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MRP-227 Revision 1

Proposed Revisions to Reactor Internals Inspection and Evaluation Guidelines

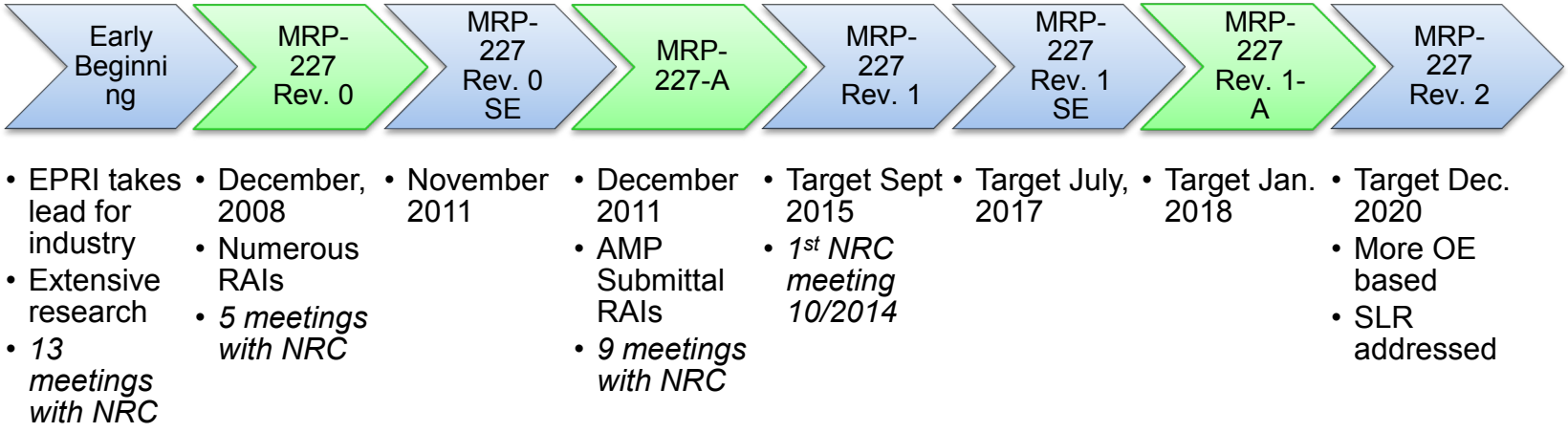
October 27, 2014

Rockville, MD

Opening Remarks

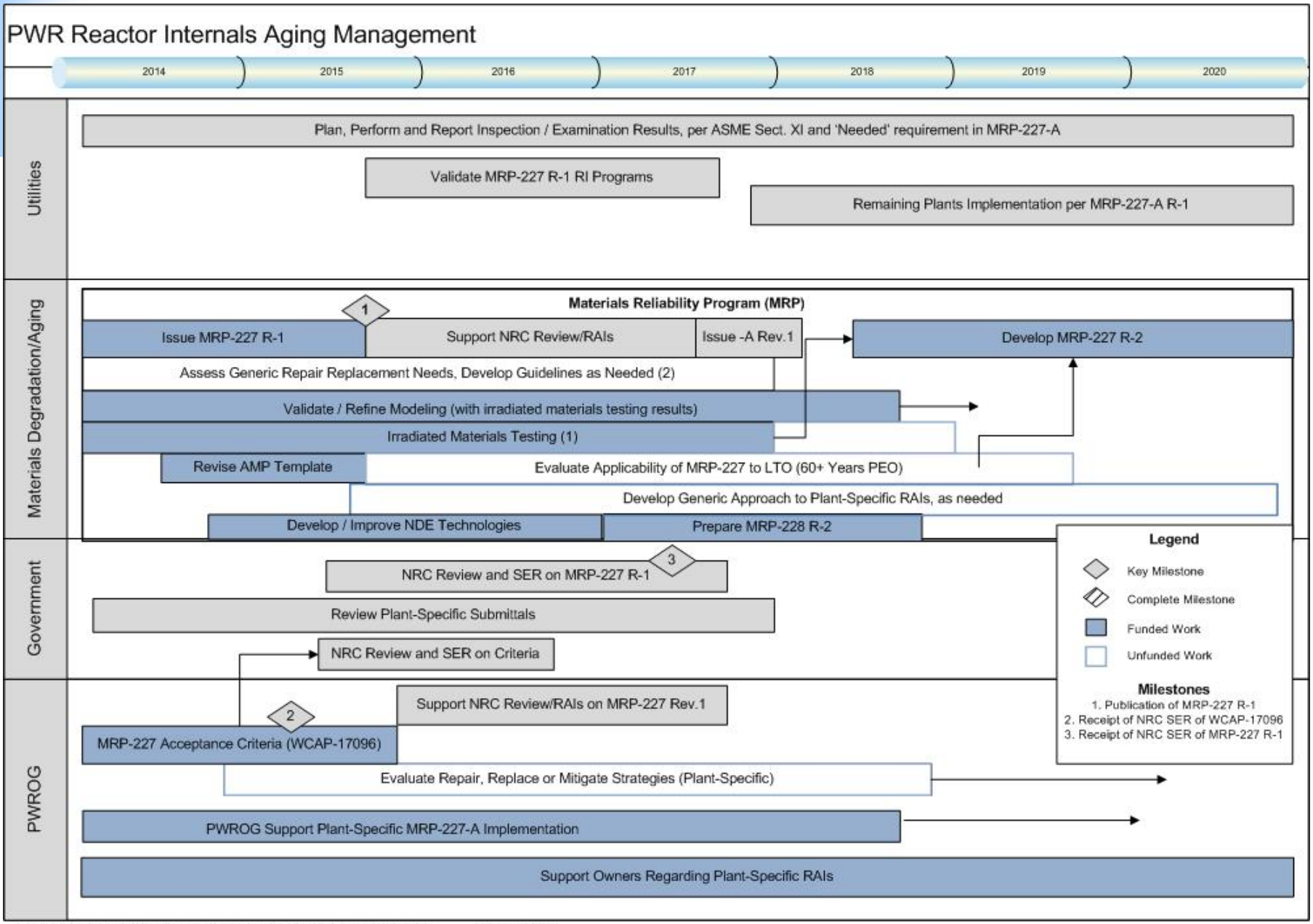
- A short review of reactor internals guidance development
- Objectives and Overview for Rev. 1

