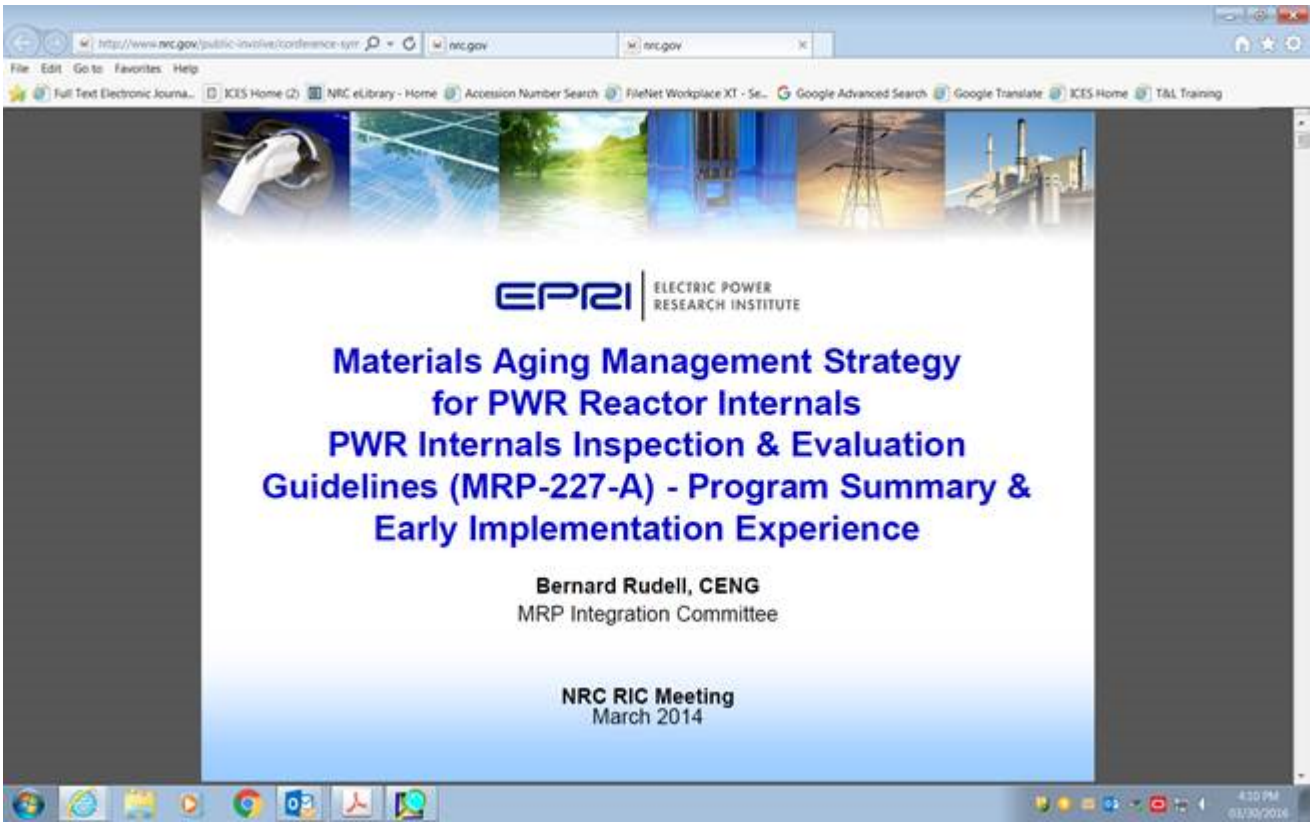
IPRenewal NPEmails

From: King, Mark
Sent: Wednesday, March 30, 2016 4:16 PM
To: Pickett, Douglas; Gray, Mel
Cc: Gray, Harold; Pinson, Brandon; Schussler, Jason
Subject: MRP-227-A - earlier results - a slide presentation on early implementation experience- a March 2014 ERPI presentation to the NRC Emailing: rudellb-t5-hv.pdf / hyperlink - FYI
Attachments: rudellb-t5-hv.pdf

See attached…or linked slide show at: http://www.nrc.gov/public-involve/conference-symposia/ric/past/2014/docs/abstracts/rudellb-t5-hv.pdf



Hearing Identifier: IndianPointUnits2and3NonPublic_EX
Email Number: 5755

Mail Envelope Properties (46de309ec03b44ecb12221af67bfb3ea)

Subject: MRP-227-A - earlier results - a slide presentation on early implementation experience- a March 2014 ERPI presentation to the NRC Emailing: rudellb-t5-hv.pdf / hyperlink - FYI
Sent Date: 3/30/2016 4:16:27 PM
Received Date: 3/30/2016 4:16:31 PM
From: King, Mark

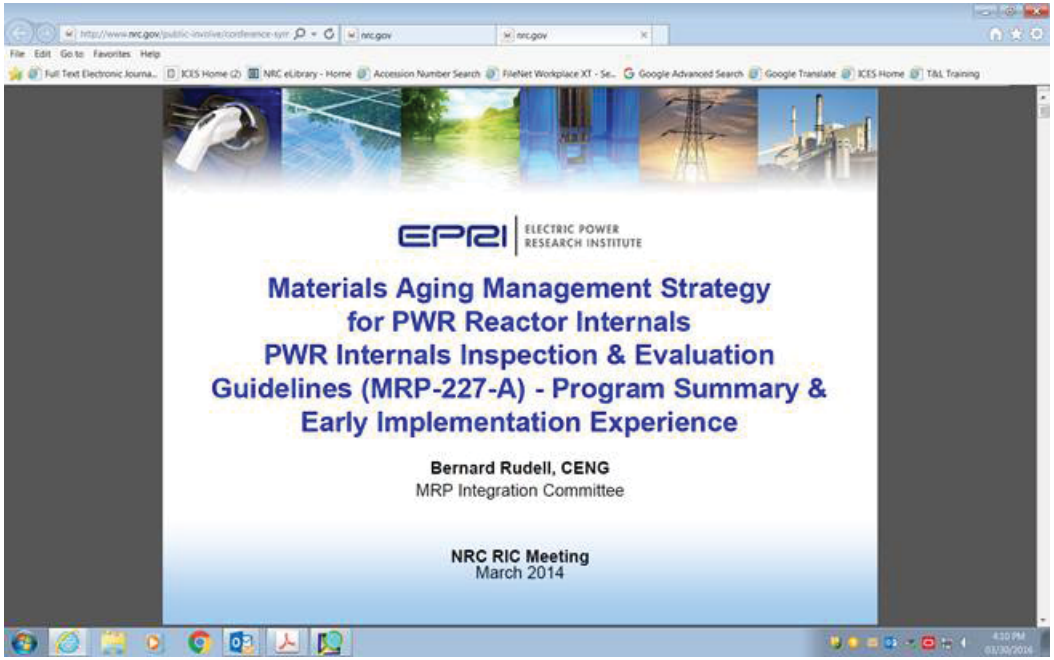
Created By: Mark.King@nrc.gov

Recipients:
"Gray, Harold" <Harold.Gray@nrc.gov>
Tracking Status: None
"Pinson, Brandon" <Brandon.Pinson@nrc.gov>
Tracking Status: None
"Schussler, Jason" <Jason.Schussler@nrc.gov>
Tracking Status: None
"Pickett, Douglas" <Douglas.Pickett@nrc.gov>
Tracking Status: None
"Gray, Mel" <Mel.Gray@nrc.gov>
Tracking Status: None

Post Office: HQPWMSMRS05.nrc.gov

Files	Size	Date & Time
MESSAGE	248	3/30/2016 4:16:31 PM
image003.jpg	37862	
rudellb-t5-hv.pdf	1504516	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:


EPRI
ELECTRIC POWER
RESEARCH INSTITUTE
Materials Aging Management Strategy
for PWR Reactor Internals
PWR Internals Inspection & Evaluation
Guidelines (MRP-227-A) - Program Summary &
Early Implementation Experience
Bernard Rudell, CENG
MRP Integration Committee
NRC RIC Meeting
March 2014

