Preliminary MRP-227-Rev. 1 RAI Responses

Kyle Amberge-PM
EPRI-MRP

Glenn Gardner
Dominion

Sarah Davidsaver
AREVA

September 6, 2017

Presentation Outline

- Background and Overview
- Discussion of RAIs

Background and Overview

- MRP-189, Revision 2 and MRP-231, Revision 3 prepared in 2014, MRP-191, Revision 1 and MRP-230, Revision 1 Supplement prepared in 2016
  - Technical basis for changes in MRP-227-Rev. 1
  - Will be provided to NRC upon formal request (industry understanding formal request forthcoming shortly)
- MRP-227-Rev. 1 completed in October 2015, submitted to NRC Staff in December 2015
- NRC transmitted RAIs to industry May 15, 2017
- Industry currently preparing formal RAI responses
- Responses here are for initial discussion
  - To be finalized and submitted by end of Sept. 2017

Background and Overview

- Twenty-seven (27) RAIs received 5/15/2017
- Eleven (11) Babcock & Wilcox-design specific RAIs
  - 1, 2, 3, 4, 6, 11, 17, 18, 21, 22, 25
- Fourteen (14) Westinghouse-design or CE-design specific RAIs
  - 5, 7, 8, 9, 10, 12, 14, 15, 16, 19, 20, 23, 24, 26
- Two (2) Generic RAIs
  - 13 and 27

Presentation Outline

- Background and Overview
- Discussion of RAIs

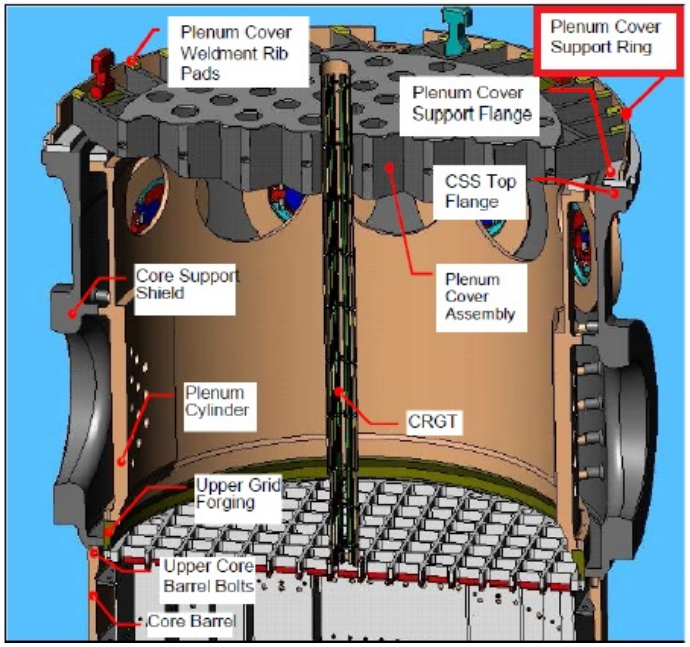
Discussion of RAIs

RAI 1

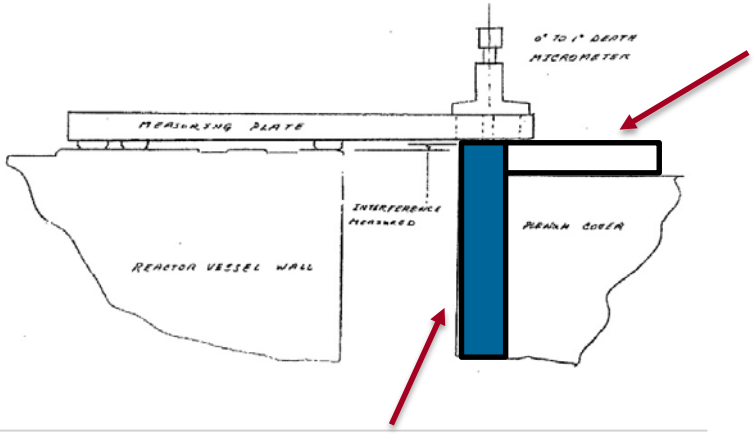
- **RAI Summary:** Clarify what the change from “during the next 10-year ISI [inservice inspection]” to “during the next 10-year ISI interval” means, i.e., can these examinations be performed until up to 20 years from now? This RAI is applicable to the CRGT spacer castings, vent valve retaining rings (top and bottom), baffle plates, and locking devices, including locking welds, of the baffle-to-former bolts and internal baffle-to-baffle bolts.
- **Industry Response:** The updated wording does not allow initial examinations 20 years into the PEO.
- The term “10-year ISI interval” is intended to mean the plant’s existing schedule associated with removal of the core barrel, i.e., during the next scheduled 10-year ISI interval examination, consistent with wording in the ASME B&PV Code.
- Therefore, the intention of this wording is for examinations to be performed prior to the end of the fourth ASME ISI interval and not more than 11 years apart, i.e., what is allowed by Section XI of the ASME B&PV Code, which is consistent with the stipulations stated in Section 4.2.6 of MRP-227-Rev. 1.

Discussion of RAIs

- **RAI 2**
  - **RAI Summary:** Why the change of the plenum cover support ring from “A” in MRP-227-A to “Primary” in MRP-227-Rev. 1.
  - **Industry Response:** Plenum cover support ring machined to a common plane with the plenum cover weldment rib pads, making it part of the core clamping items.
  - Core clamping measurements have been consistently performed at all Babcock and Wilcox-designed units, and included the plenum cover support ring
  - Clarifying change only (no technical issues), core clamping measurements always considered the ring and the pads as they are designed to share the load



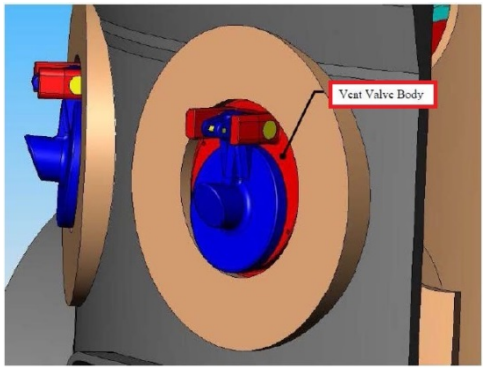
MRP-227-Rev. 1 Figure 4-1



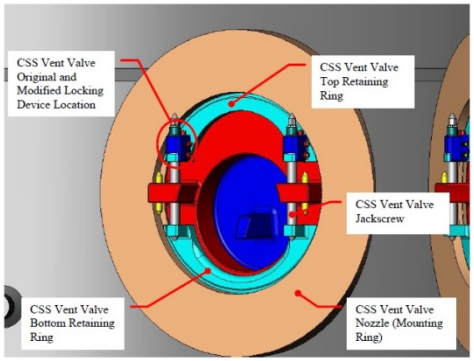
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Discussion of RAIs

- **RAI 3**
  - **RAI Summary:** Why the addition of the vent valve bodies as Expansion link to the CRGT spacer castings (previously they were no additional measures)?
  - **Industry Response:** Previously the original vent valve bodies were able to be screened out, but data for replacement vent valve bodies have not been fully gathered, hence they are conservatively screened in unless they can be shown to be below the screening criteria (see Table 4-4 Note 4)
  - This may consist of CMTR reviews and/or a statistical argument, PWROG-15032-NP
    - NRC staff performed an assessment of PWROG-15032-NP (ML16250A001)