Development and Evolution of MRP-227



- Four major stakeholders influenced development under NEI 03-08
  - Owners, NRC, EPRI, NSSS Vendors
- Extensive interaction among stakeholders during development
- Implementation began in 2009 and continues each outage season
- Results to date show no unexpected issues
- ***MRP-227 continues as a living document***

PWR Reactor Internals Aging Management



NUC_MAT_06_R2 PWR Reactor Internals Aging Management.vsd August 2014

(1) See "BWR and PWR Irradiated and Testing Degradation Models" Roadmap for MRP activities
(2) See "Welding of Irradiated Materials for BWR and PWR Internals" Roadmap for MRP activities

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Objectives and Overview

- The revision is incremental – no big changes in approach
- Incorporates lessons learned
- Every technical change has an explicit technical basis
- Operating experience evaluated and addressed
- Applicability Section 2.4 expanded with intent to eliminate some licensee action items; separately, basis for modifying or eliminating other licensee action items will be proposed
- Links between Primary and Expansion have been reviewed and in some cases adjusted
- Coverage requirements for items added in MRP-227-A adjusted consistent with sampling approach and OE
- Visual inspection of certain redundant items changed to VT-3
- Discussion on visual inspections enhanced

Proposed Revisions to
Westinghouse and Combustion Engineering Core Barrel Weld and B&W Primary and Expansion Components Inspection Requirements

Proposed Revisions to MRP-227 for B&W Units

- Updates to incorporate changes relative to MRP-189 Revision 2
  - Improved screening parameter data
  - New items identified from unit-specific record search efforts recently completed
- Updates to incorporate changes relative to MRP-231 Revision 3
  - Engineering assessments on new component items and screened in aging degradation mechanisms
  - Necessary alterations to Primary and Expansion tables
- Updates to various figures for correction and clarification

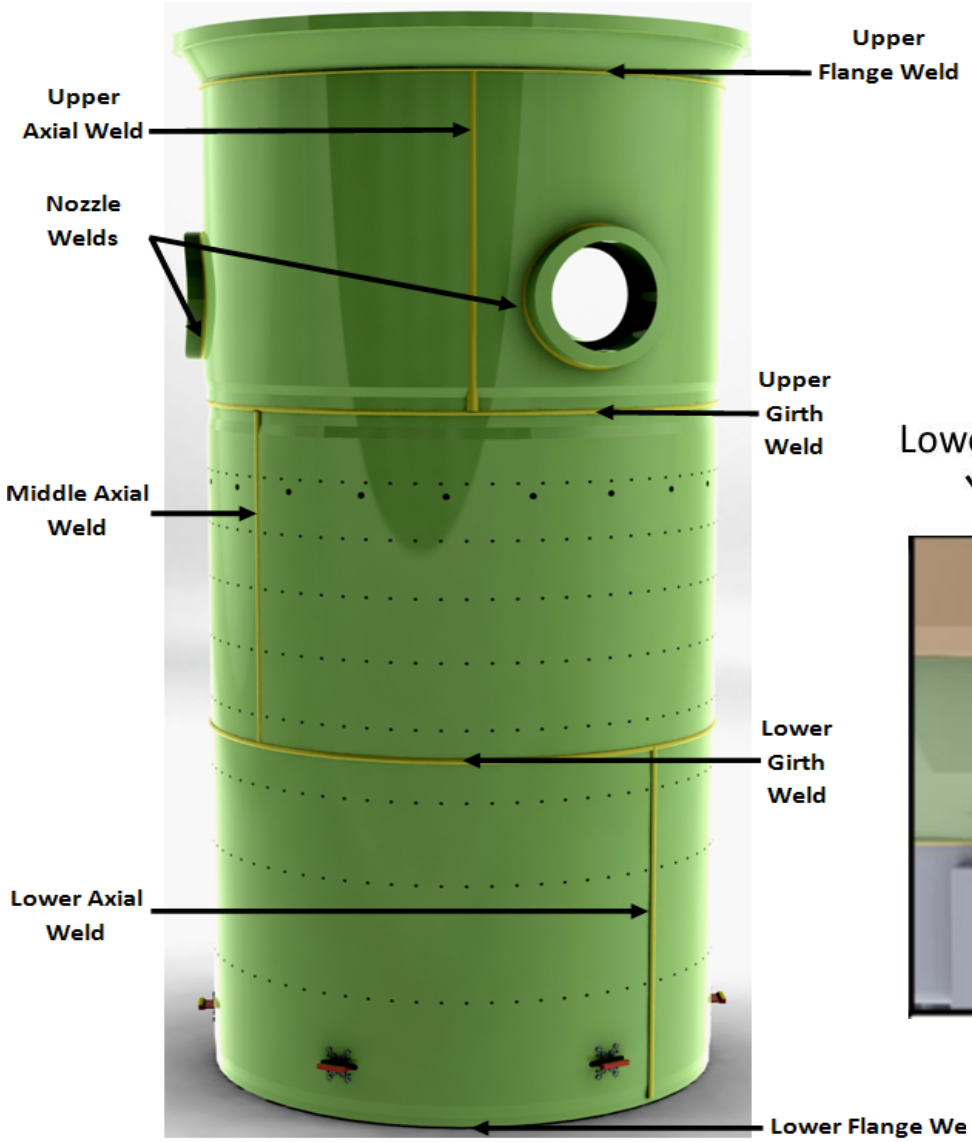
Proposed Revisions to B&W Primary and Expansion Tables in MRP-227-A