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Materials Aging Management Strategy for PWR Reactor Internals PWR Internals Inspection & Evaluation Guidelines (MRP-227-A) - Program Summary & Early Implementation Experience

Bernard Rudell, CENG
MRP Integration Committee

NRC RIC Meeting
March 2014

Reactor Internals Aging Management Background

- Aging Management, to further augment ISI, of reactor internals was needed for plant life extension (extensive BWR Program already existed)
- EPRI, supported by subject matter experts, developed strategy for managing effects of aging in PWR internals, dependent on a substantial materials database, modeling and evaluation results
  - Categorization of PWR internals, based on specific screening criteria and likelihood and severity of safety and economic consequences.
- Plant designers / PWR OEM (Westinghouse and AREVA) deeply involved and provided much of the technical basis with Regulatory review throughout the development
- Engineering assessment process and acceptance evaluation methodology also developed through PWROG

Industry Commitment and Licensing References

- NEI-03-08, Guideline for the Management of Materials Issues *(Owners adopted in 2003)*
- NUREG 1800, Standard Review Plan for License Renewal Applications
- NUREG 1801, Generic Aging Lessons Learned (GALL) Report
- LR-ISG-2011-04, Updated Aging Management Criteria for RV Internals Components for PWRs *(ensures consistence w/MRP-227-A)* revised version of GALL XI.M16A, PWR Vessel Internals

PWR Reactor Internals Aging Management Tools

- EPRI MRP prepared Inspection and Evaluation (I&E) Guidelines (MRP-227-A)
  - Considered the relative susceptibility of PWR internals to eight postulated materials-related aging mechanisms
  - Contains Mandatory and Needed NEI-03-08 elements for all PWRs
  - Includes NRC Safety Evaluation Review
  - Incorporated into License Renewal and Aging Management Program
    - *LR-ISG-2011-04, Updated Aging Management Criteria for RV Internals Components for PWRs (ML12270A436)*
- EPRI MRP prepared the "Inspection Standard" MRP-228, Rev.1
  - Provides recommendations on how to perform the inspections (an MRP-227-A Needed element)
- Owner's Group prepared Acceptance Criteria Methodology Document (WCAP-17096-NP)
  - Provides methodologies, when evaluations are needed, to address inspection results (CAP entry and disposition is a MRP-227-A Needed element)
  - NRC review of WCAP-17096-NP Revision 2 is in-process

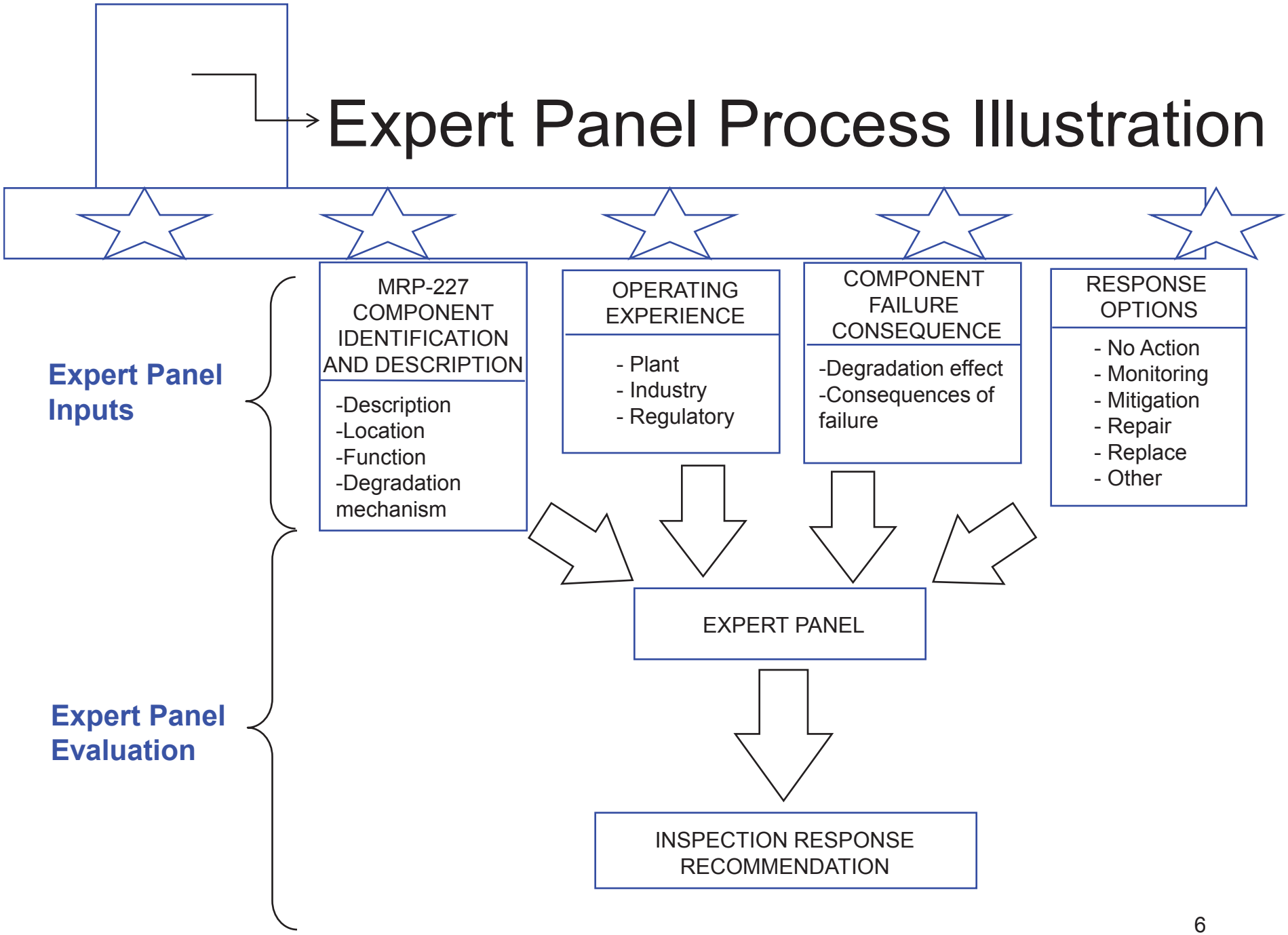
Expert Panel Process To Develop Guidelines

- Multidisciplinary review for each component
- Coordination of review activities
- Ownership from all affected stakeholders
- Integrated decision making
  - ASME Code Section XI
  - PWROG
  - EPRI MRP
  - Design-specific or plant-specific licensing & regulatory bases
  - Plant-specific differences accounted for

Process:

- Confirmed list of included components
- Confirmed the completeness and viability of identified options
- Verified accuracy of consequences (both direct and indirect impacts)
- Ensured consistent philosophy is applied
- Provided insights into risk of success/failure of intended actions

Expert Panel Process Illustration



Four Inspection Groupings Recommended

- **Primary:** those PWR internals highly susceptible to at least one of the eight aging mechanisms. The aging management requirements are described in MRP-227. Includes components which have shown tolerance to a specific aging degradation effect, but for which no highly susceptible component exists or for which no highly susceptible component is accessible.