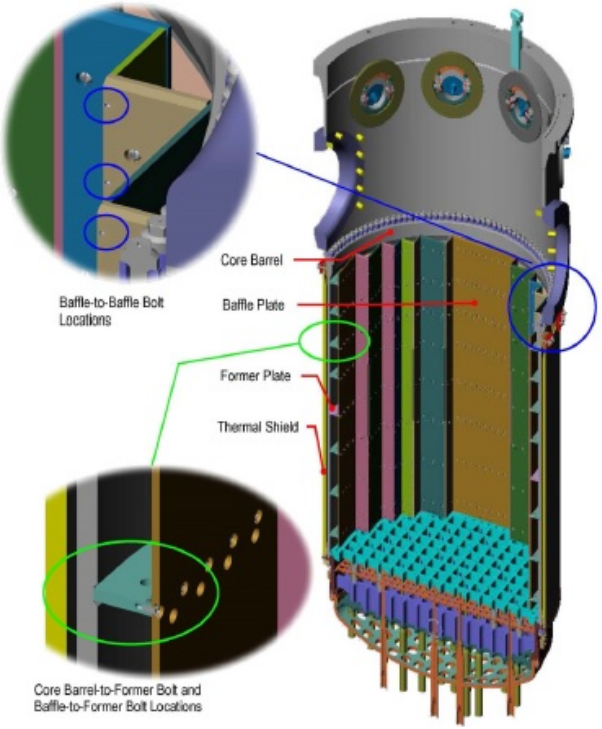
MRP-227-Rev. 1 Figure 4-9



MRP-227-Rev. 1 Figure 4-10

Discussion of RAIs

- **RAI 4**
  - **RAI Summary:** Does the initial baseline UT examination schedule for the baffle-to-former bolts in MRP-227-Rev. 1 assume an examination of baffle-to-former bolts has been completed within two RFOs from the beginning of the period of extended operation? If not, justify changing the schedule for the baseline UT examinations of the baffle-to-former bolts
  - **Industry Response:** Yes, the initial baseline UT examination schedule for the B-F bolts in MRP-227, Rev. 1 assumes an examination of B-F bolts has been completed within two refueling outages from the beginning of the period of extended operation for each operating B&W unit.



MRP-227-Rev. 1 Figure 4-2

Discussion of RAIs

- **RAI 6**
  - **RAI Summary:** Is Note 8 in Table 4-1 regarding locking devices and locking device welds for core barrel bolting correct? Is the Expansion link correct?
  - **Industry Response:** Both are correct. None of the locking device welds have irradiation-assisted stress corrosion cracking (IASCC) as an applicable aging degradation mechanism, but all bolt locking devices and locking device welds are linked by irradiation embrittlement (IE).
  - For clarification, the Table 4-1 entry for the effect (mechanism) for these items will be revised (see next slide, updated text is bold-underlined)

Discussion of RAIs

- **RAI 6 (continued)**

Table 4-1 Primary Item	Effect (Mechanism)
B11.Core Barrel Assembly **Locking devices, including locking welds, of baffle-to-former bolts and internal baffle-to-baffle bolts**	**Locking Devices: Cracking (IASCC, IE) including the detection of missing, non-functional, or removed locking devices (Note 3)** **Locking Welds: Cracking (IE) including the detection of missing, non-functional, or removed locking device welds (Note 3, 8)**

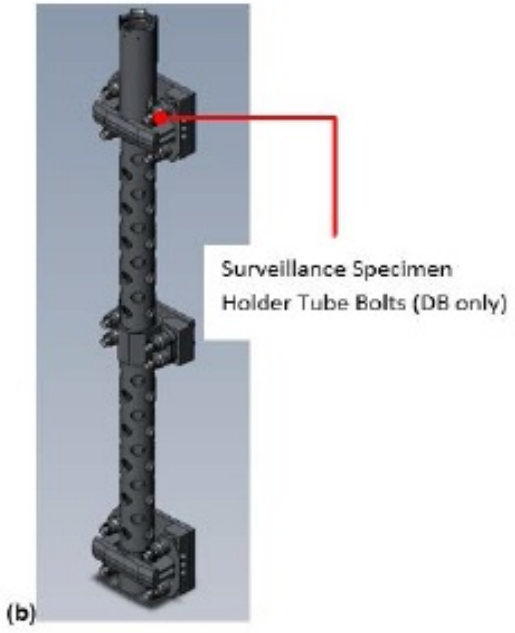
Notes:

3. Loss of ductility and fracture toughness, which are induced by thermal aging or neutron irradiation embrittlement, are not directly monitored. These effects are indirectly managed by performing periodic visual examinations capable of detecting cracking in the component.

8. The aging degradation mechanism of IASCC is only applicable to the baffle-to-former bolt and internal baffle-to-baffle bolt locking devices, not the baffle-to-former bolt and internal baffle-to-baffle bolt locking device welds. There are no Expansion component items for the baffle-to-former bolt and internal baffle-to-baffle bolt locking device welds for IASCC.

Discussion of RAIs

- **RAI 11**
  - **RAI Summary:** Why do the SSHT bolts have IC/ISR/Fatigue/Wear applicable in MRP-227-Rev. 1? Were the compression collars left out of the screening and FMECA process as an oversight and are they the same as the locking cups and tie plate in MRP-227-A?
  - **Industry Response:** After determining more accurate fluence values for the SSHT bolts, the fluence was determined to exceed the screening criteria for IC/ISR. When IC/ISR is screened in, so are fatigue and wear.
  - A plant-specific records search was performed in 2010 for DB and determined the details of the SSHT bolt and locking mechanism for DB, and the use of a compression collar was discovered at that time.
  - This component was unknown during the development of MRP-227-A. The locking cups and tie plates are in addition to the compression collar.
  - This component only exists at DB.



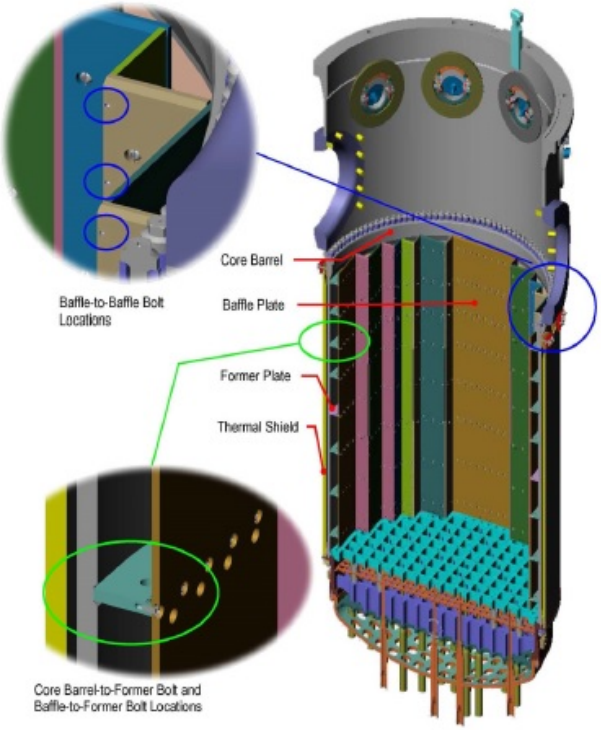
MRP-227-Rev. 1 Figure 4-8(b)

