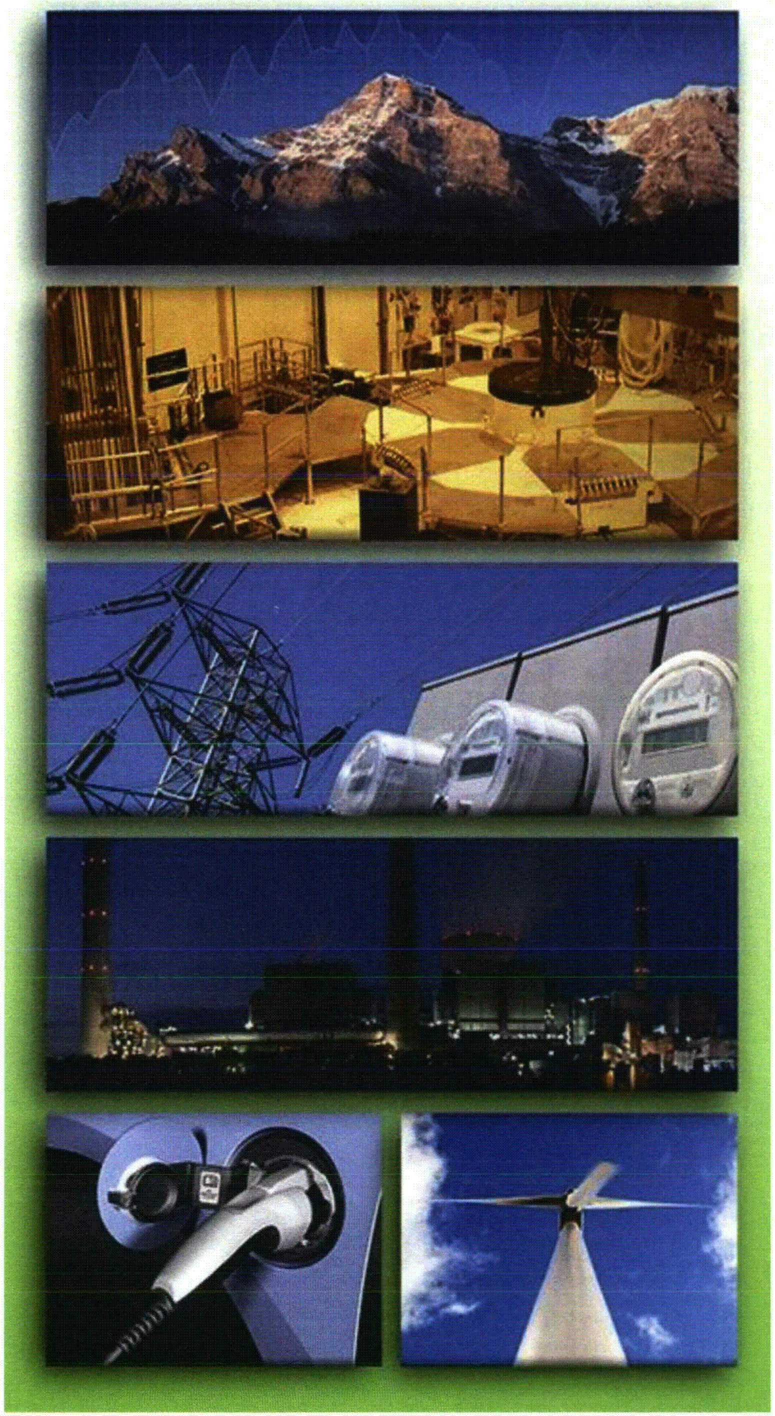

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MRP-227-A Roadmap

Background on Development Process

Randy Lott
Westinghouse Electric
November 28, 2012

Pre-Meeting Communication

- Action Item 1 Generic RAI
  - The Staff requests Licensee verification that detailed component state at end of Period of Extended Operation (PEO) is bounded by the detail assumptions of the MRP
    - Screening (MRP-191)
    - Functionality Analysis (MRP-232)
    - Bounding Values for
      - Stress
      - Fluence
      - Temperature
      - Material

Purpose of this Presentation

- Provide background information on process used to develop MRP-227 Inspection requirements.
  - Explain how stress, fluence, temperature and material data impacted the MRP-191 screening process.
  - Explain impact of analysis assumptions and their variability (including core loading) on MRP-232 functionality analysis.
  - Demonstrate that MRP-227 are based on a robust process that bounds internals performance.
  - The MRP-227-A aging management system remains effective for aging variations within the broad range of stress, temperature, fluence and material types encountered in the currently operating fleet of PWRs.

MRP-227 Overview

- MRP-227 provides the inspection recommendations needed to support safe and reliable operation of the reactor internals through the period of extended operation.
  - Process included a screening and categorization effort that was consistent with license renewal scoping and screening.
  - Process adapted to the full spectrum of licensing bases.
  - Addressed all mechanisms that could impact plant operation (not limited to safety).
  - Inspection plan based on a comprehensive strategy that includes analysis, engineering judgment.

- Includes the requirement for operating experience evaluation and inspection plan evolution
  - This critical feature ensures that inspections evolve in response to current and future uncertainties

I&E Guidelines (Westinghouse Process)

1. Identify components
   - MRP-156
2. Identify degradation screening criteria
   - MRP-175
3. Characterize components and screen for degradation (A, non-A)
   - MRP-191
4. FMECA Review
   - MRP-191
5. Categorize for severity (A,B,C)
   - MRP-191
6. Functionality analysis of high priority (C) components
   - MRP-230
7. Categorize for inspection (Primary, Expansion, Existing, No additional measures)
   - MRP-232
8. Aging Management Strategy
   - MRP-232
9. Summary and Recommendations
   - MRP-227

Screening Variables

	SCC (IGSCC, TGSCC, PWSCC & LTCP)	IASCC	Wear	Fatigue (HC, LC, Thermal & Environmental)	Thermal Aging	Irradiation Embrittlement	Void Swelling	Irradiation Creep/S.R.
Material Type	☑				☑	☑		
Operating Stress	☑	☑						
Operating Temperature							☑	
Fluence		☑				☑	☑	☑
CUF				☑				
Bolt or Spring			☑	☑				☑
Wear Factor			☑					

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Material Type Dependence

- Stress Corrosion Cracking
  - Material and Stress
- Irradiation Embrittlement
  - Material and Fluence
  - Austenitic SS / Weld /CASS
- Thermal Embrittlement
  - Austenitic SS / Weld / CASS / Martensitic