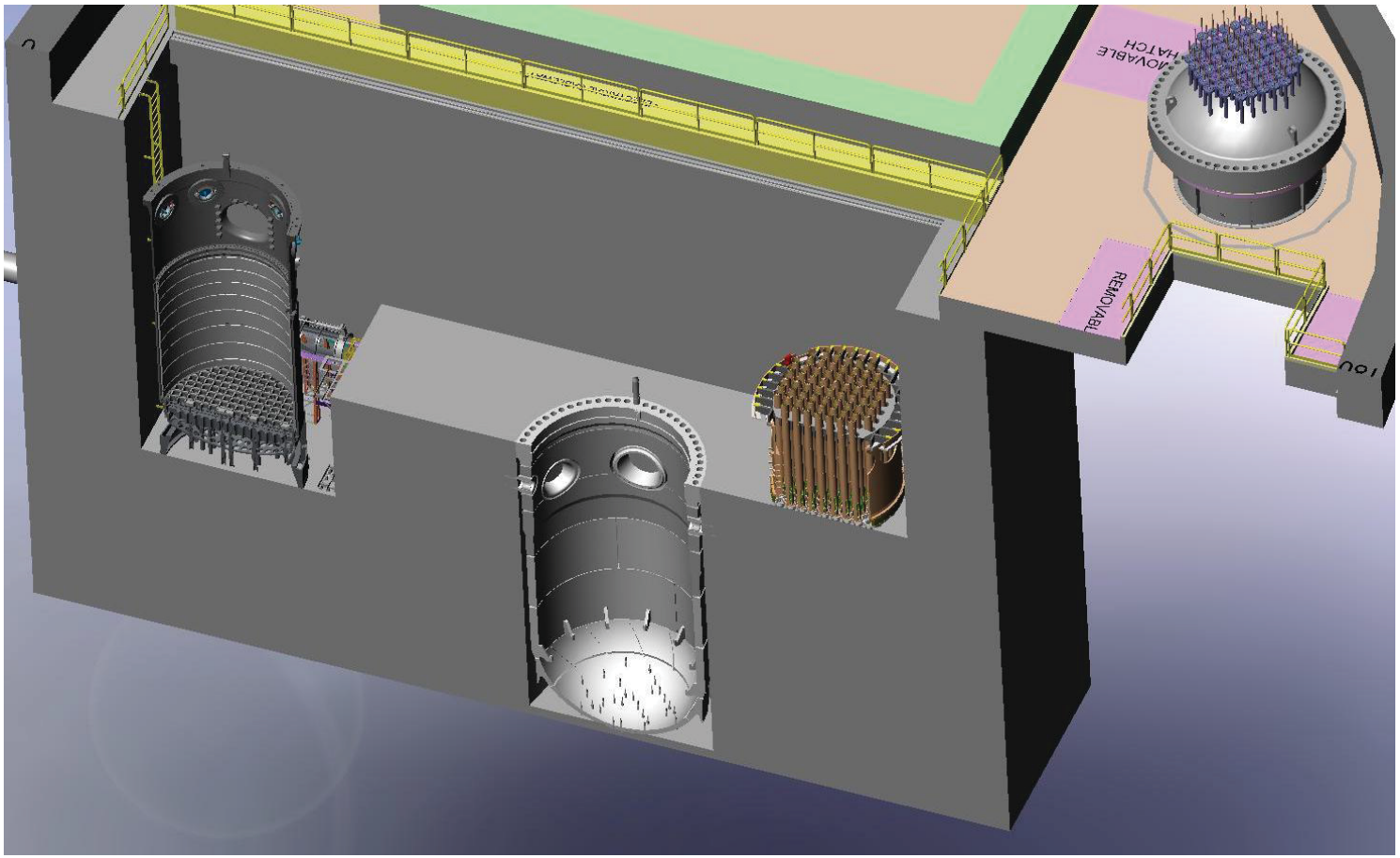
- **Expansion:** those PWR internals highly or moderately susceptible to the effects of at least one of the eight aging mechanisms, but for which functionality assessment has shown a degree of tolerance to those effects. The schedule for Expansion components will depend on the findings from the examinations of the Primary components at individual plants.

Four Inspection Groupings Recommended (Cont.)

- **Existing:** those PWR internals that are susceptible to the effects of at least one of the eight aging mechanisms and for which generic and plant-specific existing AMP elements are capable of managing those effects.

- **No Additional Measures:** those PWR internals for which the effects of all eight aging mechanisms are below the screening criteria. Additional components were placed in the No Additional Measures group as a result of FMECA and functionality assessment. No further action is required by the guidelines for managing the aging of the No Additional Measures components.

Schedule Allows Most Inspections To Be Performed During 10-Year Vessel Exam when Core Barrel Is Removed



B&W MRP-227-A RV Internals Primary Scope

- Lower Core Barrel Bolts (UT)
- Baffle-to-Former Bolts (UT)
- Flow Distributor Bolts (UT)
- Plenum Cover Weldment Rib Pads Support Flange and Core Support Shield Top Flange (VT3)
- Core Support Shield Vent Valve Top & Bottom Retaining Rings (VT-3)
- Upper Core Barrel Bolt Locking Devices/Welds (VT-3)
- Lower Core Barrel Bolt Locking Devices/Welds (VT-3)
- Baffle Plates (VT-3)
- Baffle-to-Former Bolt Locking Devices/Welds (VT-3)
- Internal Baffle-to-Baffle Bolt Locking Devices/Welds (VT-3)
- Flow Distributor Bolt Locking Devices (VT-3)
- Alloy X-750 Dowel-to-Guide Block Welds (VT-3)
- Incore Monitoring Guide Tube Spiders & Lower Grid Rib Welds (VT-3)
- Control Rod Guide Tube Spacer Castings and Cap Screws (VT-3)

CE MRP-227-A RV Internals Primary Scope

- Core Shroud Bolts (Bolted Design) (UT)
- Core Shroud Plate-Former Plate (Welded Design) (EVT-1)
- Welded Shroud Plates (Full Height Design) (EVT-1)
- Core Shroud Assemble [Bolted (VT-3); Welded (VT-1)]
- Core Barrel Upper Flange Weld (EVT-1)
- Core Barrel Lower Cylinder Girth Welds (EVT-1)
- Core Support Column Welds (VT-3)
- Core Barrel Lower Flange (TLAA or EVT-1)
- Core Support Plate (TLAA or EVT-1)
- Fuel Alignment Plate (Full Height Design) (TLAA or EVT-1)
- Instrument Guide Tubes (in CEA Shroud Design) (VT-3)
- Lower Structure Beams (Full Height Design) (EVT-1)

Westinghouse MR-227-A Primary Scope

- Control Rod Guide Card wear inspections (VT-3)
- Lower Control Rod Guide Tube (CRGT) Lower Flange welds (EVT-1)
- Baffle Former Bolts (UT)
- Baffle Former Assembly (including seams) (VT-3)
- Baffle Former Edge Bolts (VT-3)
- Upper Core Barrel Flange to Shell Weld (EVT-1)
- Lower Core Barrel Flange Weld (EVT-1)
- Thermal Shield Flexures (VT-3)
- Core Barrel Cylinder Girth Welds (EVT-1)
- Internals Hold-Down Spring (if applicable material type) (measurement)

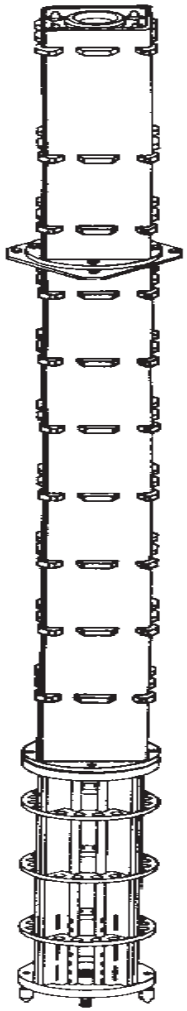
Encouraging Inspection Results to Date

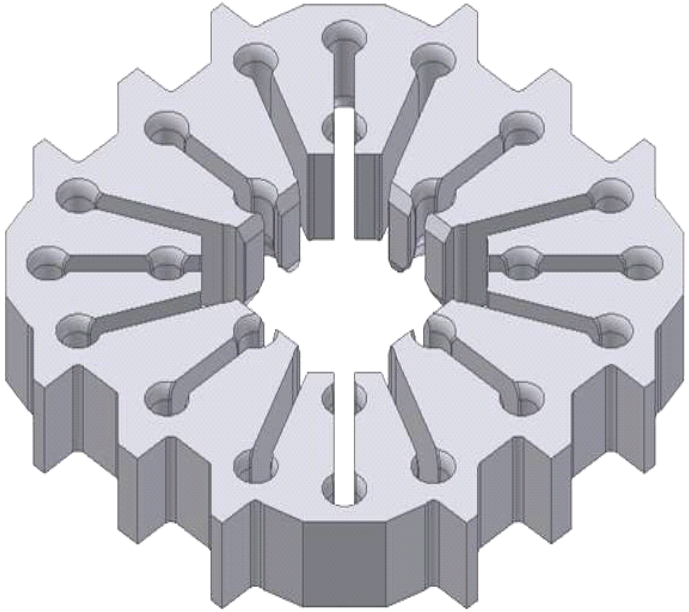
- 6 reactors inspected, others partly complete, as of Dec.2013
- In general, only minor issues identified to date, and these have been predicted and/or anticipated:
  - Guide cards wear rates are high for some reactors and revised guidance has been adopted to address results/projections
  - Baffle bolt indications not as numerous as European reactors, but there are two cases of anomalous results
- In contrast to BWR internals, PWRs have seen no indications of SCC or Irradiation Assisted SCC of stainless steel welds or heat affected zones - even for highly irradiated welds
- Results and projections show reactor internals remain structurally sound progressing well into period of extended operation (PEO), beyond 40 calendar years
- Inspections have required much special tooling and are costly
  - Regulatory safety evaluation has increased scope above base scope initially submitted in MRP-227