Discussion of RAIs

- **RAI 13**
  - **RAI Summary:** Has OE been used to modify or clarify examination coverage requirements? Identify the components and justify the change (or no change). Has OE resulted in any Primary items being reclassified as inaccessible due to actual coverage during examinations? If so, identify the component and what alternate means were taken to provide reasonable assurance of component functionality and address if the Expansion links were reevaluated and if alternate Primary items were selected.
  - **Industry Response (for B&W Units):** OE has not yet been used to modify or clarify examination coverage achieved during the examinations completed to date for the B&W-designed units.
  - Coverage has not yet been revised based on OE because, except for one instance, the expected coverage (including allowances for minimum populations of bolts and locking devices) has been able to be achieved during each examination to date.
  - At one US plant, about 99% coverage was achieved during the control rod guide tube (CRGT) spacer casting VT-3 examination; 10 spacer castings at each of the 4 screw locations were inaccessible for VT-3 examination due to permanent obstruction from the reactor vessel level monitoring system (RVLMS) installed at one CRGT location.
  - As a result, the coverage in MRP-227, Revision 1 for this Table 4-1 entry should be modified as follows:
    "*Accessible surfaces at each of the 4 screw locations (at every 90°) of ~~100% of~~ the accessible CRGT spacer castings. ~~(limited accessibility)~~*"

Discussion of RAIs

- **RAI 17**
  - **RAI Summary:** The primary link for the core barrel bolting locking devices/welds changed from "…locking devices, including locking welds, of baffle-to-former bolts or internal baffle-to-baffle bolts…" to "…locking devices, including locking welds, of baffle-to-former bolts and internal baffle-to-baffle bolts…" Does this mean you now need aging degradation in both types of locking devices/welds before Expansion?
  - **Industry Response:** No, word change is editorial in nature only. The Primary link for the B11.1 Expansion items is both types of locking devices.

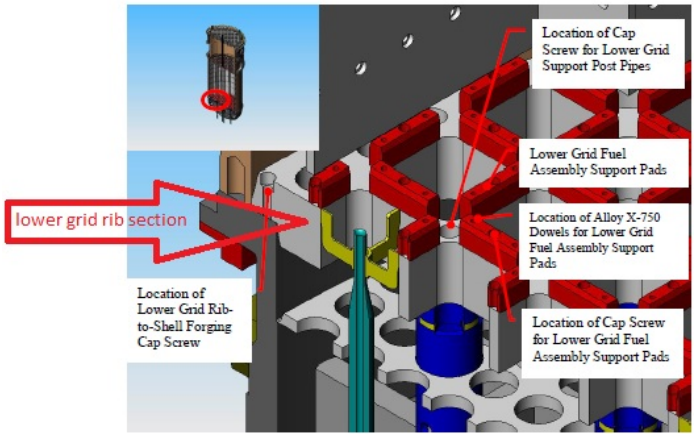


MRP-227-Rev. 1 Figure 4-2

Discussion of RAIs

RAI 18

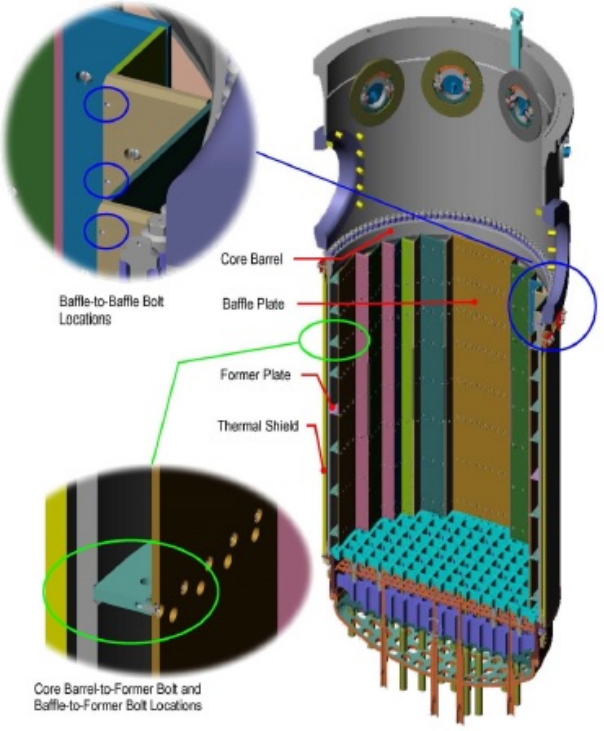
- **RAI Summary:** Explain why the lower grid rib section has been recategorized from “No Additional Measures” to “Expansion.”
- **Industry Response:** The table below shows the changes from MRP-189, Revision 1 to MRP-189, Revision 2. The screening results are the same but the change comes from a reevaluation of the safety consequences and the introduction and use of an IE susceptibility metrics table (Table 4-1 in MRP-189 Rev. 2) in performing the FMECA.



	MRP-189 Screening Result	MRP-189 FMECA Result	MRP-231 Aging Management Strategy Result
Lower Grid Rib Section in MRP-189, Revision 1	Category “Not A” for IE	Category “A” based on susceptibility of B and safety consequence of 1	Category “A” (not considered in MRP-231)
Lower Grid Rib Section in MRP-189, Revision 2	Category “Not A” for IE	Category “C” based on susceptibility of C and safety consequence of 2	Expansion (to Baffle Plates)

Discussion of RAIs

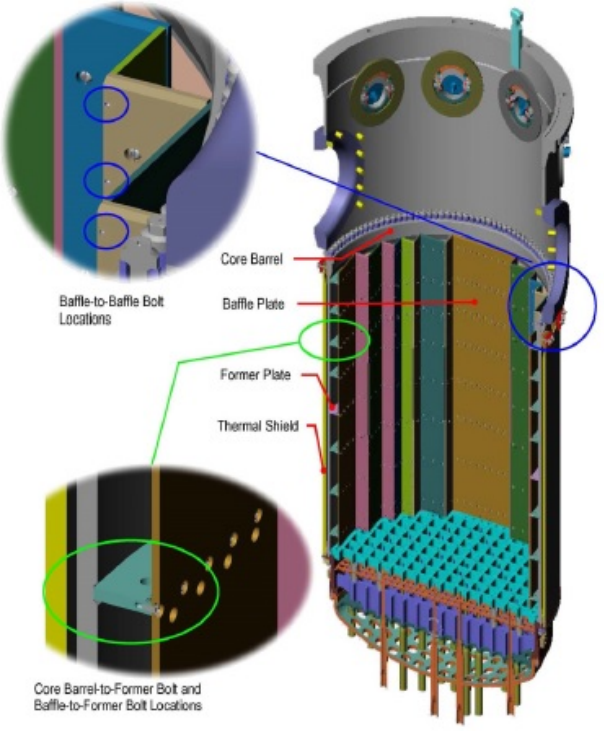
- **RAI 21**
  - **RAI Summary:** Explain why the language regarding rows 3, 4, and 5 and 25% of the bolts on a single plate was removed from the Expansion criteria of the baffle-to-former bolts.
  - **Industry Response:** The Expansion criteria were updated to include only considerations for determining that an active aging degradation mechanism in the baffle-to-former bolts is underway. Aging degradation drives the Expansion inspections.
  - Note that clustering of failures of baffle-to-former bolts is not expected in the Babcock & Wilcox-designed units, per Customer Service Bulletin 16-02 (July 2016), which are all original upflow configuration.
  - This also supported by operating experience to date in the Babcock & Wilcox-designed units.