Stress Corrosion Cracking
Material and Stress

Material	Parameter	Value
Austenitic Stainless Steels	Stress and Material	≥ 30 ksi (207 MPa) and Cold-work ≥20% or Welded Locations
Austenitic Stainless Steel Welds	Stress and Material	≥ 30 ksi (207 MPa) and Ferrite < 5%
Martensitic Stainless Steels	Stress	≥ 88 ksi (607 MPa)
Martensitic PH Stainless Steels	Stress	≥ 88 ksi (607 MPa)
Austenitic PH Stainless Steels	Stress and Material	≥ 70 ksi (483 MPa) and Surface cold-work
	Hot-headed or shot-peened bolting that meet the stress criterion are to be evaluated for SCC.	
Cast Austenitic SS	Stress and Material	≥ 35 ksi (241 MPa) and Ferrite < 5%
Austenitic Ni-base Alloys	Stress	≥ 30 ksi (207 MPa)
Austenitic Ni-base Welds	Stress	≥ 35 ksi (241 MPa)
Austenitic PH Ni-base (Alloy X-750)	Stress	≥ 100 ksi (689 MPa)
	AH and BH condition considered more susceptible than HTH condition.	
Austenitic PH Ni-base (Alloy 718)	Stress	≥ 130 ksi (896 MPa)
Co-base Alloys	Alloys not susceptible in PWR internals locations.	

Stress Dependence

- Stress Corrosion Cracking
  - All threshold stress values ≥ 30 ksi
  - Weld residual included in estimates

- Irradiation Assisted Stress Corrosion Cracking
  - All threshold stress values ≥ 30 ksi
  - 30 ksi limit not applicable below 40 dpa

In application an effective threshold of 30 ksi was universally applied .

Fluence Dependence

- Irradiation Embrittlement
  - Fluence based on material type
- Irradiation Assisted Stress Corrosion Cracking
  - All threshold fluence values ≥ 3 dpa
  - 3 dpa -10 dpa threshold stress is 89 ksi
- Void Swelling
  - ≥ 20 dpa and ≥ 608°F
- Stress Relaxation
  - Any bolt or spring ≥ 0.2 dpa

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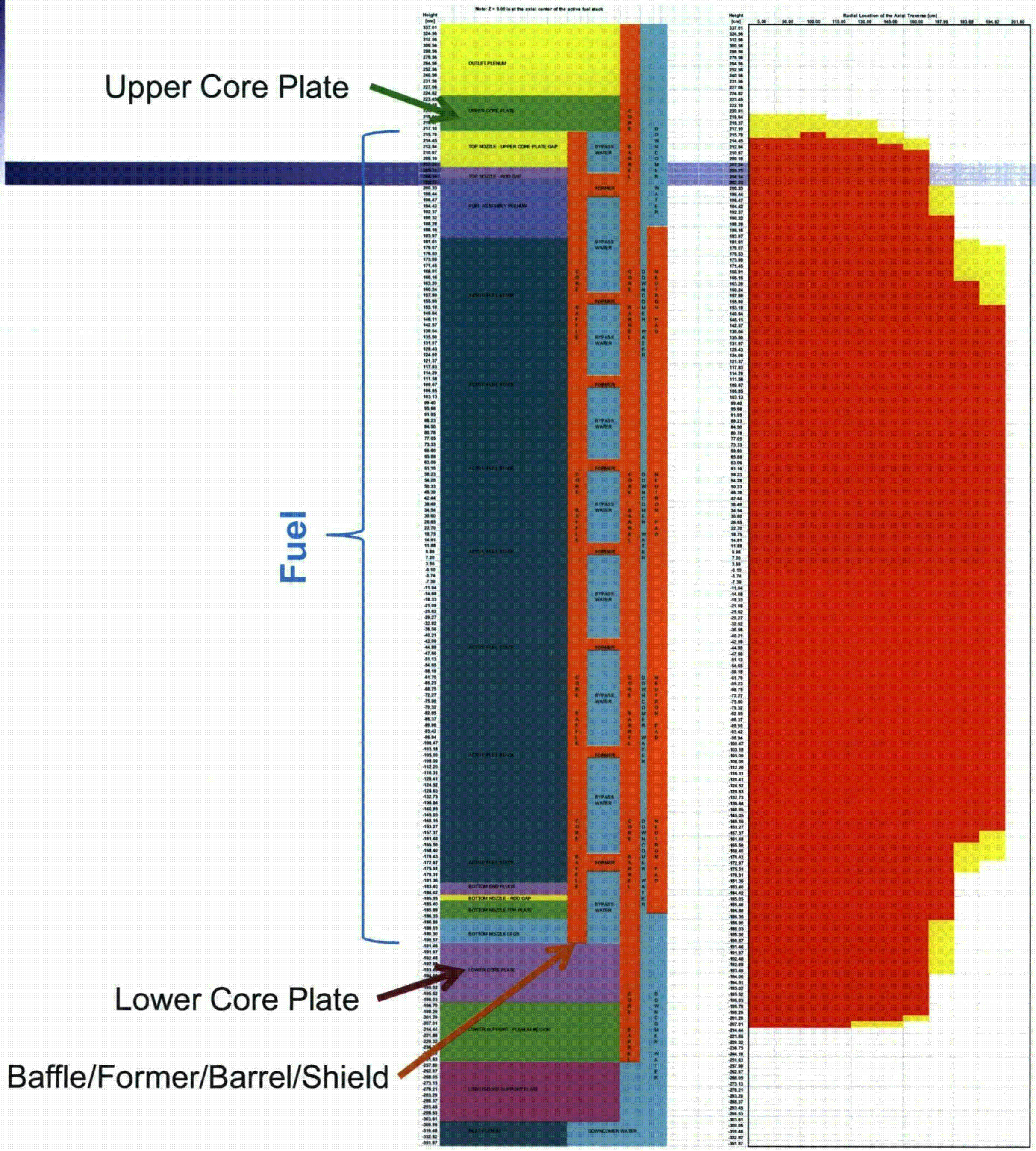
Irradiation Embrittlement Screening
Fluence and Material

MRP-175 (Expert Panel)

Material[a]	Criteria	
	Parameter	Value
Austenitic PH SS Austenitic Ni-Base Alloys Austenitic PH Ni-Base Alloys Martensitic SS Martensitic PH SS Co-Base Alloys	These materials are used in relatively low fluence locations; therefore, IE is not an applicable age-related degradation mechanism for component items fabricated with these alloys.	
Austenitic SS	Dose	$\geq 1 \times 10^{21}$ n/cm^2 (E > 1 MeV) [$\geq$ 1.5 dpa]
Austenitic SS Welds CASS	Dose	$\geq 6.7 \times 10^{20}$ n/cm^2 (E > 1 MeV) [$\geq$ 1 dpa]
	Lower screening value used are to account for large initial fracture toughness variability with these materials and possible synergistic effect on thermal aging embrittlement	