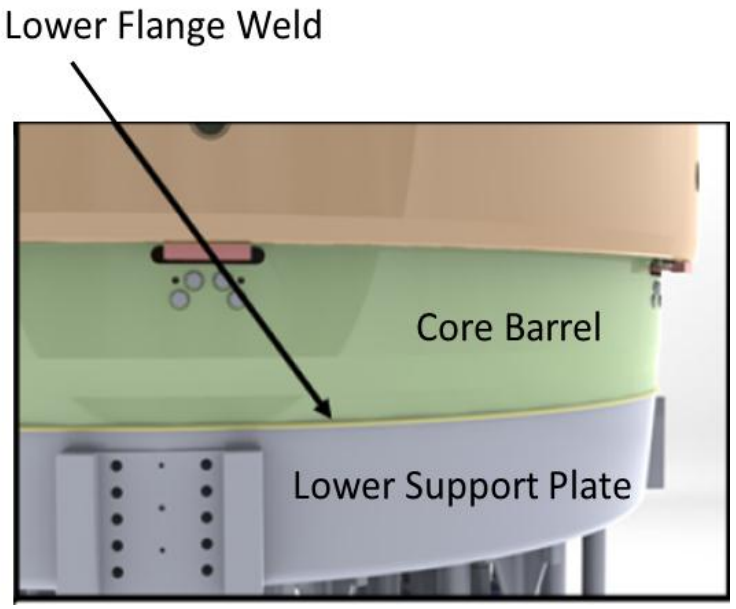
- Clarifications of original wording in table
  - Example 1: one unit does not have Alloy X-750 dowel-to-guide block welds
  - Example 2: one unit with shock pad bolts and locking devices separated into its own row item
- Removed information relative to the retired B&W unit
- New items added
  - Primary items: Vent valve assembly items (original and modified locking device items) [Wear, TE, and SCC]
  - Expansion item: Lower grid assembly lower grid rib section (IE)
  - Expansion item: Vent valve assembly vent valve body (TE)

Westinghouse NSSS Core Barrel Weld Objectives for MRP-227 R1

1. Define standard nomenclature for welds in Westinghouse core barrel.
2. Eliminate inspection requirement for core barrel outlet nozzle welds.
3. Modify SCC linkage for core barrel welds with neutron fluences below IASCC threshold.
   - Propose upper flange weld as “Primary” inspection for SCC
   - Add inspections of other low fluence welds to “Expansion” list
4. Modify IASCC linkage for core barrel welds above the IASCC threshold
   - Propose lower girth weld as “Primary” inspection for IASCC
   - Add inspections of other high fluence welds to “Expansion” list
5. Establish weld specific coverage requirements.

Nomenclature for Westinghouse Core Barrel Welds





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Elimination of Core Barrel Nozzle Welds as Expansion Item

- Nozzle Welds
  - Do not support core
  - Not a full penetration weld
  - Low neutron exposure
  - Flaw tolerant

SCC Linkage

- Sampling Based on Operating Experience
  - How many feet of unirradiated weld need to be inspected to limit SCC safety concern?
  - Diminishing safety gain of over-sampling
  - Any observation of core barrel SCC would trigger further action by both Plant and MRP
- Primary Inspection of Upper Flange Weld
  - Originally proposed in Rev. 0
- Expansion Inspections of
  - Upper Axial Weld
  - Upper Girth Weld
  - Lower Flange weld
  - ~~Nozzle Welds~~