MRP-227-Rev. 1 Figure 4-2

Discussion of RAIs

- **RAI 22**
  - **RAI Summary:** Provide technical justifications for the change in relevant condition and Expansion criteria text for the baffle plates. Clarify whether Expansion is only required if cracking links two or more openings or whether Expansion would be required if cracking is present within one inch of any opening.
  - **Industry Response:** Due to the nature of irradiation embrittlement, this examination acceptance criteria is appropriate.
  - Units have examined the baffle plates and thus far no relevant conditions have been identified
  - The Expansion criteria entry currently listed in Table 5-1 of MRP-227-Rev. 1 for the baffle plates will be updated to be consistent with the relevant condition, as noted on the next page (updated text is bold-underlined).



MRP-227-Rev. 1 Figure 4-2

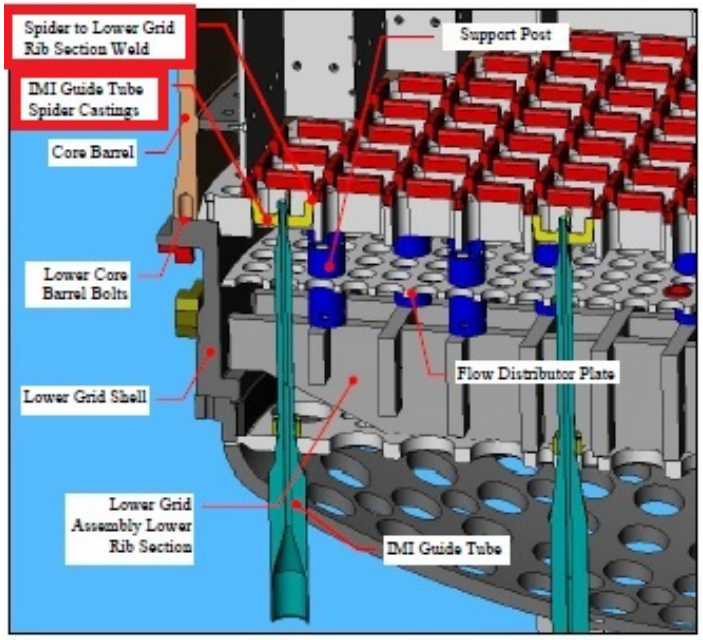
Discussion of RAIs

- **RAI 22 (continued)**

Primary Item	Applicability	Primary Item Examination Acceptance Criteria	Expansion Link(s)	Expansion Criteria	Expansion Item Examination Acceptance Criteria
Core Barrel Assembly **Baffle Plates**	All plants	Visual (VT-3) examination The specific relevant condition is readily detectable cracking connecting openings in the baffle plates (i.e., bolt hole **or** flow hole).	Former plates Core barrel cylinder (including vertical and circumferential seam welds) Lower grid rib section	**Confirmed evidence of readily detectable cracking connecting one or more openings in the baffle plates (i.e., emanating from a bolt hole or a flow hole) shall require**: a) An evaluation of the former plates and the core barrel cylinder for the purpose of determining continued operation or repair/replacement by the completion of the next refueling outage. Alternatively, repair/replacement activities may be initiated based on results of a best effort former plate and core barrel cylinder examination. b) That the VT-3 examination be expanded by the completion of the next refueling outage to include 100% of the lower grid rib section heat-affected zones adjacent to the IMI guide tube spider-to-lower grid rib section welds.	N/A

Discussion of RAIs

- **RAI 25**
  - **RAI Summary:** Explain why the examination coverage for the IMI guide tube spiders changed from “100% of top surfaces of 52 spider castings and welds to the adjacent lower grid rib section” to “Spiders: 100% of the accessible top surfaces and 100% of the accessible spider surfaces adjacent to the spider casting welds” and “Spider welds: 100% of the accessible welds to the adjacent lower grid rib section.”
  - **Industry Response:** This is a clarification of the examination coverage by separating the spiders from the welds and does not change the actual inspection coverage.



MRP-227-Rev. 1 Figure 4-3

Discussion of RAIs

- **RAI 27**
  - Will be addressed during the following presentation by Westinghouse.

Together…Shaping the Future of Electricity

Overview of Planned Responses to MRP-227, Revision 1 Requests for Additional Information

Kyle Amberge
PM, EPRI MRP

Glenn Gardner
Dominion

Joshua McKinley
Westinghouse

Rockville, MD
September 6, 2017

RAI 5 – Core Barrel Weld Coverage (Part 1)

1. Provide a technical justification for the reduction in the required examination coverage from 100 percent (minimum 75%) to 25 percent, for the component items listed in Table 1. If the technical justification relies in whole or part upon a statistical analysis, provide the detailed statistical analysis. The technical justification for the reduction in examination coverage should provide reasonable assurance that (1) the functionality of the core barrel will be maintained and (2) the structural integrity of the core barrel will be maintained to ensure safe shutdown of the reactor during the period of extended operation (PEO).

- MRP-227, Rev. 1 is based on a lead component and sampling approach to managing aging-related degradation in RVI
  - Section 3.3.1 of MRP-227 states that a sample strategy is specified for components where little or no degradation has been found
  - No indications have been detected in the multiple MRP-227 inspections conducted to date on core barrel welds
    - Multiple plants and multiple core barrel welds

RAI 5 – Core Barrel Weld Coverage (Part 1)

- Section 4.3 of MRP-227, Revision 1 outlined a statistical argument for reduced inspection coverage
- More details is provided in formal response to RAI 5
- Statistical evaluation based on:
  - Length of acceptable crack
  - Minimum size of detectable crack
  - Number cracks present
  - Expected distribution or location of cracking
  - Inspection coverage on any given core barrel weld
  - Number of welds inspected
  - Effect of past inspection operating experience

RAI 5 – Core Barrel Weld Coverage (Part 1) – Assumptions and Inputs

- Length of acceptable crack – sensitivity study
- Min.size of detectable crack – assumed crack size of 0.25 in.
  - Conservative size – not a structurally significant crack size for functionality
- Number cracks present – sensitivity study 1 to 8
- Expected distribution or location of cracking – random
- All plant-designs are one population – “a weld is a weld”
- Inspection coverage on any given core barrel weld – 25%
- Number of welds inspected – sensitivity study 1 to 20
- Effect of past inspection operating experience – no flaws detected to date

RAI 5 – Core Barrel Weld Coverage (Part 1) - Methodology

- Inspection results would follow a hypergeometric distribution
  - Fixed number of trials (1 inspection per weld)
  - Two possible outcomes (acceptable or unacceptable)
  - Probability of success is the same in each trial (based on assumed crack size)
  - Likelihood of detection for each additional crack is dependent on previous result (if first crack is not found the second crack is not located on top of first crack)
- Desired result is the probability of detecting **at least one** flaw
  - Equals the complement of the probability of detecting nothing