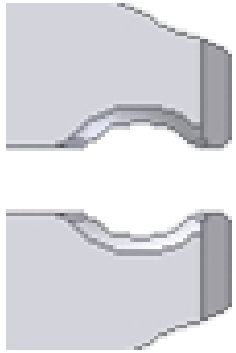
Westinghouse (W) Control Rod Guide Cards

- Aging effect – excessive wear
- VT-3 and wear measurement exam required
- Recently revised WCAP-17451-P, Rev. 1 incorporates industry experience from results to date
- More prescriptive exam requirements and evaluation adopted as a result of early exam results across the fleet
- Many perform larger scope than required
- Results – most find acceptable wear; some adopt changed management strategy based on results

W Control Rod Guide Cards







VT-3/Measurement W Control Rod Guide Cards

Acceptable

Observed Wear

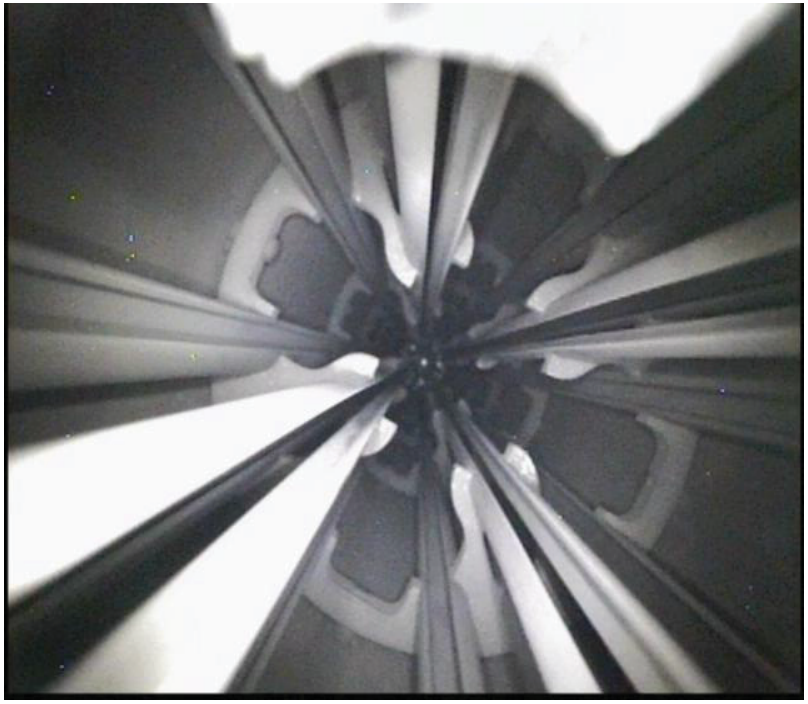
W Lower CRGT Assembly Flange Welds

- Plausible aging effects – cracking (SCC, fatigue)
- EVT-1 examination required
- CRGT Lower, upper & lower flanges (8 welds at each flange) (on oldest PWR split pin replacement activities afforded opportunity for 100% examination)
  - Only peripheral CRGT's are required by MRP-227
- All CRGT welds inspected to date were found acceptable

W Lower CRGT Flange Welds

VT-3 of B&W Control Rod Guide Tube (CRGT) Spacer Castings and Cap Screws

- Acceptable results to date



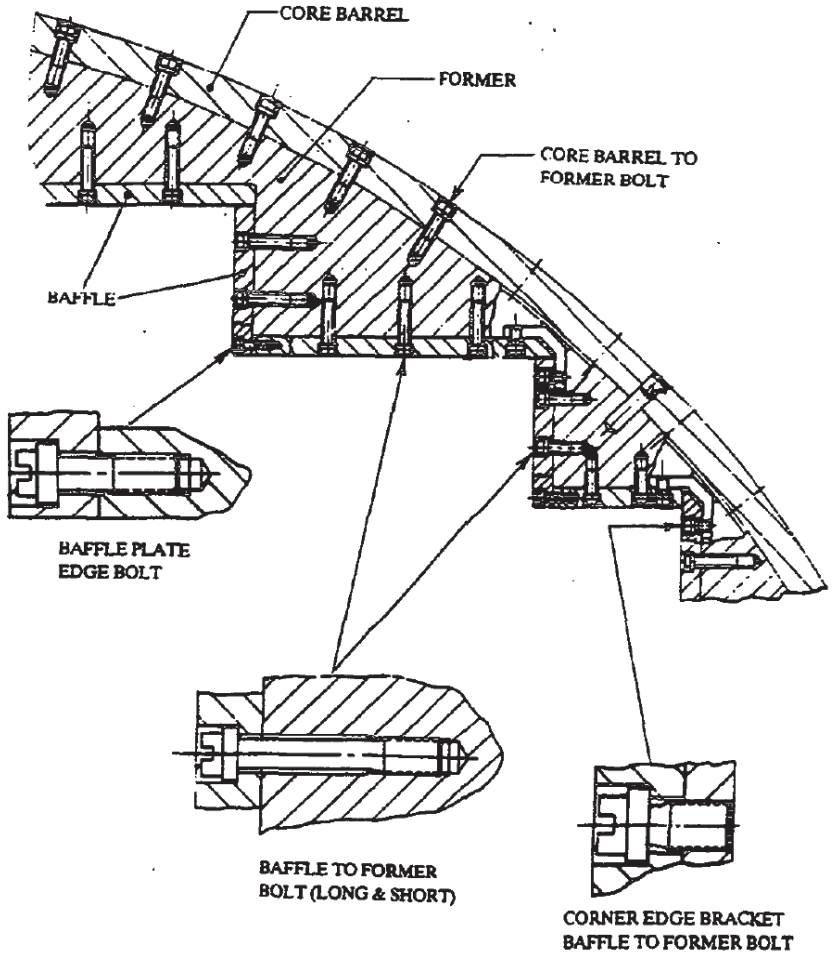
Baffle Former Assembly

- Plausible aging effects - void swelling, IASCC:
  - abnormal interaction with fuel assemblies,
  - gaps along high fluence baffle joints and seams,
  - vertical displacement,
  - broken or damaged bolt locking systems along high fluence baffle joints
- VT-3 examination required
- 100% of core side surfaces of the assembly
- No distortion observed at high fluence seams