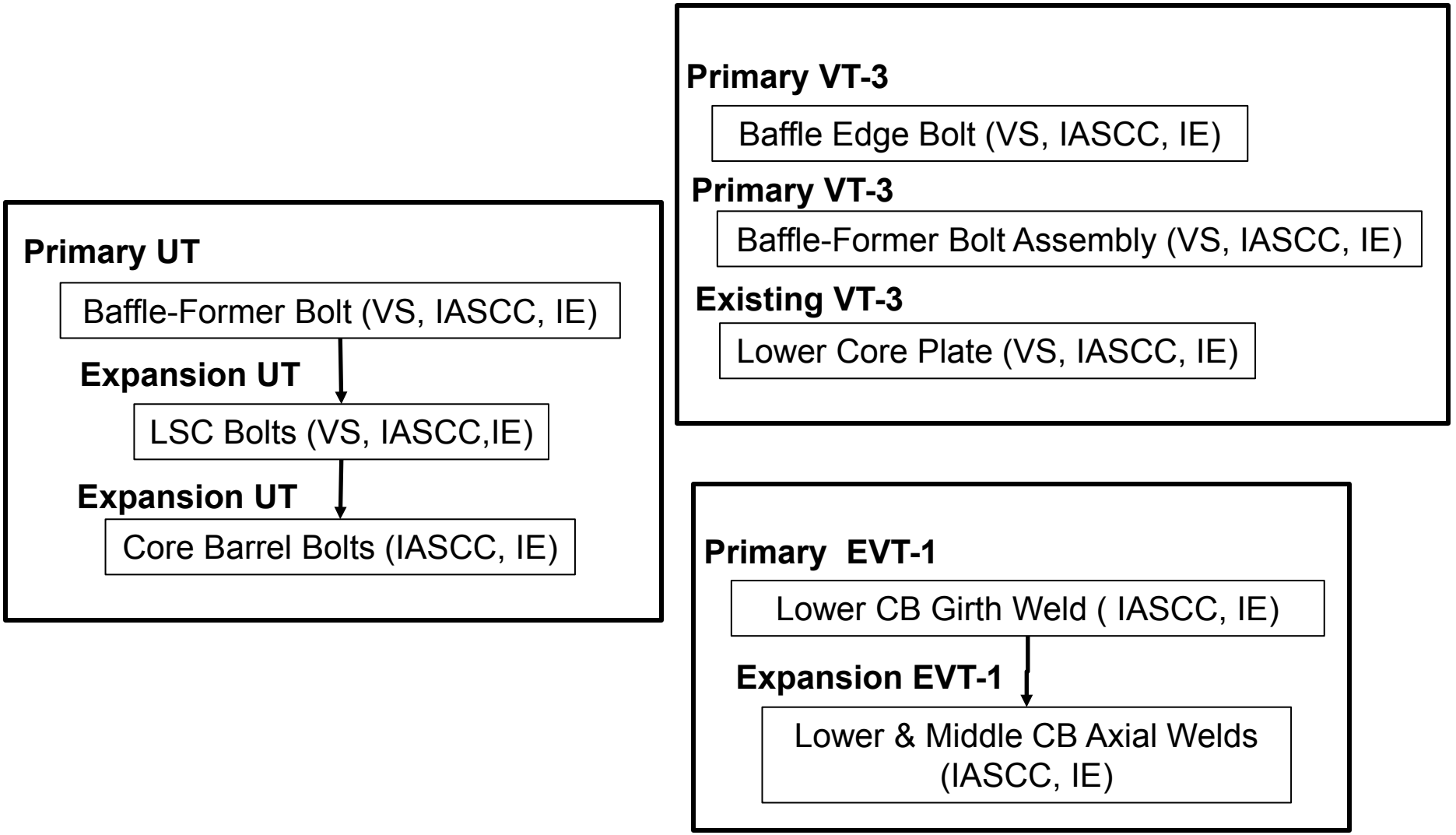
IASCC Linkage

- Monitor all accessible surfaces of irradiated girth weld
  - Accessible portions provide more than adequate sampling
  - Any observation of core barrel IASCC would trigger further action by both Plant and MRP
- Primary Inspection of Lower Girth Weld
  - Added to Rev. 0 by SE (TRC #2)
- Expansion Inspections of
  - Middle Axial Welds
  - Lower Axial Welds
- Welds Included in TRC #2 that are not subject to IASCC
  - Core Barrel Assembly Upper Girth Weld (fluence under review)
  - Control Rod Guide Tube Assembly Lower Flange Weld

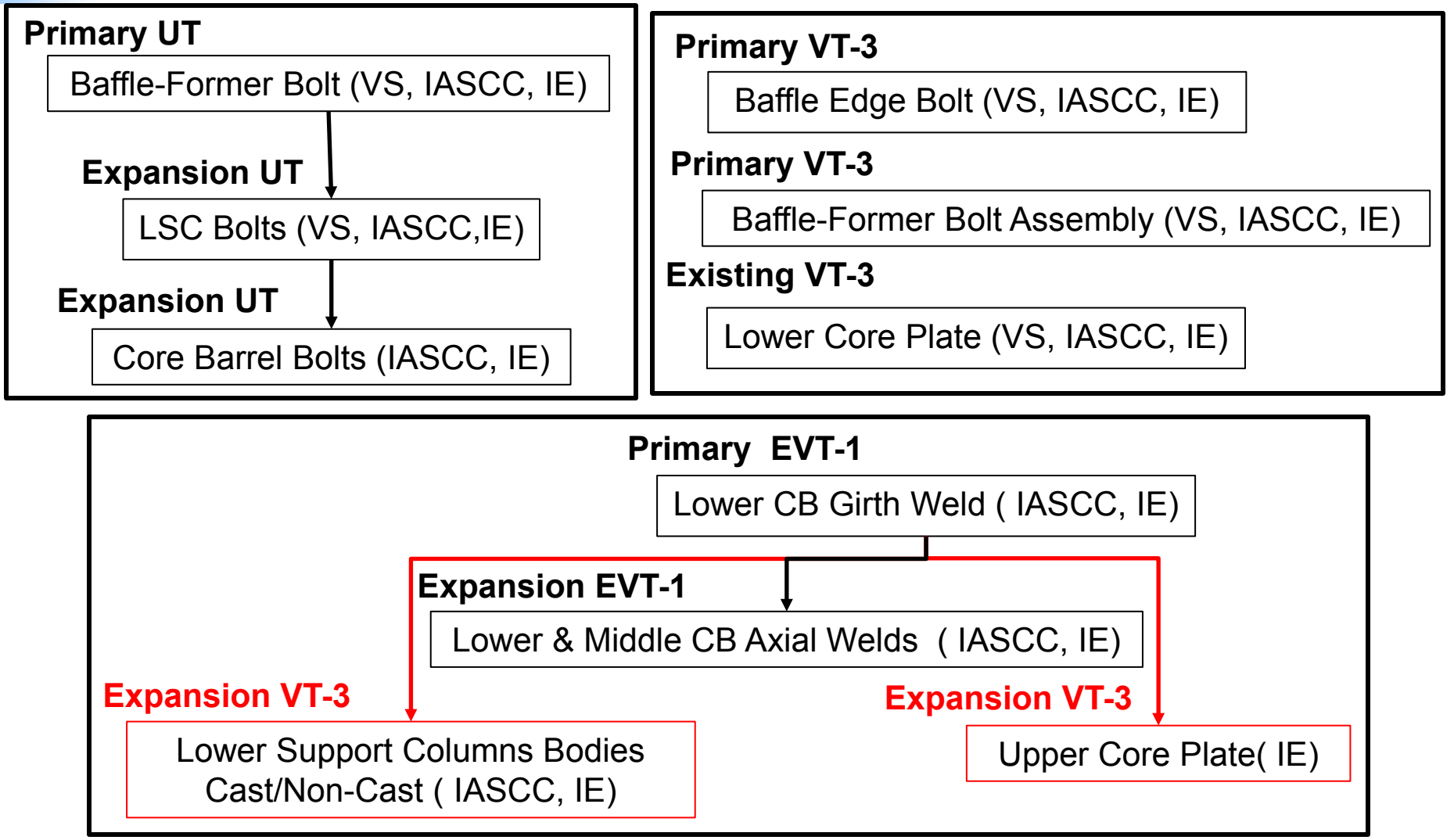
Revised Westinghouse Core Barrel Coverage Requirements

1. Goal is to provide reasonable assurance of no cracking.
2. The UFW, UGW, UAW and NW may be inspected from either the ID or the OD.
3. The LGW, LAW, MAW and LFW must be inspected from the OD.
4. A minimum of 25% of the barrel weld circumference shall be examined.
5. A minimum of 25% of the total axial length shall be examined.