RAI 5 – Core Barrel Weld Coverage (Part 1) - Findings

Crack Length (in)	0.25					
No. of Inspections	1 crack	2 cracks	3 cracks	4 cracks	5 cracks	8 cracks
1	25.0%	43.8%	57.8%	68.4%	76.3%	90.0%
2	43.8%	68.4%	82.2%	90.0%	94.4%	99.0%
3	57.8%	82.2%	92.5%	96.8%	98.7%	99.9%
4	68.4%	90.0%	96.8%	99.0%	99.7%	100.0%
5	76.3%	94.4%	98.7%	99.7%	99.9%	100.0%
6	82.2%	96.8%	99.4%	99.9%	100.0%	100.0%
7	86.7%	98.2%	99.8%	100.0%	100.0%	100.0%
8	90.0%	99.0%	99.9%	100.0%	100.0%	100.0%
9	92.5%	99.4%	100.0%	100.0%	100.0%	100.0%
10	94.4%	99.7%	100.0%	100.0%	100.0%	100.0%
11	95.8%	99.8%	100.0%	100.0%	100.0%	100.0%
12	96.8%	99.9%	100.0%	100.0%	100.0%	100.0%
13	97.6%	99.9%	100.0%	100.0%	100.0%	100.0%
14	98.2%	100.0%	100.0%	100.0%	100.0%	100.0%
15	98.7%	100.0%	100.0%	100.0%	100.0%	100.0%
16	99.0%	100.0%	100.0%	100.0%	100.0%	100.0%
17	99.2%	100.0%	100.0%	100.0%	100.0%	100.0%
18	99.4%	100.0%	100.0%	100.0%	100.0%	100.0%
19	99.6%	100.0%	100.0%	100.0%	100.0%	100.0%
20	99.7%	100.0%	100.0%	100.0%	100.0%	100.0%

- Increased numbers of 0.25 inch cracks in a given weld results in a significant increase in the likelihood of a 25% inspection detecting at least one crack
- Presence of eight cracks in a single weld results in at least 90% probability of detecting at least one crack
- Higher numbers of inspected welds have a similar impact on the likelihood of detection

RAI 5 – Core Barrel Weld Coverage (Part 1) – Summary

- Assuming one 0.25 inch flaw in each weld results in the likelihood of detecting a crack in the 25% inspection population of 95% from 10 inspections.
- More than 10 MRP-227 inspections have been performed to date on welds subject to SCC
- At least 10 inspections have been performed on welds subject to IASCC
- >75% cumulative coverage achieved at each plant
- OE to date supports the recommendation to reduce to 25% sampling strategy

RAI 5 – Core Barrel Weld Coverage (Part 2)

2. Clarify whether the justification for reduction in the required examination coverage relies on the assumption that licensees will perform a plant-specific determination of the most likely portion of the weld to experience cracking.
   - The justification provided in response to Part 1 of the question was based on a random distribution of SCC or IASCC cracking in each weld. Likelihood of SCC or IASCC at any given location will vary based on material, environment or stress conditions
   - Response addresses parameters that affect these three controlling factors for SCC and IASCC

RAI 5 – Core Barrel Weld Coverage (Part 2) - Material

- Quality assurance during fabrication expected to have reduced or eliminated possibility of many material issues
  - Quality requirements similar weld-to-weld and plant-to-plant
  - Base and weld metal composition and quality were controlled by the construction requirements
  - Non-destructive evaluation during construction would have detected weld defects (e.g. radiographic testing)
- Localized variation:
  - Thick, multi-pass welds
  - Weld stops and starts and repairs may exist
    - Expected to be randomly distributed, consistent with part 1

RAI 5 – Core Barrel Weld Coverage (Part 2) - Environment

- Water chemistry:
  - PWR chemistry is significantly better than BWR chemistry
    - Plants governed by EPRI water chemistry program which NRC has endorsed
  - CB welds are in moderate to high flow regions with few crevices
- Neutron irradiation:
  - Beltline girth welds are most highly irradiated at ID
  - Variation around circumference is expected due to core geometry
    - Dose varies with distance to core barrel ID surface

RAI 5 – Core Barrel Weld Coverage (Part 2) - Stress

- Stress expected to be most dependent on:
  - Weld residual stresses
  - Operating stresses due to thermal differential across the barrel
- Weld residual stresses are difficult to quantify
  - Could be affected by stops and starts and repairs
  - Similar on OD and ID, MRP-227 assumed these as conservatively high
- Primary stresses during operation on UFW are low
  - Weld residual stress is a major contributor to drive SCC
- Primary stresses during operation on LGW/MGW are lower than UFW
  - Thermal gradient stress is a major contributor to drive IASCC
- Core beltline weld stresses are higher on the OD due to thermal gradient
  - ID of beltline welds are inaccessible without core barrel disassembly

RAI 5 – Core Barrel Weld Coverage (Part 2) - Stress

- The most highly irradiated accessible portions of the CE MGW and the WEC LGW should be included in the 25% sample of the weld that is inspected
- Effects of variations in weld residual stress in UFW are expected to be randomly distributed

Weld	EVT-1 Inspection
UFW	25% random sample (no change)
LGW/MGW	25% sample of accessible portions including most highly irradiated regions

RAI 5 – Core Barrel Weld Coverage (Part 3)

3. Discuss how it can be assured that the 25 percent sample of each weld examined will be selected based on an evaluation of the most likely accessible portion of the weld to exhibit cracking, since Table 4-2 and 4-3 do not require such an evaluation.
   - Examination Coverage column of Tables 4-2 and 4-3 of MRP-227, Rev. 1 will be updated:
     - Westinghouse LGW, W4: “A minimum of 25% of the OD circumference of the LGW and adjacent base metal shall be examined. This 25% sample must include the accessible portion of the weld OD with the highest accumulated neutron fluence based on proximity to the core.”
     - CE MGW, C6: “A minimum of 25% of the OD circumference of the MGW and adjacent base metal shall be examined. This 25% sample must include the accessible portion of the weld OD with the highest accumulated neutron fluence based on proximity to the core.”
       - Note: neutron panels cover between 40 and 50 percent of the barrel circumference in the core beltline region and thus these regions are inaccessible; inspections under neutron panels would require disassembly.

RAI 5 – Core Barrel Weld Coverage (Part 4)

4. Discuss how the proposed 25 percent sample examination coverage accounts for the possibility of cracking initiating on the opposite side of the weld from the side examined or in a portion of the component that is inaccessible.

- UFW
  - Likelihood of OD or ID crack initiation is similar because the major driver for SCC is weld residual stress
- WEC LGW and CE MGW
  - ID is inaccessible without disassembly of the baffle or core shroud assembly
    - Disassembly of core barrel assembly is counter to ALARA and safety considerations
    - Disassembly is not physically possible
  - Stresses expected to be higher on the OD but dose higher on the ID
    - Unclear which effect is stronger and there is no OE in PWR CB welds
  - Recommended to perform inspection on the OD where the stress is highest, and include most highly irradiated regions of the OD
- Based on the statistical arguments from the response to part 1 and the favorable OE to date it is reasonable to perform the sampling from the OD
- If cracking is detected, the industry would respond with further actions

RAI 5 – Core Barrel Weld Coverage (Part 5)

- For C5., “Core Support barrel Assembly Upper Flange Weld (UFW),” clarify whether 25 percent of *both* sides of the weld are to be examined. If both sides are to be examined, explain the inconsistency with W3. Core Barrel Assembly UFW, for which MRP-227, Rev. 1 only requires one side to be examined.
  - These coverage requirements should be consistent. The examination coverage of C5 in Table 4-2 will be updated to state the following:
    - A minimum of 25% of one side of the circumference of the UFW and adjacent base metal shall be examined.