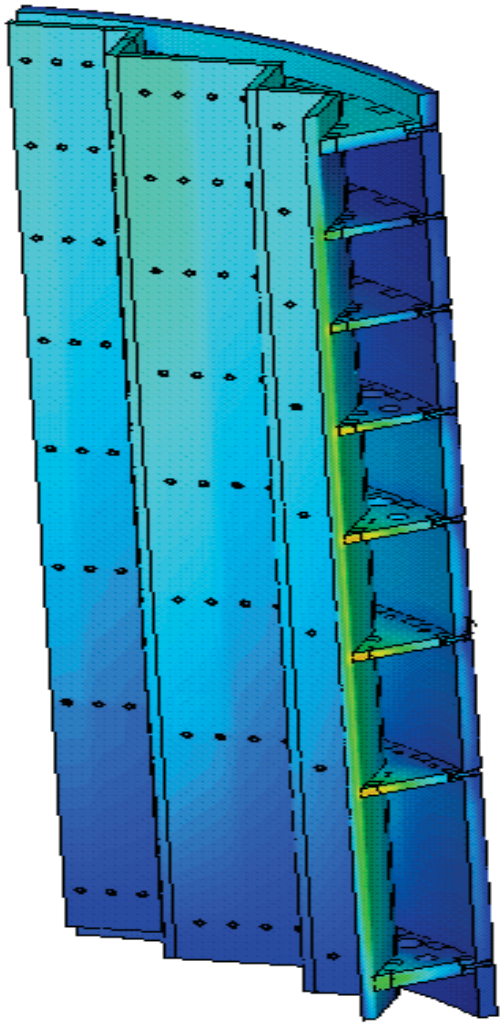
Baffle-Former Assembly "Baffle-Former Bolts" and "Baffle Edge Bolts"

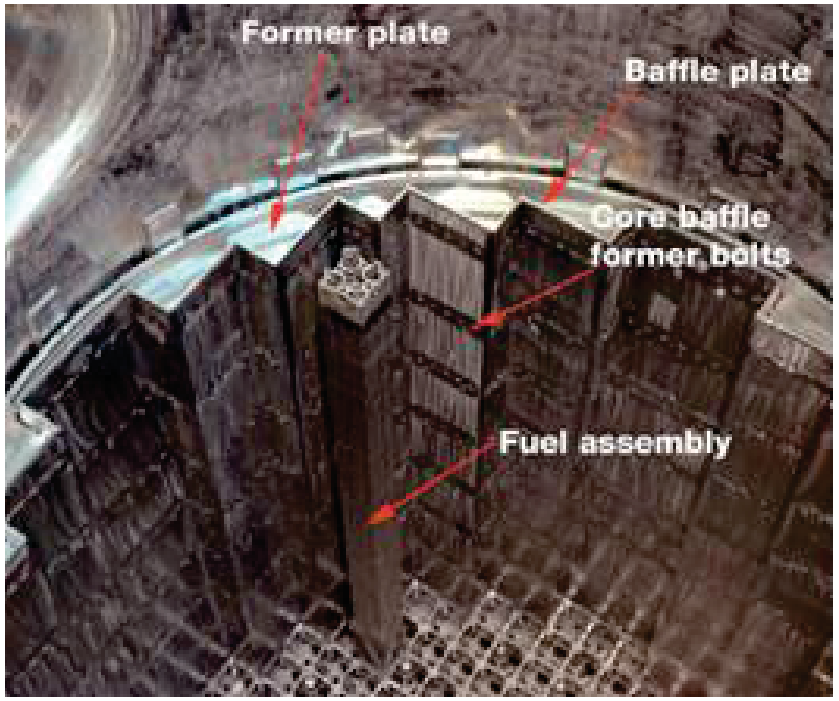
- Plausible aging effects - cracking (IASCC or fatigue):
  - Lost or broken locking devices
  - Failed or missing bolts
  - Protrusion of bolt heads
  - Void swelling/distortion
- UT of 100% of accessible Baffle-Former Bolts (BFBs), recognizing plant specific complexity of bolt head/locking device
- VT-3 all reentrant Baffle Edge Bolts and seams
- </= 1% BFBs failed in most; 10% found in one plant
- Minimum bolting pattern analysis has found above conditions acceptable (plant specific criteria satisfied for 10+ years)
- One Unit, prior to MRP-227-A required exam, while investigating fuel issue found ~ 18 BFBs failed in group, confined to only one plate - replaced

Baffle-Former Assembly Bolts

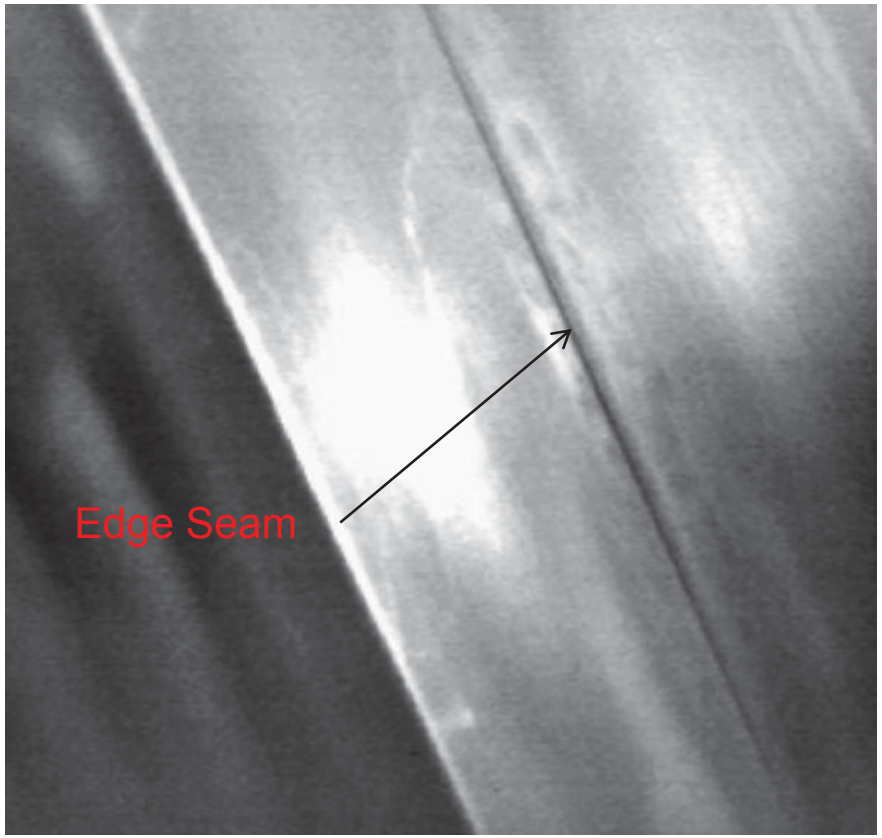


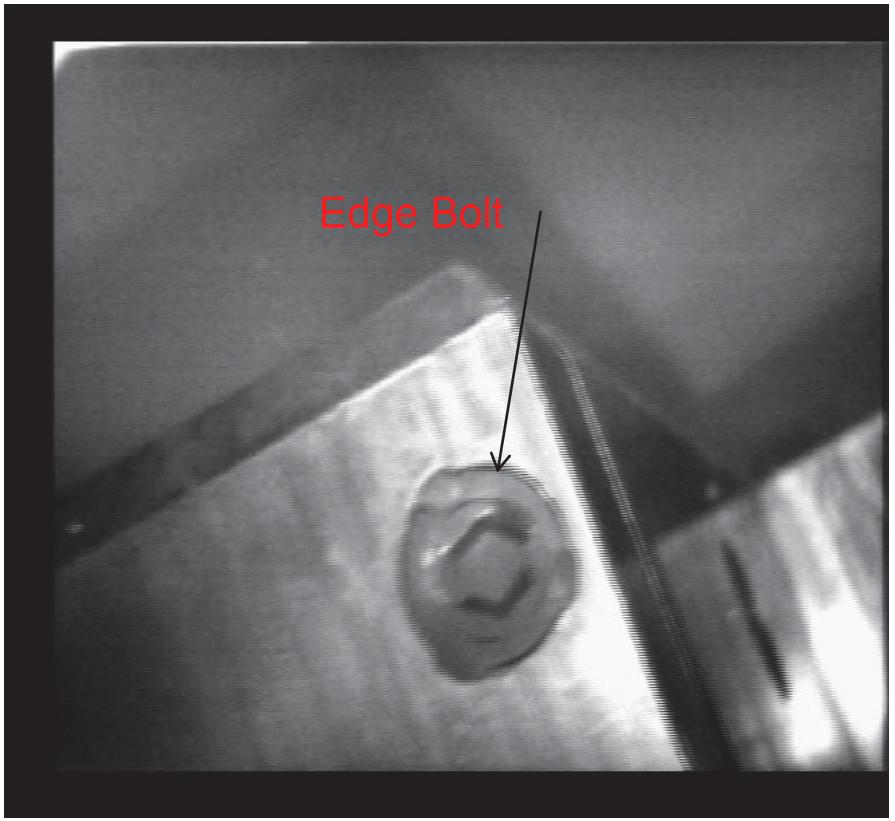
Baffle High Fluence Edge Seams/Edge Bolts