Westinghouse NSSS
Integrated Inspection Strategy for VS, IASCC and IE



Proposed Revision to Westinghouse Integrated Inspection Strategy for VS, IASCC and IE



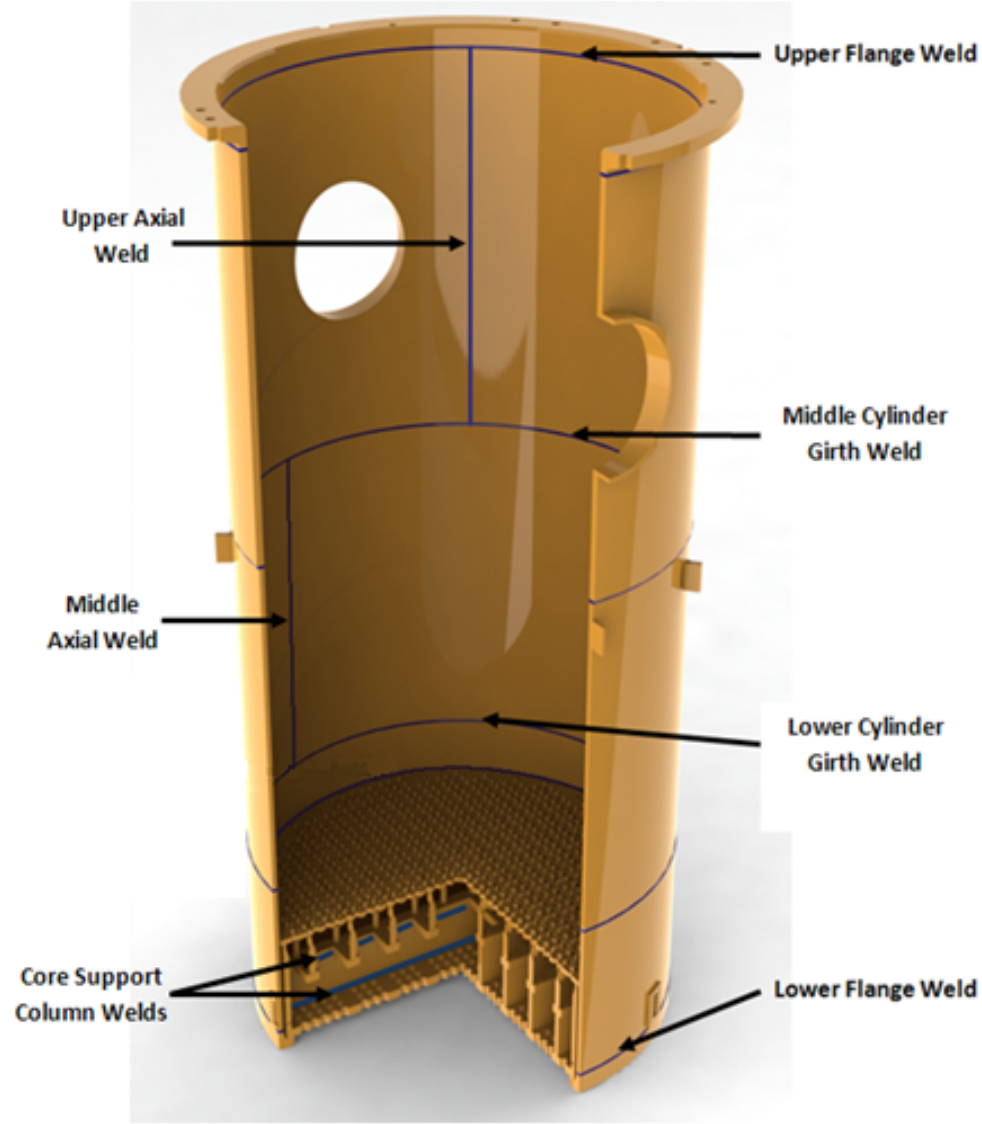
Red: Proposed MRP-227 Rev. 1

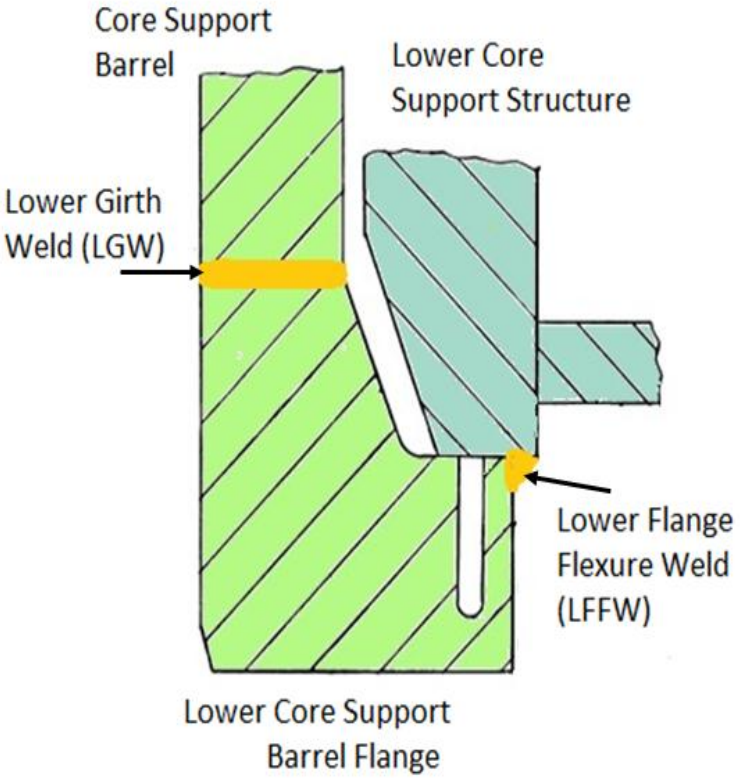
Black: MRP-227-A Rev. 0

Combustion Engineering Core Barrel Weld Objectives for MRP-227 R1

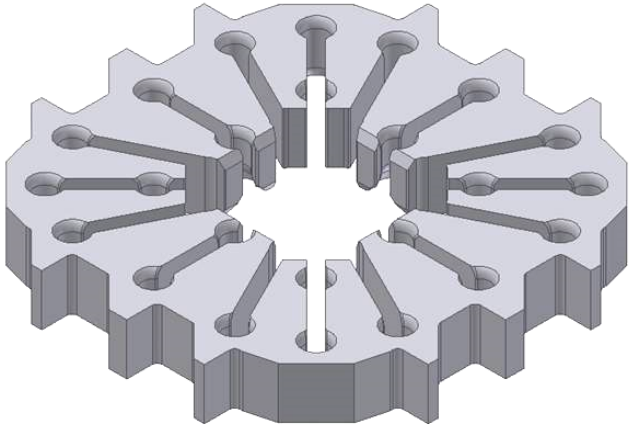
1. Define standard nomenclature for welds in CE core support barrel.
2. Re-establish SCC monitoring program based on inspection of key welds in core support barrel
3. Eliminate Expansion requirement to inspect non-cold worked Type 304 upper flange for SCC.
4. Establish requirements for IASCC monitoring program based on inspection of key locations in core support barrel.
5. Establish weld specific coverage requirements.

