary plant designs regarding 10CFR 50.62
- NUREG-1780 (Regulatory Efficiencies of ATWS Rule) and NUREG-0460 (ATWS)

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

- SRP 15.8 indicates some of the equipment required to satisfy the Rule may not be applicable for evolutionary plants
  - For example, passive BWRs do not have recirculation pumps; therefore, equivalent actions may be acceptable
  - mPower design provides for equipment actions to satisfy rule

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

- SRP 15.8 provides
  - For evolutionary designs, applicants must demonstrate that the failure probability of failing the ATWS success criteria is sufficiently small because either: (1) the criteria are met, or (2) a diverse scram system is installed that reduces significantly the probability of a failure to scram
  - Staff will evaluate the applicant's assumptions regarding the moderator temperature coefficient (MTC) and determine them to be either consistent with MTC modeling assumptions serving as bases for the Rule or adequately justified

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Overview of ATWS Rule (10CFR 50.62) and Staff Guidance

- Insights provided by NUREG-1750 and NUREG-0460 for meeting ATWS rule
  - RTS reliability dominates the risk from an ATWS
  - PWR scram system reliability is related to reactor trip breaker reliability
  - During the ATWS rulemaking the NRC staff set a goal that probability of an ATWS should be no more than 1.0E-05/reactor-year
  - ATWS mitigation capability on a PWR is highly dependent on the MTC

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mPower Reactor Design Features
– Conformance with ATWS Rule

- **Reliability of RTS**

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Reliability of RTS

The B&W mPower reactor has a highly reliable RTS

- The RTS is a safety-related system comprised of [ ] divisions and channels of instrumentation
- The generation of trip commands depends on the coincidence of instrument channel logic conditions that indicate an unsafe condition (i.e., a [ ] condition)
  - PRA predicts an RTS failure rate of [ ]
- Unlike traditional PWRs, the mPower control rod drive mechanisms (CRDMs) are internal to the reactor vessel
- CRDMs are latched by hydraulic pressure [ ]

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

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Reliability of RTS

[

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

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Reliability of RTS (cont.)

[

]

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

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Reliability of RTS (cont.)

[

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

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Reliability of RTS

- mPower Responses to Trip Signal
  - Upon receipt of a valid trip signal, the RTS [

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

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Reliability of RTS (cont.)

- RTS sends [

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- **Diverse Actuation System**

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Diverse Actuation System

- In addition to the RTS, the mPower design includes a [ ] diverse actuation system (DAS)
- DAS requires [ ]
- DAS trips
  - [ ]
- DAS automatically actuates [ ]

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- Diverse Actuation System
- **Breaker Voltage**

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Breaker Voltage

- The B&W mPower plant [ ]
  - Each SCRAM discharge and block valve is expected to draw approximately [ ] VDC
  - The valves will be controlled by small relay contacts

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- mPower Reactor Design Features
- Reliability of RTS
- Diverse Actuation System
- Breaker Voltage
- **Operator Actions**

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Operator Actions

- RTS signal actuation does not preclude operator-initiated manual reactor trip at any time from the main control room (MCR) or remote shutdown panel (RSP)
  - If pressure remains in the CRDM seal chamber, the operators have the option of [ ]
  - If all of the above fail to adequately trip the reactor, manual operator action to [ ]

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- Diverse Actuation System
- Breaker Voltage
- Operator Actions
- **Moderator Temperature Coefficient**

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Moderator Temperature Coefficient

- Moderator temperature coefficient (MTC) is a concept used to describe the change in reactivity caused by changes in moderator temperature
  - At the time of the ATWS rulemaking, MTC was known to be insufficiently negative for existing PWR designs to limit peak pressure below 3200 psig (3215 psia), the ASME Service Level C pressure, for some portion of the cycle and/or power range
  - Peak ATWS pressure primarily is a function of the MTC and the primary system relief capacity
  - For PWRs, MTC is affected primarily by boron poison concentration in the RCS/moderator

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Moderator Temperature Coefficient (cont.)

Table 6 ATWS MTC and Peak Pressure for PWRs

Parameters		1979 ATWS Analysis	1988 Update of ATWS Analysis	1994 NRC Technical Specification Survey
CE	MTC	-2.0 to -6.8	-2.6 to -5.7	0 to +3 above 70% power
	Peak Pressure	4290 psia	4153 psia	
B&W	MTC	-10.5	18 month cycle: -11.0 24 month cycle: -4.3	0 above 95% power
	Peak Pressure	3464 psia	3764psia 18 month cycle: > 3200 24 month cycle: > 3200	
W	MTC	-8.0	-8.0 average range -5 to -15	Linear to 0 from 70% to 100% power One plant at + 2 at 100% power
	Peak Pressure	3197 psia	3497 psia (-5pcm/°F)	

Ref. NUREG-1780 Page C-17

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Moderator Temperature Coefficient for mPower Design

- The B&W mPower reactor does not use boron in the coolant/moderator for management of lifetime reactivity
- This results in a [
  ]
- Preliminary analysis indicates approximate MTC ranging from [

  ]

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mPower Moderator Temperature Coefficient and Power Level (Preliminary Information)

[

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- Diverse Actuation System
- Breaker Voltage
- Operator Actions
- Moderator Temperature Coefficient
- **Temperature and Pressure Responses**

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Temperature Pressure Responses

- Preliminary RELAP analysis assuming
  - [

]

- Preliminary analysis indicates
  - [

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Temperature Pressure Response

RELAP Analysis (Preliminary Information)

[

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Temperature Pressure Response

RELAP Analysis (Preliminary Information) (cont.)

[

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
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- Temperature and Pressure Responses
- **Pressure Relief Capability**

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Pressure Relief Capability

The mPower reactor design includes [
]

- Each valve sized to relieve pressure with reactor operating at [
]
- [
]
- [
]

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

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Pressure Relief Capability

- Additional Pressure Relief Measures
- Emergency core cooling system (ECC) automatic depressurization valves (ADVs)
  - Designed to relieve reactor pressure rapidly
  - Fully redundant
  - Set pressure below the pressurizer safety valves

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- Diverse Actuation System
- Breaker Voltage
- Operator Actions
- Moderator Temperature Coefficient
- Temperature and Pressure Responses
- Pressure Relief Capabilities
- **Auxiliary Feedwater Initiation (Alternative)**

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Auxiliary Feedwater Initiation (Alternative)

- The B&W mPower design does not include an AFW system
  - [

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Auxiliary Feedwater Initiation (Alternative) (cont.)

- [

]

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Position on AFW Requirement

- mPower position on AFW Requirement
  - B&W mPower plant is an evolutionary design and, as such, some of the equipment originally specified as being required to satisfy the ATWS Rule may not apply
  - Similar to the example given in SRP 15.8, the [

    ]

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

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mPower Reactor Design Features
– Conformance with ATWS Rule

- Reliability of RTS
- Diverse Actuation System
- Breaker Voltage
- Operator Actions
- Moderator Temperature Coefficient
- Temperature and Pressure Responses
- Pressure Relief Capabilities
- Auxiliary Feedwater Initiation (Alternative)
- **Turbine Generator Trip**

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Turbine-Generator Trip

- For the mPower Reactor:
  - [

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

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mPower Reactor Design Features
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ATWS Rule 10CFR 50.62 Compliance SUMMARY

- Highly reliable, [ ] RTS backed up by a [ ] DAS
- [ ] MTC
- Robust RCS pressure relief system
- Unique design features + defense in depth that meet or exceed the requirements of the ATWS rule

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