RAI 7 – Core Barrel Assembly LGW Inspection Coverage

- For all the welds listed in Table 1 except for Item W4., “Core Barrel Assembly – Lower Girth Weld (LGW),” the examination acceptance and expansion criteria in Table 5-2 and Table 5-3 require the inspection coverage to be extended to include 100% of the accessible length of the weld during the same refueling outage, if there is confirmed detection of a surface breaking linear indication in that weld. Should this expansion also be applied to Item W4? If not, provide a technical justification.
  - A confirmed surface breaking indication of the LGW from the initial exam coverage would require an expansion to 100% of the accessible length of the weld during the same outage.
  - Markups to MRP-227, R1 Table 5-3 are provided to reflect this change

RAI 8 – Baffle-Former Bolts

a) Discuss whether revised guidance for BFB needs to be incorporated into MRP-227, Rev. 1. If not, why not?

- NEI-03-08 “Needed” Interim Guidance will be incorporated into MRP-227, R1, including responses to the staff’s questions on the IG.
- IG transmitted in EPRI letter MRP 2017-009 (ML17087A107)

b) If such guidance should be incorporated, provide specifics on the initial examination coverage and schedule, and on how the subsequent examination coverage and timing would be determined.

- Initial examination coverage and schedule for the BFBs are dependent on the plant “tier” as defined by NSAL-16-1.
- Re-examination periods shall be determined by plant-specific evaluation per MRP-227 “Needed” Requirement 7.5, but cannot exceed 10 years.

RAI 8 – Baffle-Former Bolts

c) Considering the recent OE with BFB degradation, justify that a ten-year subsequent examination interval remains appropriate for BFB. This justification should consider the possible effects of clustering.

Re-examination periods shall be determined by plant-specific evaluation per MRP-227 “Needed” Requirement 7.5, but cannot exceed 10 years. MRP 2017-009 groups the plants in categories based on number of indications and clustering and provides a length of time that cannot be exceeded for re-examination.

RAI 8 – Baffle-Former Bolts

d) How will the schedule for subsequent examination be determined if examination results show that greater than 50 percent of the numerical margin of bolts is degraded?

- WCAP-17096-NP-A is still the applicable document
  - WCAP-17096-NP-A guidance will be updated, including a review of the baffle-former bolt acceptance criteria guidance
- Exceeding the allowed margin would require a plant to either perform a plant-specific evaluation or address the issue through another path (e.g., replacements)

RAI 8 – Baffle-Former Bolts

e) Provide a justification that the criteria allowing subsequent examination of BFB may be performed in ten years, provided 50 percent or less of the numerical margin of BFB is degraded, is still appropriate considering the discovery of clustering of degraded BFB, and the discovery of more extensive BFB degradation than expected.

- Limitations have been placed on the 10-year re-examination period by the NEI-03-08 “Needed” Interim Guidance in MRP 2017-009
- Observation of clustered degradation or degradation above specific levels dependent on plant configuration results in limits on the re-examination period
  - Unless justified by plant-specific evaluation performed by station
- PWROG program will update WCAP-17096, including potential updates to the baffle-former bolt acceptance criteria methodology
  - This includes an evaluation of the 50% margin criteria.

RAI 9 – Reduced Coverage for the CE Core Support Columns and Westinghouse Lower Support Column Bodies

a) Justify the required coverage of 25 percent as visible from above the core plate for Item C8 and W4.4 is sufficient to provide reasonable assurance of functionality.

- PWROG-14048 was developed to provide justification that the lower support columns will remain functional through the PEO (Rev. 1 provided for information 3/1/2017 – ML17066A266)
- Performed a FMEA to evaluate likely failure modes and direct failure tolerance analyses
- Failure tolerance analyses evaluated up to a case where 50% of the columns were failed
- Inspection of 25% of the columns as visible from above the core plate is justified based on:
  - Low likelihood of failure: quality controls during fabrication, low susceptibility to TE (CASS), low tensile stresses, no credible mechanism for flaw initiation, complete loss of compressive support unlikely
  - Significant redundancy in design: greater than 50% of the columns can be non-load bearing and core will remain adequately supported

– Technically acceptable to sample the lower support columns for evidence of aging-related degradation

- Disassembly of lower core support assembly is counter to ALARA and safety considerations
- Disassembly is not physically possible

RAI 9 – Reduced Coverage for the CE Core Support Columns and Westinghouse Lower Support Column Bodies

b) Justify the use of VT-3 examination instead of EVT-1 to detect cracking.

- Technical basis outlined in response to part a – based on PWROG-14048 evaluation
- Functionality would be impacted by multiple fully fractured, misaligned, or missing columns
- VT-3 examination through the lower core plate holes is sufficient to detect this level of gross failure

RAI 9 – Reduced Coverage for the CE Core Support Columns and Westinghouse Lower Support Column Bodies

c) Clarify the meaning of “25% of column assemblies as visible using a VT-3 examination from above the lower core plate.” Does this mean that 1) only 25 percent of the total number of columns visible need to be inspected, 2) 25 percent of the total number of columns (visible and not visible) must be examined to claim credit for the examination, or that 3) 25 percent of the total columns should be inspected if this number is visible? Should all columns visible from above the core plate be examined, or just enough to constitute 25 percent of the total population (visible plus not visible).

- Intention of this examination coverage is consistent with option 2 in the question: 25% of the total number of columns (visible and not visible) must be examined to claim credit for the examination, but the examination will be conducted from above the lower core plate and only those parts of the columns that are visible from above the plate with a VT-3 inspection are included in the coverage requirement.
- MRP-227, R1 Table 4-5 (Expansion component table) will be updated to make this clear

RAI 9 – Reduced Coverage for the CE Core Support Columns and Westinghouse Lower Support Column Bodies

d) What expansion of the examination scope to the remaining columns will be conducted if degradation is observed in the 25 percent sample?

- MRP-227, R1 Table 4-5 and Table 5-2 will be updated to specify that the examination coverage expands to 100% of the LSC bodies if degradation is found in the initial inspection population

e) For CE-design RVI, explain why examination of the core support columns is specified only for plants with full-height bolted shroud plates and not for plants with core shrouds assembled in two vertical sections.

- The current applicability in MRP-227, Revision 1 is “Plants with full-height bolted or half-height welded core shroud plates”. The half-height welded shroud plates correspond to those plants with core shrouds assembled in two vertical sections.
- MRP-227, Revision 1 does have a difference in examination coverage between the two designs (25% coverage of the columns for bolted plants and 100% coverage of the accessible weld surfaces for plants with shrouds assembled in two vertical sections)
- However, the conclusions in PWROG-14048 provide sufficient technical justification for the same requirements for both core shroud designs, 25% coverage for both configurations

RAI 9 – Reduced Coverage for the CE Core Support Columns and Westinghouse Lower Support Column Bodies

f) Explain why the core support columns are a Primary component for CE plants but the component in Westinghouse plants with the same function (lower core support columns) is an Expansion component.