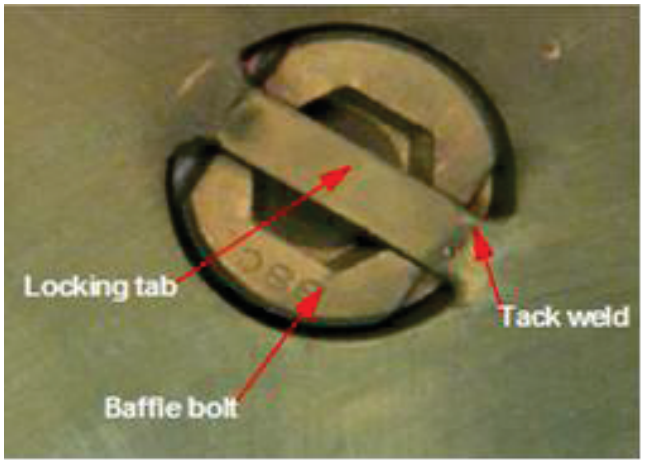
Baffle Edge Seams/Edge Bolts



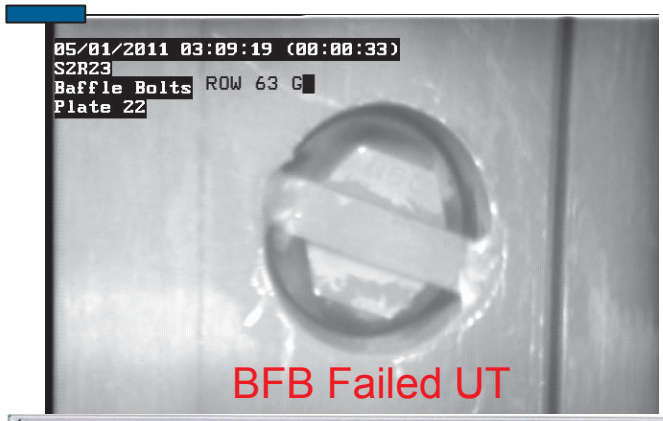


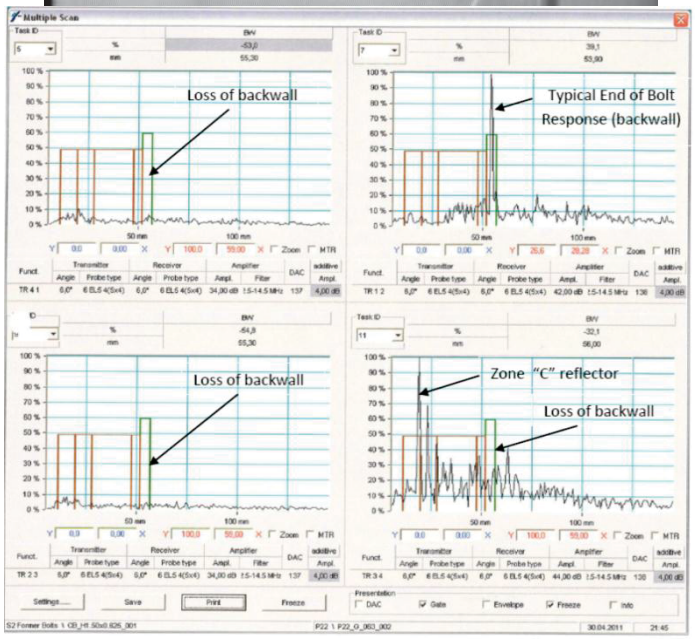
Baffle-Former Bolts (BFB)

Internal Hex



External Hex





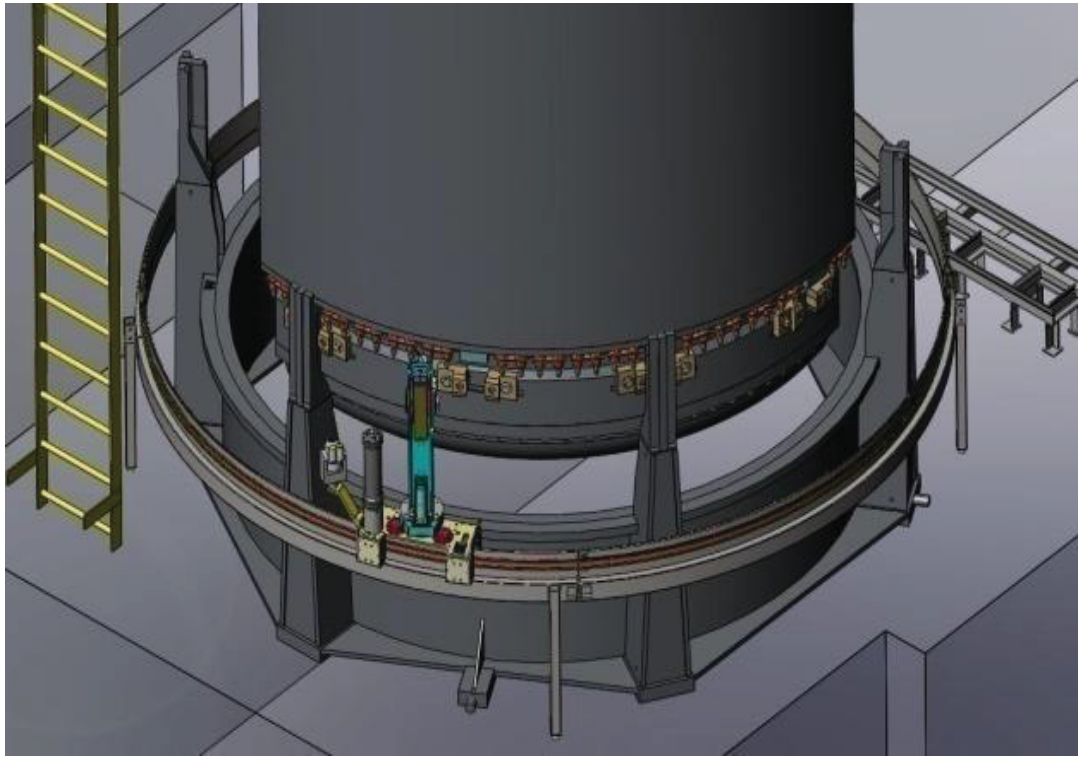
Failed Bolt for Destructive
Causal Examination