Westinghouse Plant

Screening for Irradiation Embrittlement



Fluence Map
(E>1MeV)

- Red: ≥$1x10^{21}$n/cm^2
- Yellow: ≥$7x10^{20}$ >$1x10^{20}$ n/cm^2

RAI Components

Lower Core Plate
Core Barrel Flange
Barrel-Former Bolts
Upper Core Barrel Welds
Lower Core Barrel Welds
Upper Core Barrel Alignment Pins

Westinghouse Components Irradiation Embrittlement – Screening Results

- Baffle-Former
  - Baffle-Former Bolts
  - Baffle Plates
  - Barrel-Former Bolts
  - Former Plates
  - Baffle Edge Bolts
  - Baffle Bolting Lock Bars
- Core Barrel
  - Lower Core Barrel
  - Upper Core Barrel
- Surveillance Capsules
  - Specimen Plugs
  - Irradiation Specimen Guide Bolts
  - Irradiation Specimen Guide Lock Caps
  - Irradiation Specimen Guide
- Lower Core Plate Assembly
  - XL Lower Core Plate
  - LCP-Fuel Alignment Pin lock caps
  - Lower Core Plate
  - Fuel Alignment Pins
  - LCP-Fuel Alignment Pin Bolts
- Control Rod Guide Tube Assemblies
  - Flanges – Lower (CASS)
- Thermal Shield/Neutron Panels
  - Thermal Shield Flexures
  - Thermal Shield Dowels
  - Neutron Panel lock caps
  - Thermal Shield or Neutron Panels
  - Thermal Shield Bolts
  - Neutron Panel Bolts
- Lower Support Columns
  - Lower Support Column Bodies (CASS/Non CASS)
  - Lower Support Column Bolts
- Bottom Mounted Instrumentation
  - BMI Column Extension Tubes
  - BMI Column Extension Bars
  - BMI Column Nuts
  - BMI Column Collars
  - BMI Column Bodies
  - BMI Column Cruciforms (CASS)
- Flux Thimbles
  - Flux Thimble Tube Plugs
  - Flux Thimbles (Tubes)
- Upper Support Assembly
  - Mixing Devices (CASS)
  - UHI Flow Column Bases (CASS)
  - Upper Support Column Bases (CASS)

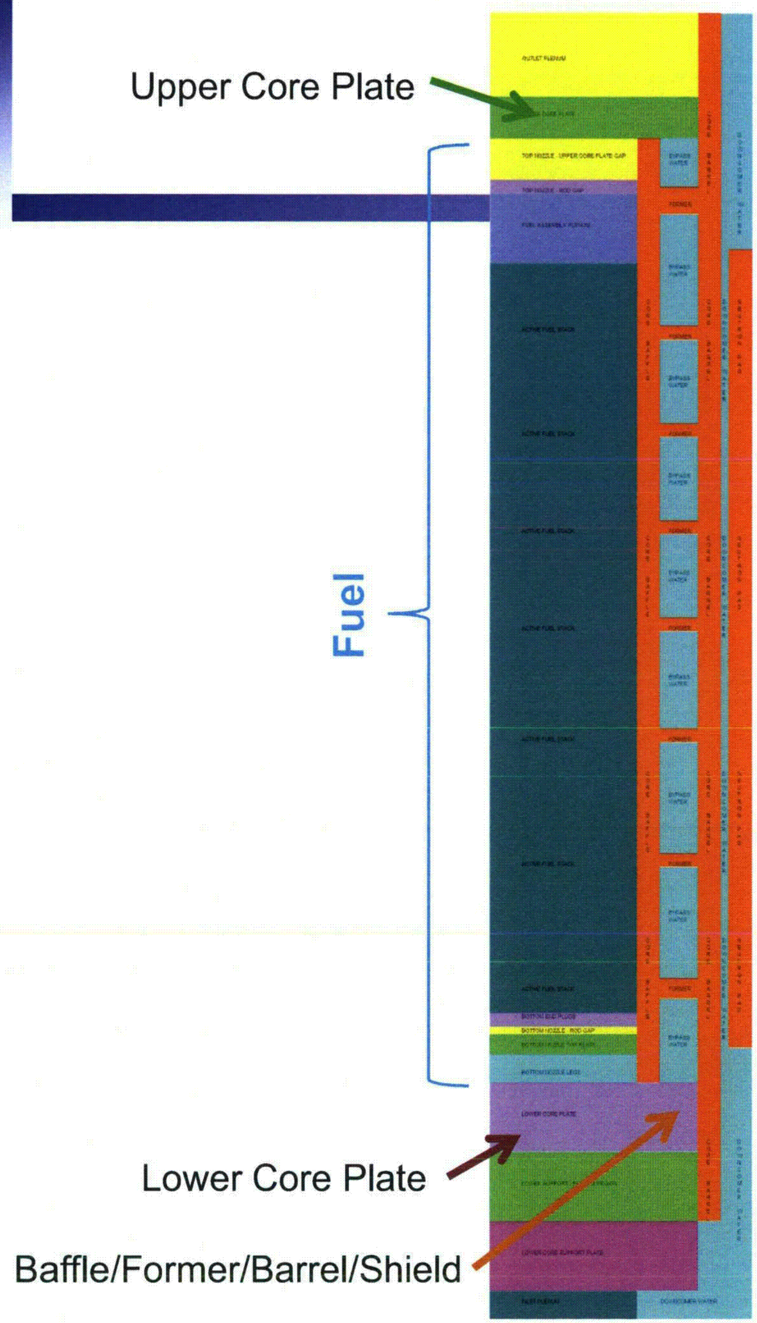
Irradiation Assisted Stress Corrosion Cracking

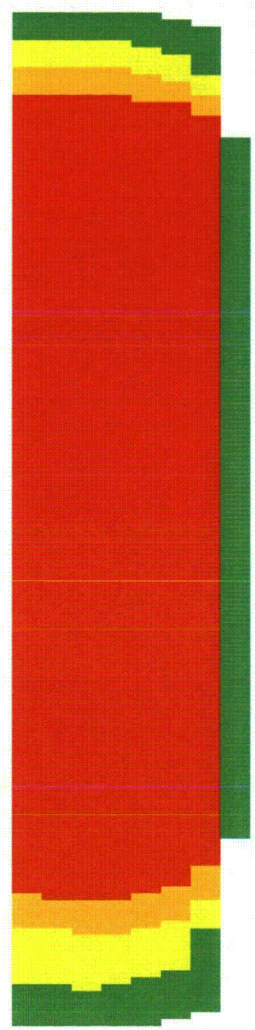
Fluence and Stress

Material	Parameter	Value
All Alloys	Stress <u>and</u> Dose	See SCC criteria (Table 3-1) (IASCC not considered applicable) <u>and</u> < 2.0 X 10^{21} n/cm^2 (E > 1 MeV) [< 3 dpa]
		$\geq$ 89 ksi (616 MPa) <u>and</u> 2.0 X 10^{21} n/cm^2 (E > 1 MeV) [3 dpa]
		$\geq$ 62 ksi (425 MPa) <u>and</u> 6.7 X 10^{21} n/cm^2 (E > 1 MeV) [10 dpa]
		$\geq$ 46 ksi (315 MPa) <u>and</u> 1.3 X 10^{22} n/cm^2 (E > 1 MeV) [20 dpa]
		$\geq$ 30 ksi (207 MPa) <u>and</u> 2.7 X 10^{22} n/cm^2 (E > 1 MeV) [40 dpa]