- PWROG-14048 now (after publication in February 2017) provides a basis for both components to be Expansion items. MRP-227, Revision 1 was published before this, and the CE core support columns were originally included in MRP-227-A as a Primary component and were left as Primary.
- MRP-227, R1 Table 4-5 and 5-2 will be updated to include the CE LSC as an Expansion component from the CE MGW
  - This will make them consistent with WEC LSC

RAI 10 – Examination Coverage of Deep Beams and Lower Core Support Beams

a) Provide a justification for the reduction in coverage for these two items. The technical justification for the reduction in examination coverage should provide reasonable assurance that (1) the functionality of the components will be maintained and (2) the structural integrity of the components will be maintained to ensure safe shutdown of the reactor during the PEO.

- The 25% of the welds inspected will be the population that is closest to the core where irradiation effects would be the most severe.
  - The current MRP-227, Rev. 1 requirement specifies the top 4 inches of each weld for this reason.
- Table 4-2 of MRP-227, R1 will be updated to reflect these clarifications
- It is reasonable to conclude that structural integrity of the components are maintained if no indications are found during the inspection of the top 4 inches of each weld
- Functionality would be supported by acceptance criteria provided by WCAP-17096-NP if indications were found during the inspection

b) What expansion to the remaining beam-to-beam welds will be conducted if degradation is found in the initial 25 percent inspection sample?

- If degradation is found during the 25% inspection, then the exam would be expanded to include 100% of the accessible beams and welds. Table 4-2 and 5-2 of MRP-227, R1 will be updated to reflect this clarification.
- These beam-to-beam welds are accessible without disassembly

RAI 12 – Remaining Axial Welds and Ribs and Rings Examination Coverage

a) For Item C2.1 and 3.1, does 75 percent of the remaining axial weld length for the remaining axial welds mean a minimum of 75 percent of the total accessible plus inaccessible length of these welds must be examined to claim examination credit?
   - This means that 75% of the un-inspected weld length that is visible on the core side of the shroud must be examined. This is the high fluence side of the weld.

b) Justify the 25 percent sample size for the ribs and rings (Item C3.2).
   - After further technical review, it has been determined that the ribs and rings are not accessible for inspection due to insufficient gap (3/16”) between the core shroud top plate and core support barrel. Table 4-5 of MRP-227, R1 will be updated to reflect this clarification.

c) Clarify whether the ribs and rings are accessible for visual examination.
   - The ribs and rings are not accessible given current inspection capabilities.
     - Disassembly of ribs and rings assembly is counter to ALARA and safety considerations
     - Disassembly is not physically possible
   - Justification based on an evaluation or some other approach would be required. Table 4-5 of MRP-227, R1 will be updated to reflect this clarification, similar to considerations of accessibility for B&W plant components (A/LAI 6).

RAI 13 – Operating Experience

1. In MRP-227, Rev. 1, has OE been used to modify or clarify examination coverage requirements of MRP-227-A based on the actual accessibility achieved during the examinations completed to date? If so, identify the components that have had examination coverage revised based on OE, and describe the reason for the change. If coverage requirements have not been revised based on OE, justify why this has not been done.

- OE and additional information since publication of MRP-227-A were utilized when modifying and clarifying the inspection requirements for the core barrel welds.
  - Typical naming and location of the welds were clarified during preparation for inspections
  - Accessibility of the core barrel girth welds behind the thermal shield and neutron panels drove the need to clarify inspection coverage for the beltline welds
  - Only 50-60% of the weld OD circumference is accessible with neutron panel plants
    - Disassembly of core barrel assembly is counter to ALARA and safety considerations
- No other component requirements have been modified based on OE
- CE ribs and rings from RAI 12 were determined to be inaccessible based on technical review of the gaps available for inspection access and not based on OE

RAI 13 – Operating Experience

2. Has OE with actual coverage achieved resulted in any primary component that was previously considered to be accessible being reclassified as inaccessible, either because of the percentage of the component surface area, length, or population that is accessible was insufficient to provide reasonable assurance of functionality, or because insufficient coverage was achieved of the most likely portion of the component to exhibit degradation? Identify any primary components that have been reclassified as inaccessible and identify what alternate measures, such as an engineering analysis, were taken to provide reasonable assurance of component functionality.
   - OE has not resulted in the reclassification of a component as inaccessible.
3. For primary components reclassified as inaccessible, were the expansion links reevaluated for these components?
   - Not Applicable
4. For any primary components reclassified as inaccessible, were alternate primary components selected?
   - Not Applicable

RAI 14 – Upper Core Plate and the Lower Internals Assembly & Lower Support Forging or Casting Examination

a) Justify the use of VT-3 examination for these components;

- The upper core plate and the lower support forging/casting are thick components with many holes through their thickness resulting in a low likelihood of substantial degradation
  - Holes are expected to act as natural crack arrestors
  - Cracks are not expected to propagate through the entire structure without encountering a hole
- The likelihood of degradation in lower support forging/casting is further reduced by the lack of screened-in degradation mechanisms: thermal embrittlement was screened in for the casting and no mechanisms were identified for the lower support forging
  - Thermal embrittlement in CASS addressed by industry by statistical assessment in PWROG-15032-NP
  - NRC staff performed technical assessment of PWROG-15032-NP in ML16250A001
- Due to the geometry of these components, loss of functionality would require full section cracking of a ligament, bent ligaments, or missing pieces of the plate
- VT-3 examination is sufficient to detect this type of gross degradation that could possibly lead to loss in functionality

RAI 14 – Upper Core Plate and the Lower Internals Assembly & Lower Support Forging or Casting Examination

b) Justify the reduction in examination coverage from 100 percent to 25 percent. The technical justification for the reduction in examination coverage should provide reasonable assurance that (1) the functionality of the components will be maintained and (2) the structural integrity of the components will be maintained to ensure safe shutdown of the reactor during the PEO.

- WCAP-17096-NP-A concludes that a network of connected cracks would be required for sufficient degradation of the upper core plate such that functionality would be affected
  - This gross type of failure would expect to be detected by a 25% examination of the surface of the plate using a VT-3 inspection technique.
  - Similar justification would apply to the lower support forging/casting
- Further, the reduced requirement for the lower support forging/casting also considers the core barrel lower flange weld (LFW)
  - The forging/casting is attached to the core barrel through the LFW
  - LFW is already an expansion from the same Primary item (UFW) as the forging/casting
  - LFW is the most likely location on the lower support for degradation to initiate (weld, geometry, stress)
  - Since the most likely location for degradation (LFW) is being inspected an argument could even be made that the lower support forging/casting could be removed completely from MRP-227—at a minimum reducing the coverage requirement to 25% is reasonable
    - Condition #1 in SER of MRP-227-A imposed inspection of lower support forging/casting

RAI 14 – Upper Core Plate and the Lower Internals Assembly & Lower Support Forging or Casting Examination

c) Is it intended that if the examination of the 25 percent sample of these items reveals indications, the examination coverage will be expanded to include the remaining accessible surfaces of these components? If not, why not?

- If surface-breaking indications are discovered in the initial inspection population, then the examination would be expanded to include 100% of surface (as defined in MRP-227, R1) of the plate inspected. Table 4-6 and 5-3 will be updated to make these clarifications.

RAI 15 – Guide Tube Support Pins (Split Pins)

a) Clarify if type 316 stainless steel split pins require a plant-specific aging management program, or whether they are a “no additional measures component.” Modify the wording of section 4.4 of MRP-227, Rev. 1 as necessary.