Nomenclature for Combustion Engineering Core Barrel Welds





Guide Card Wear OE Implementation in MRP-227 R1



Guide Card Wear
PWROG Program: WCAP-17451-P

Report Contains:

- Evaluation of guide card wear experience.
- Finite element wear models.
- Operational Time-Extension Curves to project wear.
  - CRGT design specific
  - Based on observed wear: “self-benchmarking”
- CRGT card wear acceptance criteria
- Plant-specific (coded) recommended initial inspection time
- Process for determining re-inspection schedule

Guide Card Wear
NEI 03-08 Needed Requirements in WCAP-17451-P

1. Baseline examination per the schedule in the guidance.
2. Scope shall include minimum number of wear measurements to capture outliers.
   - Visual screening of 20% may be adequate if observed wear levels are low.
3. Scope to include bottom six guide cards.
4. Re-inspection requirement based on wear prediction.
5. Wear criteria (Green, Yellow and Red) based on margin to wear-through of ligament.
6. Rodded use of guide tube to be discontinued for wear beyond the Red criteria.

Interim Guidance on Guide Card Wear

- Thus Utilities should modify their CRGT examination plans to adhere to the requirements of WCAP-17451-P Revision 1 or prepare a deviation under the NEI 03-08 protocol.
- The attached table entries comprise the extent of the interim guidance.

Item	Applicability	Effect (Mechanism)	Expansion Link (Note 1)	Examination Method/Frequency (Note 1)	Examination Coverage
Control Rod Guide Tube Assembly Guide plates (cards)	All plants	Loss of Material (Wear)	None	Visual (VT-3) Per the schedule requirements of WCAP-17451-P Section 5 including subsequent examinations (note 7)	Minimum examination of 20% of the number of CGRT assemblies, and as per the requirements of WCAP-17451-P Revision 1 Section 5 (note 7) See Figure 4-20

Notes to Table 4-3:

1. Examination acceptance criteria and expansion criteria for the Westinghouse components are in Table 5-3.
7. *WCAP-17451-P Revision 1 requires a remote visual examination consistent with visual (VT-3) for minimum compliance and examination coverage of a minimum of 20% of the number of CRGT guide card assemblies. The baseline examination schedule has been adjusted for various CRGT designs, the extent of individual CRGT examination modified, and flexible subsequent examination regimens correlating to initial baseline sample size, accuracy of wear estimation and examination results.*

Visual Screening of Guide Plates/Cards

- 20% Minimum inspection coverage is based on screening evaluation, additional inspections required if wear projections exceed limit.
- Screening Evaluation:
  - Visual inspection of 20% sample
  - Estimate wear volume based on visual appearance (comparison to chamfer width)
  - Increase estimated wear volume (x2.2) to allow for uncertainty and outliers
  - Estimate time to reach “Yellow” limit based on operational time extension curves provided in WCAP-17451-P
  - If time limit less than 10 years, adjust inspection schedule or inspect number of guide tubes specified in WCAP-17451-P

Clevis Insert Bolt OE Implementation in MRP-227 R1

Clevis Insert Bolt OE

- During the March 2010 10-year ISI of the reactor vessel lugs at D.C. Cook Unit 1, seven of forty-eight clevis insert bolts showed evidence of failure.
- Clevis insert bolt failures were evidenced by wearing of the lock bars which retain the torque of the clevis insert bolts.
- At one location, the clevis insert dowel pin tack welds were fractured and the dowel pin was rotated and displaced deeper into the clevis insert.
- Westinghouse performed engineering evaluations of the as-found conditions to justify operation without immediate repair.
- Following the repair campaign in Spring 2013, it was confirmed that all 29 bolts removed were either completely separated or were cracked at the head to shank transition.
- Of these 29 only 8 had visual indications of potential failure prior to lock bar and bolt removal.

Clevis Insert Bolts OE Continued

- Preliminary results of metallurgical analysis conducted on failed bolts indicates IGSCC as being the cause of failure.
- All Westinghouse and CE designed plants have clevis inserts (or shims) with Inconel X-750 bolts
- There are three basic designs of clevis inserts installed in Westinghouse plants in the US and one basic design for CE plants.
- To date there have been no other reports of degraded clevis insert bolts.
- Qualitative safety evaluations considering all of the different clevis insert designs concluded no safety or operability concerns (IG-10-1).
- Concern is mainly commercial in nature.
  - Disengagement of the insert when pulling the lower internals
  - Replacement of the inserts would be a significant undertaking

Clevis Insert Bolt Operating Experience Westinghouse Tech Bulletin TB-14-5

- Conclusions:
  - Failure of the bolts would not result in a loss of safety function
  - Significant number of redundancies prevent the loss of the intended safety function
  - Concerns related to bolt failures are generally non-safety in nature

Clevis Insert Bolt Inspections Implementation of OE

- Ensure that clevis insert inspections performed during 10-year ISI exams include following scope:
  - Radial key/clevis insert interfacing surfaces; look for aggressive or abnormal wear as compared to previous inspection, if available. The radial key does not make contact with the full length of the clevis insert; if wear is significant it would be visible as a step located toward the bottom end of the clevis insert as shown in Figure 2.
  - Interface between the clevis insert and vessel lug (see Figure 3); look for signs of looseness or dislocation. Faces of the insert and vessel lug are generally flush; dislocations may be visible by the insert protruding toward the vessel centerline as compared to the vessel lug.