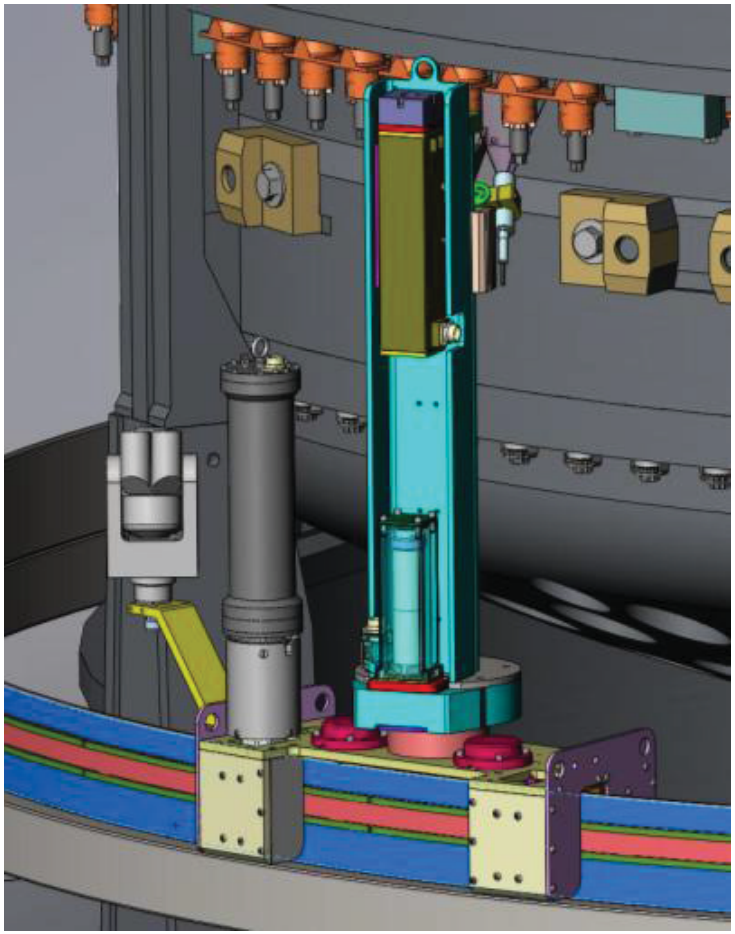
EPRI ELECTRIC POWER RESEARCH INSTITUTE

B&W Lower Barrel and Flow Distributor Bolts

- Plausible aging effects - cracking (SCC):
  - Lost or broken locking devices
  - Failed or missing bolts
  - Wear or fatigue damage
- UT of 100% of accessible bolts
- ~ 5% Lower Core Barrel (LCB) Bolts w/ UT indications
- ~ 1% Flow Distributor (FD) Bolts w/ UT indications
- Structural adequacy shown through evaluation of the remaining LCB & FD bolts for one cycle w/ follow up evaluation for additional
- Loose Parts Analyses performed to address LCB and FD Bolts, Locking Devices & Locking Clip

B&W Lower Barrel and Flow Distributor Bolts

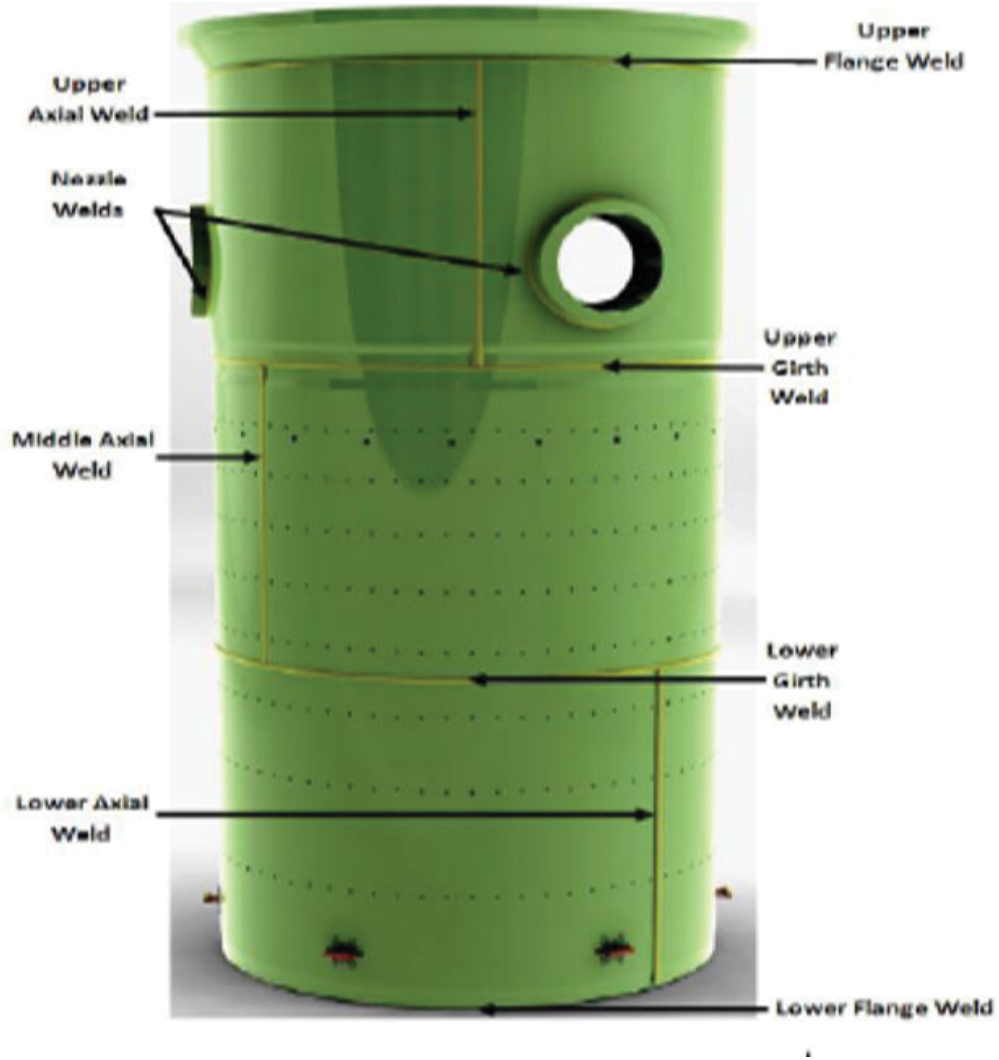




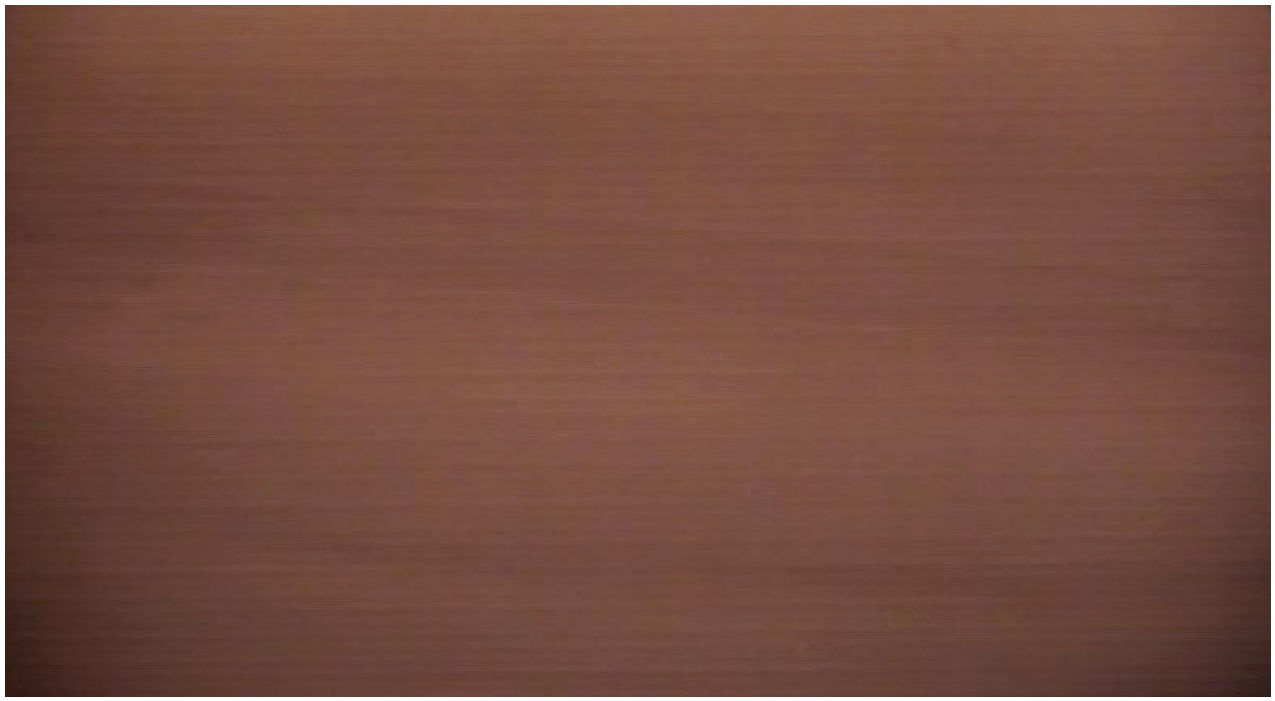
Upper Core Barrel Flange To Shell Weld & Core Support Barrel Girth Welds