Westinghouse Plant

Screening for IASCC





Fluence Map
(E>1MeV)

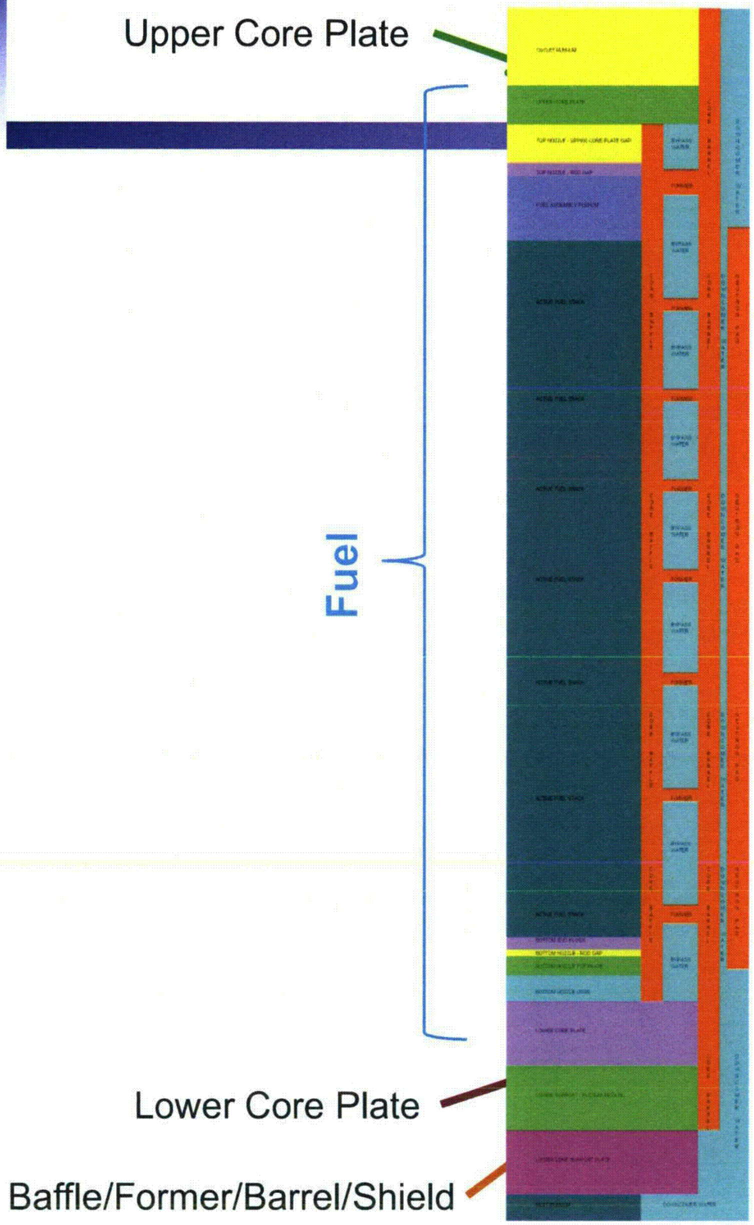
- Red: $\geq 2.7 \times 10^{22}$ n/cm^2
- Orange: $\geq 1.3 \times 10^{22} > 2.7 \times 10^{22}$ n/cm^2
- Yellow: $\geq 6.7 \times 10^{21} > 1.3 \times 10^{22}$ n/cm^2
- Green: $\geq 2 \times 10^{21} > 6.7 \times 10^{21}$ n/cm^2

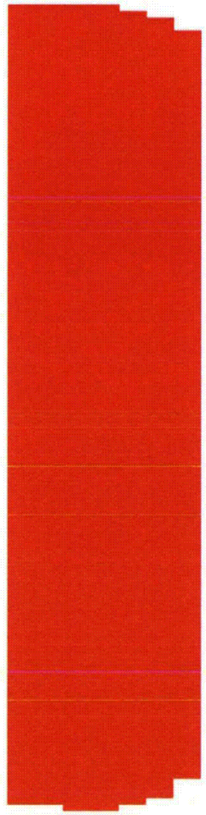
RAI Components

Lower Core Plate
Core Barrel Flange
Barrel-Former Bolts
Upper Core Barrel Welds
Lower Core Barrel Welds
Upper Core Barrel Alignment Pins

Screening
Temperature Dependence

- Void Swelling
  - $\geq$ 20 dpa (1.3×10^{22} n/cm^2) <u>and</u> $\geq$ 608^{o}F





Westinghouse Plant

Screening for Void Swelling

Fluence Map
(E>1MeV)

■ $\geq 1.3 \times 10^{22} n/cm^2$

RAI Components

Lower Core Plate
Core Barrel Flange
Barrel-Former Bolts
Upper Core Barrel Welds
Lower Core Barrel Welds
Upper Core Barrel Alignment Pins

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   – MRP-230
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   – MRP-227

Westinghouse FMECA Analysis

- Performed on a component level
  - FMECA status based on combined effects of all identified degradation mechanisms.
  - Multiple active mechanisms contributing factor to likelihood of failure
- Confirmed Screening of all Category A components
- Simple 9-box matrix for all Non-A components
  - Failure likelihood vs. Damage likelihood
  - Reported FMECA Ranking (0-3)
  - Moved Additional Components to Category A

Westinghouse – Failure Likelihood (Susceptibility)

Category	Description
None	Expert panel concurs that failure of the component is not credible in a 60-year lifetime (i.e. no screened-in age-related degradation mechanisms or other evidence to support a concern).
Low	Expert panel believes the component is unlikely to fail in a 60-year lifetime either due to known or potentially emerging issues based on current knowledge base.
Medium	Expert panel believes there is the potential for concern, multiple degradation modes are a possibility, or believes further investigation is merited to solidify classification.
High	Expert panel expects this component to fail or cannot exclude the possibility of failure or susceptibility to failure within the 60-year lifetime.

Note: Failures were identified to be specific to the material/design combination that is recognized as having failed in service or under test conditions.