Clevis Insert Inspection Guidelines Westinghouse TB-14-5

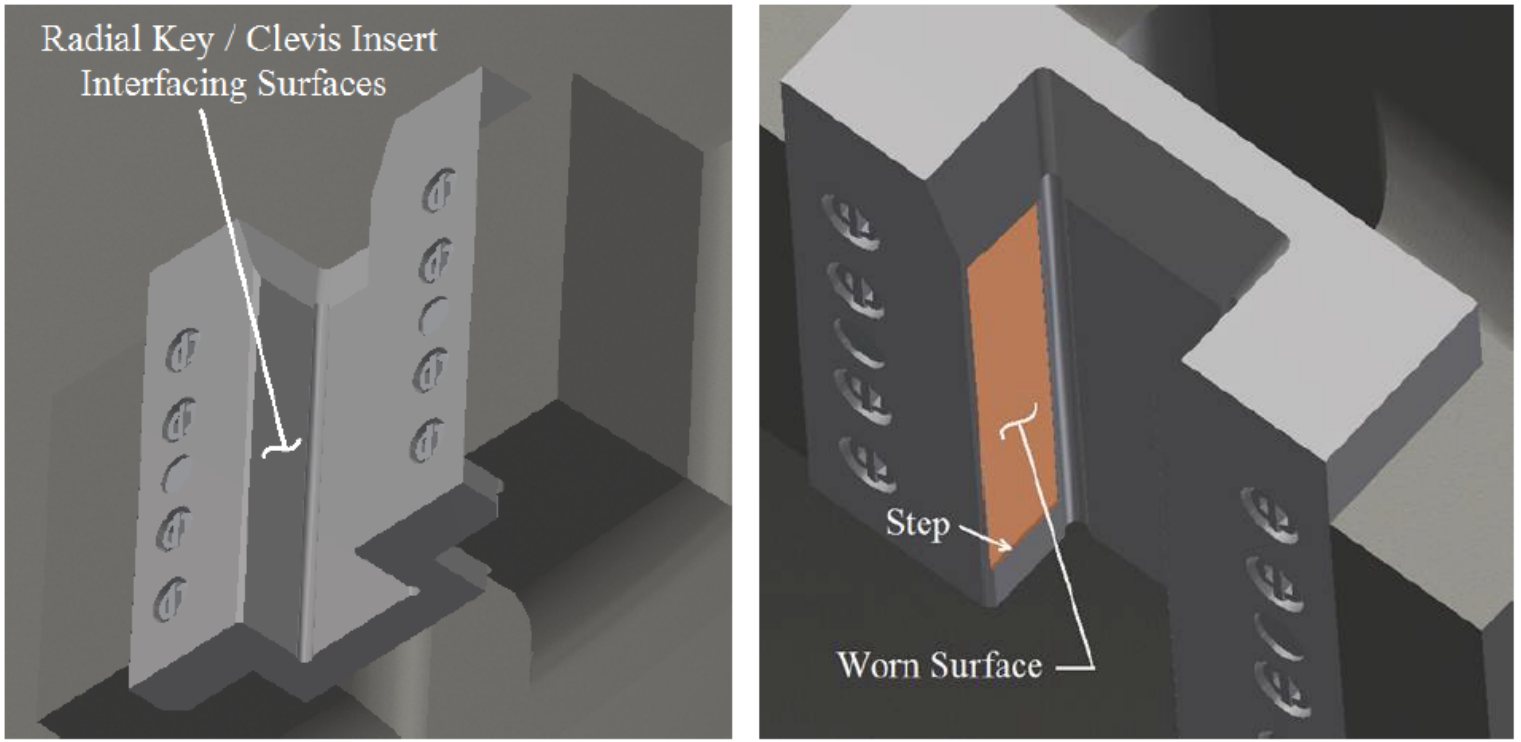


Figure 2 - Example of Wear at the Radial Key/Clevis Insert Interfacing Surface

Clevis Insert Inspection Guidelines Westinghouse TB-14-5

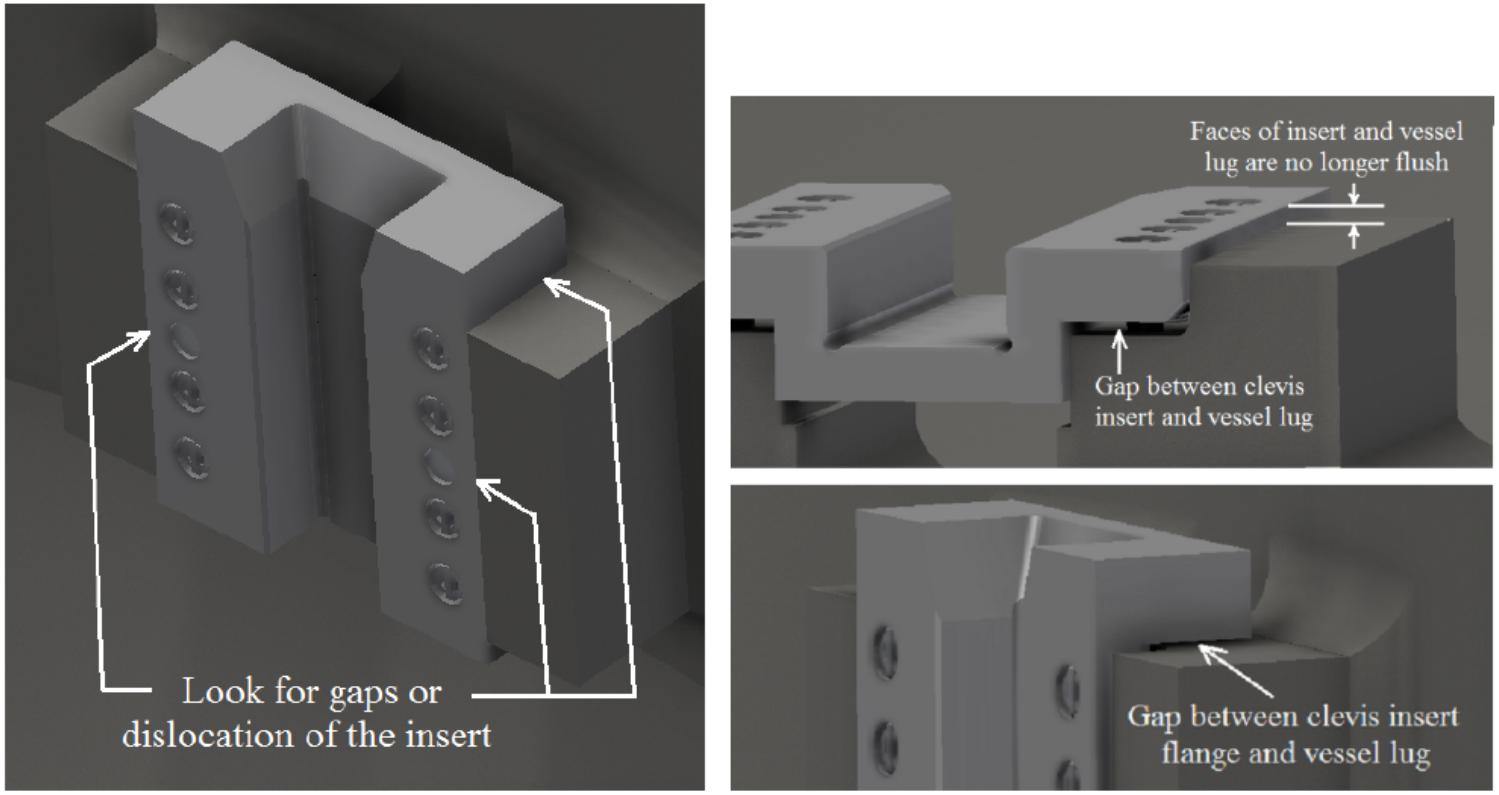


Figure 3 - Example of Dislocation of the Clevis Insert from the Vessel Lug

Identification of Potential Maintenance Risk Associated with Bolt Degradation

Westinghouse TB-14-5

- Look for wear between the bolt head and lock bar and/or bolt head dislocation.
- Look for broken tack welds and dislocation of the dowel pin.

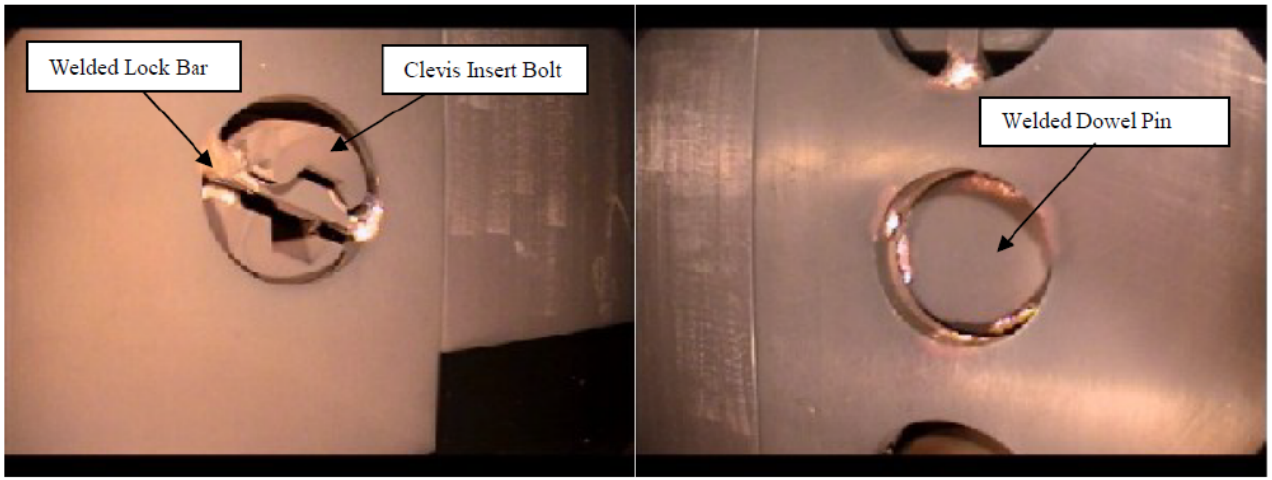


Figure 4 - Examples of Bolt and Dowel Pin Related Degradation

Industry Response

- PWROG Clevis Insert Program
  - Document technical basis supporting safe operation with failed clevis insert bolts for all W & CE NSSS.
  - Develop an RAI response template
  - Advise of potential commercial implications of failed bolts
- MRP-227 Revision 1
  - Add to existing note to reference Westinghouse TB-14-5

Updating of MRP-227 Appendix A

- Reference to GALL AMP XI.M16A
- Operating Experience Summary
- Rev. 1 will contain a substantial update to operating experience based on US domestic and available foreign reporting.
- To be completed in full for Revision 1 publication.

MRP-227-A Topical Report Licensee Action Items

Applicant/Licensee Action Item #1
Generic Applicability (Westinghouse, CE)

- Confirm Baseline Assumptions of MRP-227-A apply.
- Relevant Guidance in MRP-2013-025 to be added to Revision 1.

- Definition of Load-Follow
  - Impact of Flexible Operations

Applicant/Licensee Action Item #2 Components within Scope of License Renewal

- Review plant-specific components/materials