- Plausible aging effects: cracking (SCC) for flange; (IASCC) for girth
- EVT-1 examination required
- 100% of the OD or ID or combination
- All welds examined to date were found to be acceptable

Core Barrel Welds



Upper Core Barrel to Flange Weld



Core Barrel Welds are Generally Difficult to Discern
Very Smooth and Machine/Ground Flush

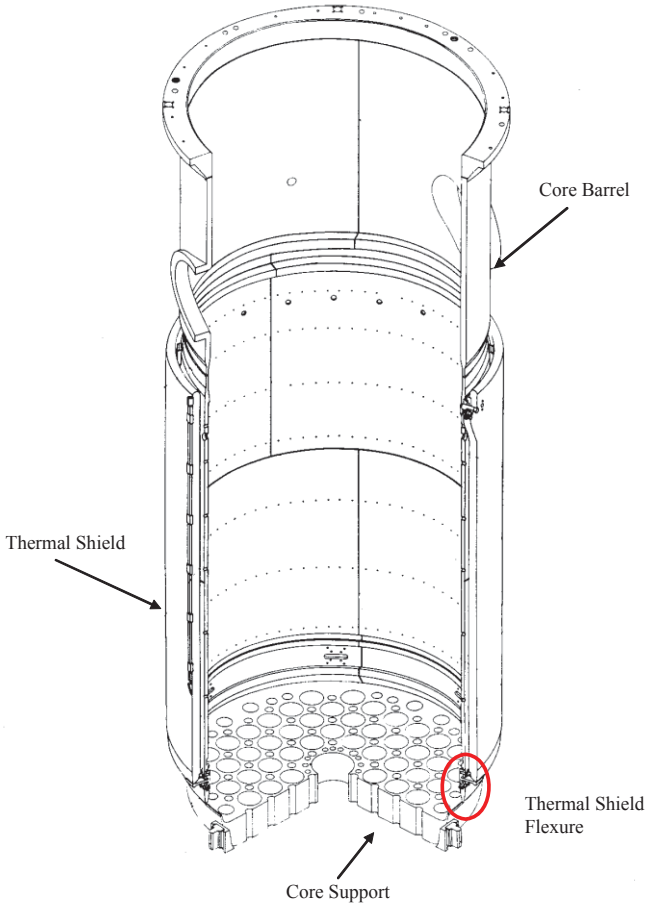
Units with Thermal Shields have

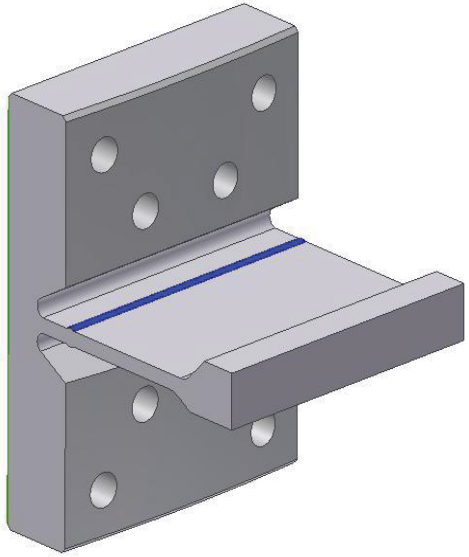
Challenging Access to Girth Welds

Thermal Shield Assembly "Thermal Shield Flexures"

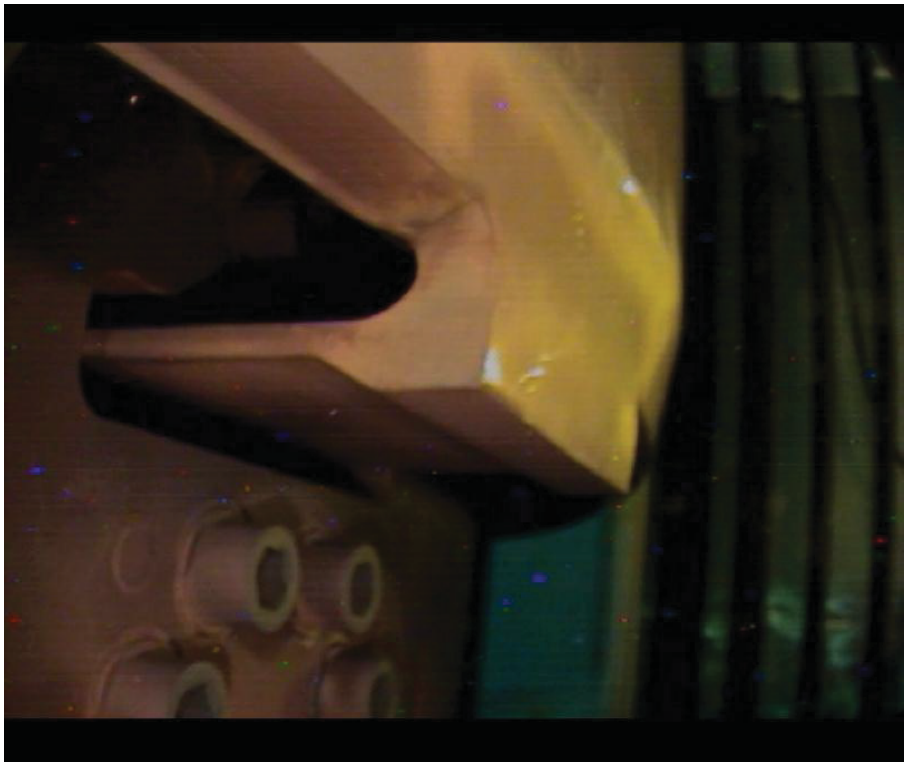
- Plausible aging effects: cracking or loss of material (wear) that results in:
  - Thermal shield flexures excessive wear
  - Fracture
  - Complete separation
- VT-3 examination required (6 flexures)
- All thermal shield flexure welds, fasteners and locking devices acceptable

Thermal Shield Assembly “Thermal Shield Flexures”





Thermal Shield Flexures (VT-3)



MRP-227-A Early Application Lessons Learned

- **Be prepared to resolve out-of-scope and construction/fabrication issues**
  - Missing or undersized locking bar and locking cup welds
  - Emergent loose parts analysis required
  - Dent/Ding/Grinding/Scratch marks
  - Indications in other than exam scope item (vent valve jack screw)
- **Component Verification**
  - Re-inspection was necessary due to component verification issues or lost coordinates
- **Emergent UT/Exam Demonstrations to Address As-Found Conditions**
  - Planned Transducer qualified for exam could not accommodate as-found geometry
  - Oversized lock bar/lock washer welds preventing coupling
  - New qualification (procedure & personnel) required to be performed emergently on site
- **Missing Videos**
  - Re-inspection due to video recording issues. (Not required by MRP-228; however, useful in subsequent examinations and verification.)
- **Environment / Equipment Work Hardening / Physical Interference/Accessibility**
  - Underwater camera radiation tolerance issues/backups/repair
  - Stability of very long underwater tooling in harsh environment
  - Pre-inspection evaluation of weld accessibility proved beneficial
  - Flange protector ring limited access to CSB lower flange and CRGT lower flange welds

PWR Industry Internals Program is in Place

- *Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines* (MRP-227-A). EPRI, Palo Alto, CA: 2011. 1022863.
- *Materials Reliability Program: Inspection Standard for Reactor Internals - 2012* (MRP-228 Rev. 1). EPRI, Palo Alto, CA: 2012. 1025147.
- PWROG WCAP-17451-P, Rev. 1: *Reactor Internals Guide Tube Wear – Westinghouse Domestic Fleet Operational Projections*
- PWROG WCAP-17096-NP: *Reactor Internals Acceptance Criteria and Data Requirements (Revision 2 in review/RAI response/draft SE status)*

Together…Shaping the Future of Electricity