Westinghouse – Damage Likelihood (Severity)

Category	Description
None	The component has no screened-in degradation mechanism. No need to assess damage; no financial impact
Low	Expert panel believes there is no credible means for component failure(s) to cause damage but with potential financial impacts
Medium	Expert panel believes the potential exists for damage as a result of component (or multiple) failure(s) but that the ability to shut down the reactor in a controlled manner remains; financial impact
High	Expert panel believes that some damage could possibly result from failure of the component(s); financial impact

Review of Westinghouse FMECA Results

- Evaluation was by component
- Summary by degradation mode
  - FMECA Classification determined by most limiting factor or combination of factors

Westinghouse Components Irradiation Embrittlement – FMECA Results

- Baffle-Former
  - Baffle-Former Bolts (H,L)
  - Baffle Plates (M,L)
  - Barrel-Former Bolts (H,L)
  - Former Plates (M,L)
  - Baffle Edge Bolts (H,M)
  - Baffle Bolting Lock Bars (L,L)
- Core Barrel
  - Lower Core Barrel (M,H)
  - Upper Core Barre (M,H)
- Surveillance Capsules
  - Specimen Plugs (L,L)
  - Irradiation Specimen Guide Bolts (L,L)
  - Irradiation Specimen Guide Lock Caps (L,L)
  - Irradiation Specimen Guide (L,L)
- Lower Core Plate Assembly
  - XL Lower Core Plate (M,M)
  - LCP-Fuel Alignment Pin lock caps (L,L)
  - Lower Core Plate (M,M)
  - Fuel Alignment Pins (L,L)
  - LCP-Fuel Alignment Pin Bolts (L,L)
- Control Rod Guide Tube Assemblies
  - Flanges – Lower (CASS) (M,M)
- Thermal Shield/Neutron Panels
  - Thermal Shield Flexures (M,L)
  - Thermal Shield Dowels (L,L)
  - Neutron Panel lock caps (L,L)
  - Thermal Shield or Neutron Panels (L,L)
  - Thermal Shield Bolts (L,L)
  - Neutron Panel Bolts (L,L)
- Lower Support Columns
  - Lower Support Column Bodies (CASS/Non CASS) (M,L)
  - Lower Support Column Bolts (M,L)
- Bottom Mounted Instrumentation
  - BMI Column Extension Tubes (M,L)
  - BMI Column Extension Bars (L,L)
  - BMI Column Nuts (L,L)
  - BMI Column Collars (M,L)
  - BMI Column Bodies (M,L)
  - BMI Column Cruciforms (CASS) (M,L)
- Flux Thimbles
  - Flux Thimble Tube Plugs (M,L)
  - Flux Thimbles (Tubes) (H,L)
- Upper Support Assembly
  - Mixing Devices (CASS) (L,L)
  - UHI Flow Column Bases (CASS) (L,L)
  - Upper Support Column Bases (CASS) (L,M)

Westinghouse FMECA Classification

Failure Likelihood	Consequence (Damage Likelihood)		
	Low	Medium	High
High	2	3	3
Medium	1	2	3
Low	1	1	2
None	0	0	0

Category A

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Westinghouse Components Irradiation Embrittlement – FMECA (Low Failure, Low Consequence)

- Baffle-Former
  - Baffle-Former Bolts (H,L)
  - Baffle Plates (M,L)
  - Barrel-Former Bolts (H,L)
  - Former Plates (M,L)
  - Baffle Edge Bolts (H,M)
  - Baffle Bolting Lock Bars (L,L) *[A]*
- Core Barrel
  - Lower Core Barrel (M,H)
  - Upper Core Barre (M,H)l
- Surveillance Capsules
  - Specimen Plugs (L,L) *[A]*
  - Irradiation Specimen Guide Bolts (L,L) *[A]*
  - Irradiation Specimen Guide Lock Caps (L,L) *[A]*
  - Irradiation Specimen Guide (L,L) *[A]*
- Lower Core Plate Assembly
  - XL Lower Core Plate (M,M)
  - LCP-Fuel Alignment Pin lock caps (L,L) *[A]*
  - Lower Core Plate (M,M)
  - Fuel Alignment Pins (L,L) *[A]*
  - LCP-Fuel Alignment Pin Bolts (L,L) *[A]*
- Control Rod Guide Tube Assemblies
  - Flanges – Lower (CASS) (M,M)
- Thermal Shield/Neutron Panels
  - Thermal Shield Flexures (M,L)
  - Thermal Shield Dowels (L,L) *[A]*
  - Neutron Panel lock caps (L,L) [A]
  - Thermal Shield or Neutron Panels (L,L) *[A]*
  - Thermal Shield Bolts (L,L) *[A]*
  - Neutron Panel Bolts (L,L) *[A]*
- Lower Support Columns
  - Lower Support Column Bodies (CASS/Non CASS) (M,L)
  - Lower Support Column Bolts (M,L)
- Bottom Mounted Instrumentation
  - BMI Column Extension Tubes (M,L)
  - BMI Column Extension Bars (L,L) *[A]*
  - BMI Column Nuts (L,L) *[A]*
  - BMI Column Collars (M,L)
  - BMI Column Bodies (M,L)
  - BMI Column Cruciforms (CASS) (M,L)
- Flux Thimbles
  - Flux Thimble Tube Plugs (M,L)
  - Flux Thimbles (Tubes) (H,L)
- Upper Support Assembly
  - Mixing Devices (CASS) (L,L) [A]
  - UHI Flow Column Bases (CASS) (L,L) *[A]*
  - Upper Support Column Bases (CASS) (L,M)

Westinghouse Components Irradiation Embrittlement – FMECA (Low Failure, Medium Consequence)