- Process to resolve plant-specific differences with MRP-189 or MRP-191.
- Document comparison review, identify exceptions, document aging management necessary for exceptions.

Applicant/Licensee Action Item #3
Adequacy of Existing Programs

LAI 3 is relevant only to

- CE – Thermal Shield positioning pins, bottom mounted in-core thimble tubes
- W - Guide tube support pins if not replaced by SS
- Document plant-specific measures taken or needed to manage aging of these items, i.e. replacement and/or inspection based on replacement history and replacement component design life.

Applicant/Licensee Action Item #4: B&W Core Support Shield Upper Flange Stress Relief

- Document plant-specific measures taken or needed to manage aging of these items, i.e. replacement and/or inspection based on replacement history and replacement component design life.

Applicant/Licensee Action Item #5: Application of Physical Measurements

- Revision 1 will provide steps necessary for CE and W designs
- Adequate technical basis for when best to determine the criteria will be incorporated within next revision.

Applicant/Licensee Action Item #6: Evaluation of Inaccessible B&W Components

- Document plant-specific measures taken or needed to manage aging of these items, i.e. replacement and/or inspection based on replacement history and replacement component design life

Applicant/Licensee Action Item #7: Plant Specific Evaluation of CASS Materials

- Guidance to be documented in MRP-227 Revision 1
- Pending resolution with NRC by the MRP/BWRVIP CASS Working Group (i.e. BWRVIP-234 SER)
- What are staff's current plans for re-write of A/LAI #7?

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