- Type 316 SS split pins were ranked as Category A in MRP-191 as compared to Category C for X-750 split pins.
- Also, degradation of split pins is an asset management concern, not a safety issue.
- Thus, they were assigned to the “no additional measures” category.
- Section 4.4 and 4.5 of MRP-227, R1 will be revised to clarify that split pins are a “no additional measures” component

RAI 15 – Guide Tube Support Pins (Split Pins)

b) Discuss whether it would be appropriate to include a requirement in MRP-227, Rev. 1 that the specific aging management program for split pins be documented in the plant-specific RVI program, including the replacement and/or inspection schedule, replacement material, examination method and coverage, technical basis for the replacement schedule or the remaining life of the split pins (if already replaced), and technical basis for the inspection schedule or lack of inspections.

- For Type 316 SS split pins, the categorization as “no additional measures” would not require the inclusion of such a requirement in MRP-227, Revision 1.
- For the remaining plants with an X750 split pin, Section 4.5 of MRP-227, R1 is updated to state that the X750 split pins should be included in the plant-specific RVI program for the PEO or until replacement is performed.
- Small number of affected plants do have plans in-place to address these.

RAI 16 – Components Subject to Fatigue Screening

a) Define and justify the criteria that are to be used for screening for fatigue. Is a specific cumulative usage factor (CUF) value used as a screening criterion? Are environmental effects to be considered? If so, how are environmental effects to be included in the evaluation? EPRI should also discuss whether such a criterion should be added to Table 4-2.

- The fatigue screening criterion that is provided in MRP-175, Revision 0 and was used in the development of MRP-227-A will be applied. MRP-175, Revision 0 provides a screening CUF of 0.1 at 40 years, which was intended to address potential environmental effects.

RAI 16 – Components Subject to Fatigue Screening

b) Justify how fatigue screening accounts for possible SCC contributions for Item C.7? Is additional evaluation or inspection of the CSBFW needed to address possible SCC?

- Fatigue screening does not account for possible SCC contributions.
- If fatigue screens out for the CSBFW, an evaluation would need to be performed to technically justify not performing an inspection of the CSBFW to check for SCC degradation.
- Table 4-2 of MRP-227, R1 will be updated to make this clarification

RAI 19 – Guide Card Wear

- Discuss how MRP-227, Rev. 1 and/or WCAP-17451-P, Rev. 1 should be modified to address the OE discussed in the 10 CFR Part 21 notification related to guide cards (Ref. 9).
  - MRP-227, Revision 1 currently references WCAP-17451-P, Revision 1 for the guide card Primary inspection requirements.
    - WCAP-17451-P was endorsed by NRC as part of the WCAP-17096-NP SER
  - Similar to MRP-227 guidance, the WCAP-17451-P is a ‘living program’
    - A PWROG program is currently in progress to evaluate the most recent OE and revise WCAP-17451-P, Revision 1.
  - The reference to WCAP-17451-P will be updated in MRP-227, Revision 1 to be “current revision” such that the newest version is referenced as it is issued.
    - This will include any interim guidance issued by industry to address the 10CFR Part 21 notification

RAI 20 – Welded Items – Adjacent Base Metal to be Examined

- Define what extent of the adjacent base metal must be examined (e.g., a certain distance from the weld fusion line or centerline).
  - This question is already addressed in Section 4.2.2 of MRP-227, Revision 1 by the following text:
    - "When adjacent base metal is specified in the inspection coverage requirement, it is intended to include the base metal heat affected zone adjacent to the weld. If not otherwise specified, three quarter inch of base metal coverage may be assumed."

RAI 23 – Core Shroud Assembly (welded) – Assembly Inspection Technique

- Clarify whether VT-1 or VT-3 is the intended technique. If VT-3 is the intended technique, explain why this technique is acceptable to address the amount of physical separation expected if distortion is occurring.
  - This appears to be a typographical error. The inspection method requirement in Table 5-2 should align with the inspection technique specified in Table 4-2, which is VT-1.

RAI 24 – Lower Core Support Beams Inspection Time Frame

- What is the technical basis for changing the time frame for the expansion inspection of the lower core support beams to within the next three refueling cycles?
  - Technical justification:
    - Relative MRP-191 FMECA grouping and categorization
      - Core barrel welds were in FMECA group 2 or 3 and Category B or C
      - Core support beams were in FMECA group 1 and Category A
    - Geometric and location differences between the beams and the core barrel
      - Lower core support beams are redundant items, since there are multiple beams and multiple structural welds on the beams
      - Reduces the likelihood of having enough cracking to lose functionality.
  - Change in timing was also motivated by recognition that this would be a difficult inspection that would require time to develop and qualify tooling

RAI 26 – Reclassification of Welds

a) Justify reclassifying the UGW and LGW from Primary to Expansion.

- Previous naming and degradation mechanism assignment was confusing (e.g., upper and lower core barrel cylinder girth welds were assigned SCC, IASCC, and fatigue when only the MGW was subject to IASCC)
  - After further technical review, it was determined that degradation mechanisms assigned to LGW were incorrect: fatigue was not screened in though it was included in MRP-227 Table 4-2 → LGW only subject to SCC, IASCC and IE.
- More details on the exact locations of the welds clarified what the radiation levels would be (SCC versus IASCC)
- According to the lead component approach only the lead weld needs to be inspected for each degradation mechanism (UFW for SCC and fatigue; MGW for IASCC and fatigue)
- UGW was moved to an Expansion component from the UFW because both welds have similar operating stresses and the UFW has potential of elevated bending stresses due to the proximity to the upper flange

RAI 26 – Reclassification of Welds

b) Justify making the UAW a “secondary expansion” to the UGW and LFW.

- The likelihood and consequence of degradation of the axial welds is less than that of the girth welds.
  - Likelihood: UAW is not as highly stressed as the girth welds and therefore is less susceptible to cracking
  - Consequence: Girth welds are considered a primary core support structure, whereas axial welds are not, therefore the consequence of failure of the axial welds is low.

RAI 26 – Reclassification of Welds

c) Justify reclassifying the LFW from Primary to Expansion. Explain why the LFW classification is not consistent with the analogous CE component, the CSBFW, which is classified as Primary.

- The LFW was moved to an Expansion component due to experiencing lower stresses than the UFW. The UFW would lead the LFW in experiencing SCC degradation.

- While the general location of the WEC LFW and the CE CSBFW is comparable, the welds are different in design.
  - The CSBFW is a smaller weld used to attach a flexure which needs to accommodate thermal expansion.
- The design differences subject the CE CSBFW to fatigue as a degradation mechanism in addition to SCC which drives it to being a Primary component.

RAI 27 – Omitted Information in Section 7.3 of MRP-227

- Justify the basis for omitting these paragraphs from the scope of Section 7.3 of the MRP-227, Revision 1 report.
  - This information was omitted because key parts of the previous text, such as the requirement to provide a technical justification for a deviation from a Needed or Mandatory Requirement or the contents of the NEI 03-08 Implementation Protocol are included by reference to NEI 03-08.
  - The rest was omitted because the details provided were not the only possible approaches to dealing with a justification, and it was not the intention of this section of MRP-227, Revision 1 to be prescriptive about how the technical justifications should be approached.

Together…Shaping the Future of Electricity