- Baffle-Former
  - Baffle-Former Bolts (H,L)
  - Baffle Plates (M,L)
  - Barrel-Former Bolts (H,L)
  - Former Plates (M,L)
  - Baffle Edge Bolts (H,M)
  - Baffle Bolting Lock Bars (L,L)
- Core Barrel
  - Lower Core Barrel (M,H)
  - Upper Core Barre (M,H)l
- Surveillance Capsules
  - Specimen Plugs (L,L)
  - Irradiation Specimen Guide Bolts (L,L)
  - Irradiation Specimen Guide Lock Caps (L,L)
  - Irradiation Specimen Guide (L,L)
- Lower Core Plate Assembly
  - XL Lower Core Plate (M,M)
  - LCP-Fuel Alignment Pin lock caps (L,L)
  - Lower Core Plate (M,M)
  - Fuel Alignment Pins (L,L)
  - LCP-Fuel Alignment Pin Bolts (L,L)
- Control Rod Guide Tube Assemblies
  - Flanges – Lower (CASS) (M,M)
- Thermal Shield/Neutron Panels
  - Thermal Shield Flexures (M,L)
  - Thermal Shield Dowels (L,L)
  - Neutron Panel lock caps (L,L)
  - Thermal Shield or Neutron Panels (L,L)
  - Thermal Shield Bolts (L,L)
  - Neutron Panel Bolts (L,L)
- Lower Support Columns
  - Lower Support Column Bodies (CASS/Non CASS) (M,L)
  - Lower Support Column Bolts (M,L)
- Bottom Mounted Instrumentation
  - BMI Column Extension Tubes (M,L)
  - BMI Column Extension Bars (L,L)
  - BMI Column Nuts (L,L)
  - BMI Column Collars (M,L)
  - BMI Column Bodies (M,L)
  - BMI Column Cruciforms (CASS) (M,L)
- Flux Thimbles
  - Flux Thimble Tube Plugs (M,L)
  - Flux Thimbles (Tubes) (H,L)
- Upper Support Assembly
  - Mixing Devices (CASS) (L,L)
  - UHI Flow Column Bases (CASS) (L,L)
  - Upper Support Column Bases (CASS) (L,M) ***[A]***

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Severity Categorization

- Category A: component items for which aging degradation significance is minimal and aging effects are below the screening criteria
- Category C: “lead” component items for which aging degradation significance is high or moderate and aging effects are above screening levels
- Category B: component items above screening levels but are not “lead” component items and aging degradation significance is moderate

All remaining “non-A” components were placed in either Category “B” or “C”

Westinghouse Components Irradiation Embrittlement – FMECA (L,H), (M,L), (M,M), (M,H), (H,L), (H,M) &(H,H)

- Baffle-Former
  - Baffle-Former Bolts (H,L) *[C]*
  - Baffle Plates (M,L) *[B]*
  - Barrel-Former Bolts (H,L) *[C]*
  - Former Plates (M,L) *[B]*
  - Baffle Edge Bolts (H,M) *[C]*
  - Baffle Bolting Lock Bars (L,L)
- Core Barrel
  - Lower Core Barrel (M,H) *[C]*
  - Upper Core Barre (M,H)l *[C]*
- Surveillance Capsules
  - Specimen Plugs (L,L)
  - Irradiation Specimen Guide Bolts (L,L)
  - Irradiation Specimen Guide Lock Caps (L,L)
  - Irradiation Specimen Guide (L, L)
- Lower Core Plate Assembly
  - XL Lower Core Plate (M,M) *[C]*
  - LCP-Fuel Alignment Pin lock caps (L,L)
  - Lower Core Plate (M,M) *[C]*
  - Fuel Alignment Pins (L,L)
  - LCP-Fuel Alignment Pin Bolts (L,L)
- Control Rod Guide Tube Assemblies
  - Flanges – Lower (CASS) (M,M) ***[B]***
- Thermal Shield/Neutron Panels
  - Thermal Shield Flexures (M,L) *[B]*
  - Thermal Shield Dowels (L,L)
  - Neutron Panel lock caps (L,L)
  - Thermal Shield or Neutron Panels (L,L)
  - Thermal Shield Bolts (L,L)
  - Neutron Panel Bolts (L,L)
- Lower Support Columns
  - Lower Support Column Bodies (CASS/Non CASS) (M,L) *[B]*
  - Lower Support Column Bolts (M,L) *[B]*
- Bottom Mounted Instrumentation
  - BMI Column Extension Tubes (M,L) *[B]*
  - BMI Column Extension Bars (L,L)
  - BMI Column Nuts (L,L)
  - BMI Column Collars (M,L) *[B]*
  - BMI Column Bodies (M,L) *[B]*
  - BMI Column Cruciforms (CASS) (M,L) *[B]*
- Flux Thimbles
  - Flux Thimble Tube Plugs (M,L) *[B]*
  - Flux Thimbles (Tubes) (H,L) *[C]*
- Upper Support Assembly
  - Mixing Devices (CASS) (L,L)
  - UHI Flow Column Bases (CASS) (L,L)
  - Upper Support Column Bases (CASS) (L,M)

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Application of the FEA Model

- Representative Plants
  - Westinghouse 3-Loop
    - Baffle/Former/Barrel and Lower Core Plate Models
    - Short Bolts
    - Aggressive Power Distribution
  - CE Welded Core Shroud
    - Stacked Sections (Tie Rods)
    - Aggressive Power Distribution
- Plan for Interpretation
  - General trends and abrupt impacts not strict numbers
  - Identify factors that cause component failure
  - Extend conclusions to other designs

Recommendations for Remaining Components

- Lessons learned from FEA
  - Swelling conditions
  - Dose dependence of stress relaxation
- Direct application of degradation models
- Existing analysis of stress/temperature/fluence
- General Engineering Judgment
  - Recognized uncertainty in analysis
  - Defaulted to conservative inspection requirements

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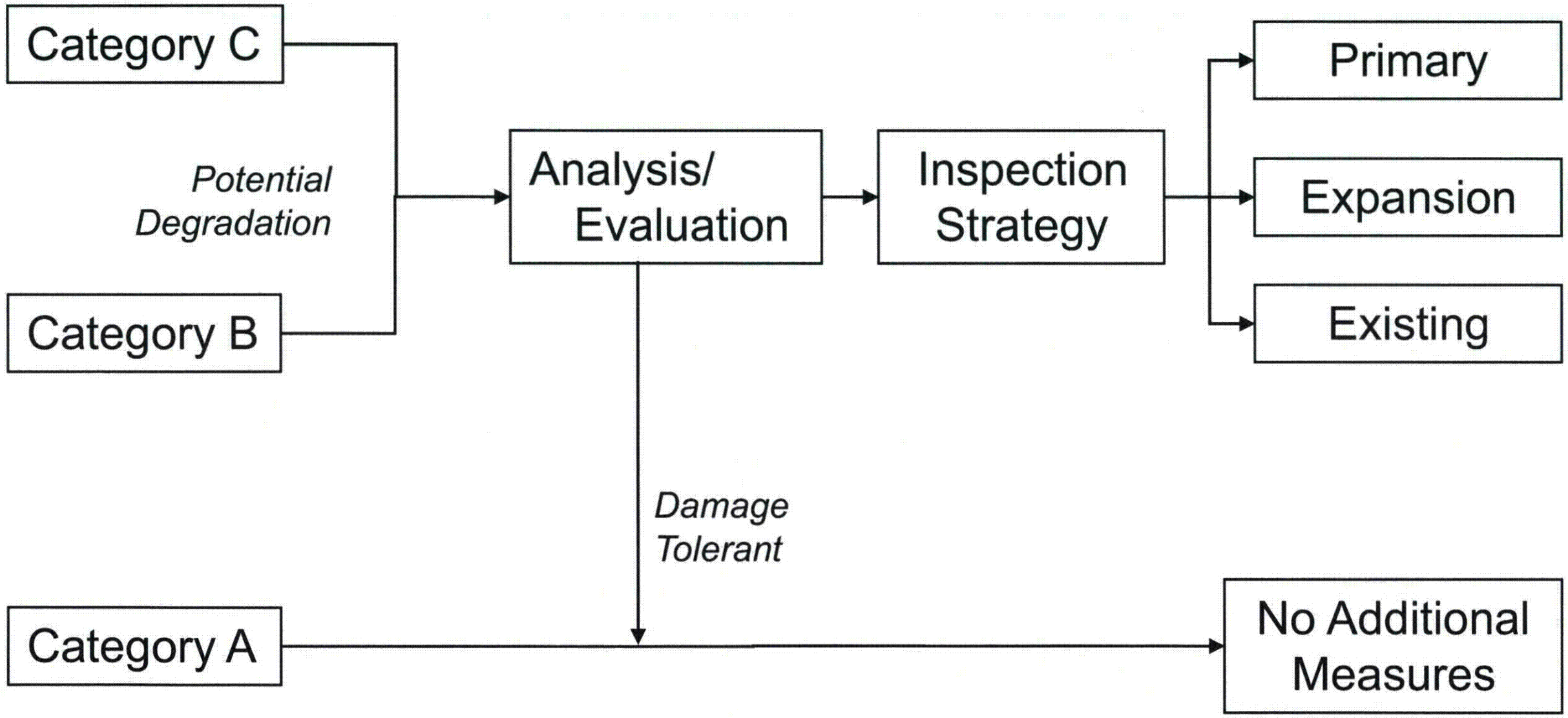
   - MRP-227

Determination of Inspection Recommendation



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Disposition of Category B & C Components

Component	Material	Initial Category	SCC	IASCC	Wear	Fatigue	TE (Note 1)	IE (Note 1)	VS	ISR and IC	Final Group
Control Rod Guide Tube Assembly											
Lower Flanges	CF8	B	P	A	A	P	P	P	A	A	P
Guide Plates (Cards)	304 SS	C	N	A	P	N	A	A	A	A	P
C-Tubes (Note 2)	304 SS	C	A	A	P	A	A	A	A	A	N
Sheaths (Note 2)	304 SS	C	A	A	P	A	A	A	A	A	N
Guide Tube Support Pins	Alloy X-750	C	X	A	X	X	A	A	A	N	X
Upper Internals Assembly											
Upper Support Ring or Skirt	304 SS	B	E	A	A	X	A	A	A	A	X
Upper Core Plate	304 SS	A	A	A	E Note 5	E Note 5	A	A	A	A	E Note 5
Baffle-Former Assembly											
Baffle-Edge Bolts	316 SS, 347 SS	C	A	P	N	P	A	P	P	P	P
Baffle Plates and Former Plates (Note 3)	304 SS	B	A	N	A	A	A	N	P	A	P
Baffle-Former Bolts	316 SS, 347 SS	C	A	P	N	P	A	P	P	P	P
Barrel-Former Bolts	316 SS, 347 SS	C	A	E	N	E	A	E	E	E	E
Bottom Mounted Instrumentation System											
BMI Column Bodies	304 SS	B	N	N	A	E	A	E	N	A	E
BMI Column Collars	304 SS	B	A	N	A	A	A	N	N	A	N
BMI Column Cruciforms	CF8	B	A	N	A	A	N	N	N	A	N
BMI Column Extension Tubes	304 SS	B	N	N	A	A	A	N	N	A	N
Flux Thimble Tube Plugs	304 SS	B	N	N	A	A	A	N	N	A	N
Flux Thimbles (Tubes)	316 SS	C	N	N	X	A	A	N	N	A	X

* Guide tube support pins identified as an already managed problem by Westinghouse. MRP did not include in formal recommendations (See MRP-227 Section 4.4.3).

Disposition of Category B & C Components
(Continued)

Table 3-3
Final disposition of Westinghouse internals (continued)

Component	Material	Initial Category	SCC	IASCC	Wear	Fatigue	TE (Note 1)	IE (Note 1)	VS	ISR and IC	Final Group
Core Barrel Assembly											
Core Barrel Flange	304 SS	B	E	A	X	A	A	A	A	A	X
Core Barrel Outlet Nozzle Welds	304 SS	B	E	A	A	E	A	A	A	A	E
Core Barrel Girth Welds	304 SS	C	P Note 6	P Note 6	A	A	A	P Note 6	A	A	P Note 6
Core Barrel Axial Welds	304 SS	C	E	E	A	A	A	E	A	A	E
Upper Core Barrel Flange Weld	304 SS	C	P	E	A	A	A	A	A	A	P
Lower Internals Assembly											
Lower Core Plate	304 SS	C	N	X	X	X	A	X	N	A	X
XL Lower Core Plate	304 SS	C	N	X	X	X	A	X	A	A	X
Lower Support Casting	CF8	A	A	A	A	A	E Note 5	A	A	A	E Note 5
Lower Support Forging	304 SS	A	A	A	A	A	A	A	A	A	E Note 5
Lower Support Assembly											
Lower Support Column Bodies	CF8	B	A	E	A	A	N	E	N	A	E
Lower Support Column Bodies	304 SS	B	A	E	A	A	A	E	N	A	E
Lower Support Column Bolts	304 SS	B	A	E	N	E	A	E	N	E	E
Thermal Shield Assembly											
Thermal Shield Flexures	304 SS	B	A	N	P	P	A	N	A	N	P
Alignment and Interfacing Components											
Clevis Insert Bolts	Alloy X-750	B	A	A	X	A	A	A	A	A	X
Internals Hold Down Spring (Note 4)	304 SS	B	A	A	P	A	A	A	A	A	P
Upper Core Plate Alignment Pins	304 SS	B	X	A	X	A	A	A	A	A	X

I&E Guidelines Process

1. Identify components
   - MRP-156
2. Identify degradation screening criteria
   - MRP-175
3. Characterize components and screen for degradation (A, non-A)
   - MRP-191
4. FMECA Review
   - MRP-191
5. Categorize for severity (A,B,C)
   - MRP-191
6. Functionality analysis of high priority (C) components
   - MRP-230
7. Categorize for inspection (Primary, Expansion, Existing, No additional measures)
   - MRP-232
8. Aging Management Strategy
   - MRP-232
9. Summary and Requirements
   - MRP-227

What is Required to Demonstrate That These Guidelines Apply to a Specific Plant?

- MRP-227 provides requirements that apply to all plants (Westinghouse, CE and B&W)
- Utilities must:
  - Confirm applicability of requirements for plant
  - Prepare plant specific implementation plans
- Logic assumes that plant has moved to a low leakage core loading plan. Plant uprates that result in return to high leakage conditions may require additional analysis.
  - No expectation that plants would return to this practice
  - Impact on inspection requirements would be limited

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Additional Industry Activities to Support MRP-227-A Conclusions

- Comparison to WCAP-14577 R1-A and BAW-2248-A
- Review of Acceptance Criteria (WCAP-17096NP)
- Additional Operating Experience
- Sensitivity Studies to Confirm Section 2.6 Applicability Requirements Based on Original FEA Assumptions.

Existing Westinghouse AMR Guidance WCAP-14577-R1-A

NRC Safety Evaluation Issued

BAW-2248-A: 12/99

WCAP-14577 R1-A: 2/01

Plants may use the reports in a license renewal application to satisfy the requirements of

1) 10 CFR 54.21(a)(3) for demonstrating that the effects of aging on the reactor vessel internals components within the scope of this topical report will be adequately managed and
2) 10 CFR 54.21(c)(1) for demonstrating the appropriate findings in the evaluation of time-limited aging analysis for the reactor internals.

Comparison to MRP-227-A shows general agreement.

Acceptance Criteria

- WCAP-17096-NP
  - Verification of failure consequences
  - Many criteria based on operating criteria
    - No related safety concern
  - Work may be basis for revisions to MRP 227-A
    - Re-evaluation of components

Operating Experience

- MRP-227-A is designed to be a living document.
  - Initial Inspection Plan reflected in 227-A
    - Based on broad assumptions to capture and prioritize aging scope
    - Initiates at first Regulatory opportunity (PEO)
    - Inspection Frequencies are consistent with aging mechanisms
  - It is not possible or practical to eliminate all current and future component uncertainties
  - Revisions will be based on OE
    - Good experience with initial inspections
    - Regular OE updates to industry
      - Industry following recent experience with
        - Baffle-former bolts
        - Clevis insert bolts
        - Guide card wear
        - …

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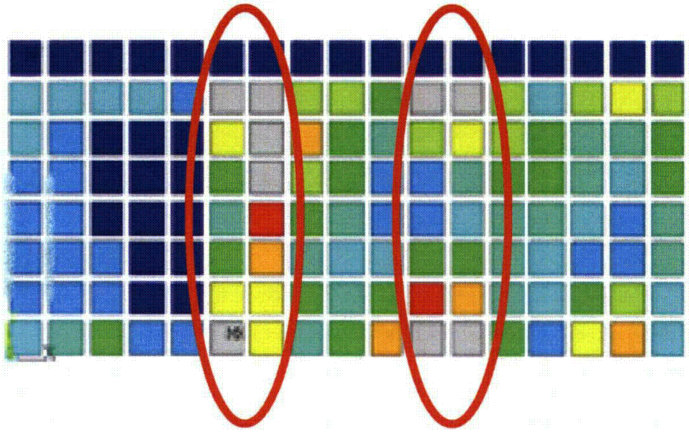
Recently Completed Westinghouse Sensitivity Studies

- Original (MRP-230) to New Basis
  - Original: 20 cyc. OUT/IN, 20 cyc. Low Leak
    - Fuel Cycle used Beginning, Middle, and End-of Cycle Temperatures
  - New Basis: 7 cyc. OUT/IN, 33 cyc. Low Leak
    - End-of-Cycle Temperatures use for each Fuel Cycle
- New Basis w/3 Sensitivity Conditions
  - Sens. 1: Slower Creep, Original Void Swelling
  - Sens. 2: Slower Creep, Slower Void Swelling
  - Sens. 3: Slower Creep, Faster Void Swelling
- Applied to Representative Westinghouse BFB and CE Shroud Analytical Models

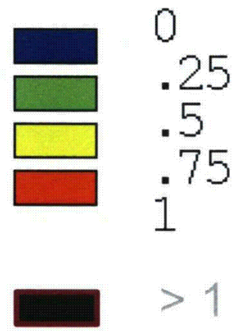
Impact of More Realistic Fluence Distribution on Baffle-Former Bolt Failure Patterns

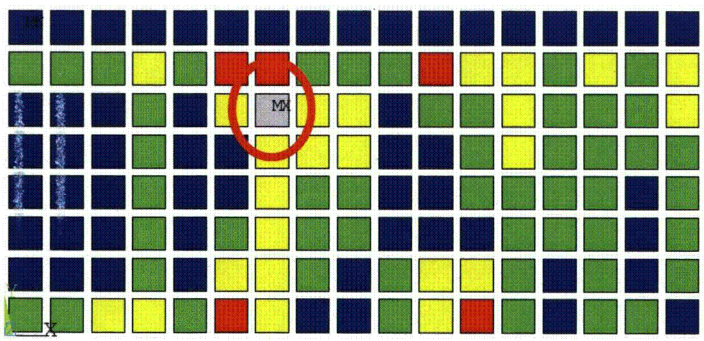


Original IASCC @ 60 years

Out/In: Years 0 – 30

Low-Leakage: Years 31 - 60





New Basis IASCC @ 60 yrs

Out/In: Years 0 – 10

Low-Leakage: Years 11 - 60

IASCC Susceptibility

Sensitivity Studies
– Predicted Baffle-Former Bolt Failures

- New Basis: Bolt 6G @ 56 years
- Sensitivity 1, Slower Creep
  - Bolt 6G @ 51 – 55 yrs, Bolts 1F & 7G @ 56 – 60 yrs
- Sensitivity 2, Slower Creep & Void Swelling
  - Bolt 6G @ 56 – 60 yrs
- Sensitivity 3, Slower Creep, Faster Void Swelling
  - Bolts 1F & 6G @ 41 – 45 yrs, Bolts 7F & 7G @ 51 – 55 yrs, Bolts 4G, 5G, & 7K @ 56 – 60 yrs (most similar to original case)

Summary

- List of components identified in original MRP screening process is relatively insensitive to stress, fluence, temperature and material assumptions. The final list of inspection recommendations is robust and does not require bounding assumptions on all possible screening variables.
- Functionality Analysis provides insight into complex interactions of multiple irradiation related degradation mechanisms. These studies provide guidance on trends in reactor internals behavior. The MRP-227-A requirements are not based numerical results.
  - 30 year "out-in" core loading assumptions produced aggressive conditions in baffle/former barrel structure.
  - Sensitivity studies indicate that significant changes in aging degradation models would not change inspection recommendations
- The MRP-227-A aging management system remains effective for aging variations within the broad operational limits of various core designs and operation.
- MRP-227-A provides a robust inspection strategy that bounds internals performance.
  - Inspection requirements and schedules are insensitive to plant specific values of stress, temperature, fluence and material type based upon bounding process used by MRP.