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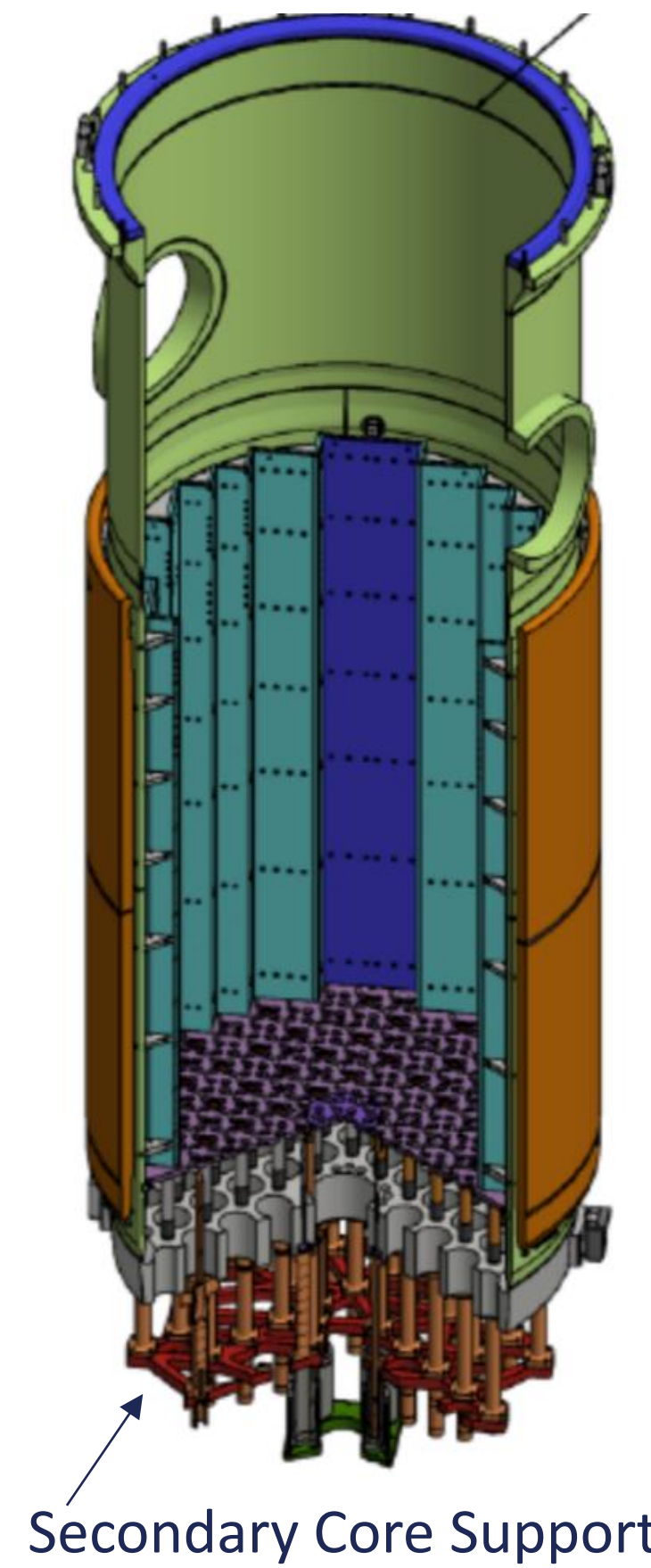
Kemper Young (FC Chair) – Industry Core Barrel Focus Group Update – Presentation #15

Agenda

- Background: OE and MRP-227
- Industry Core Barrel Focus Group
- Interim Guidance
- Ongoing and Future Work

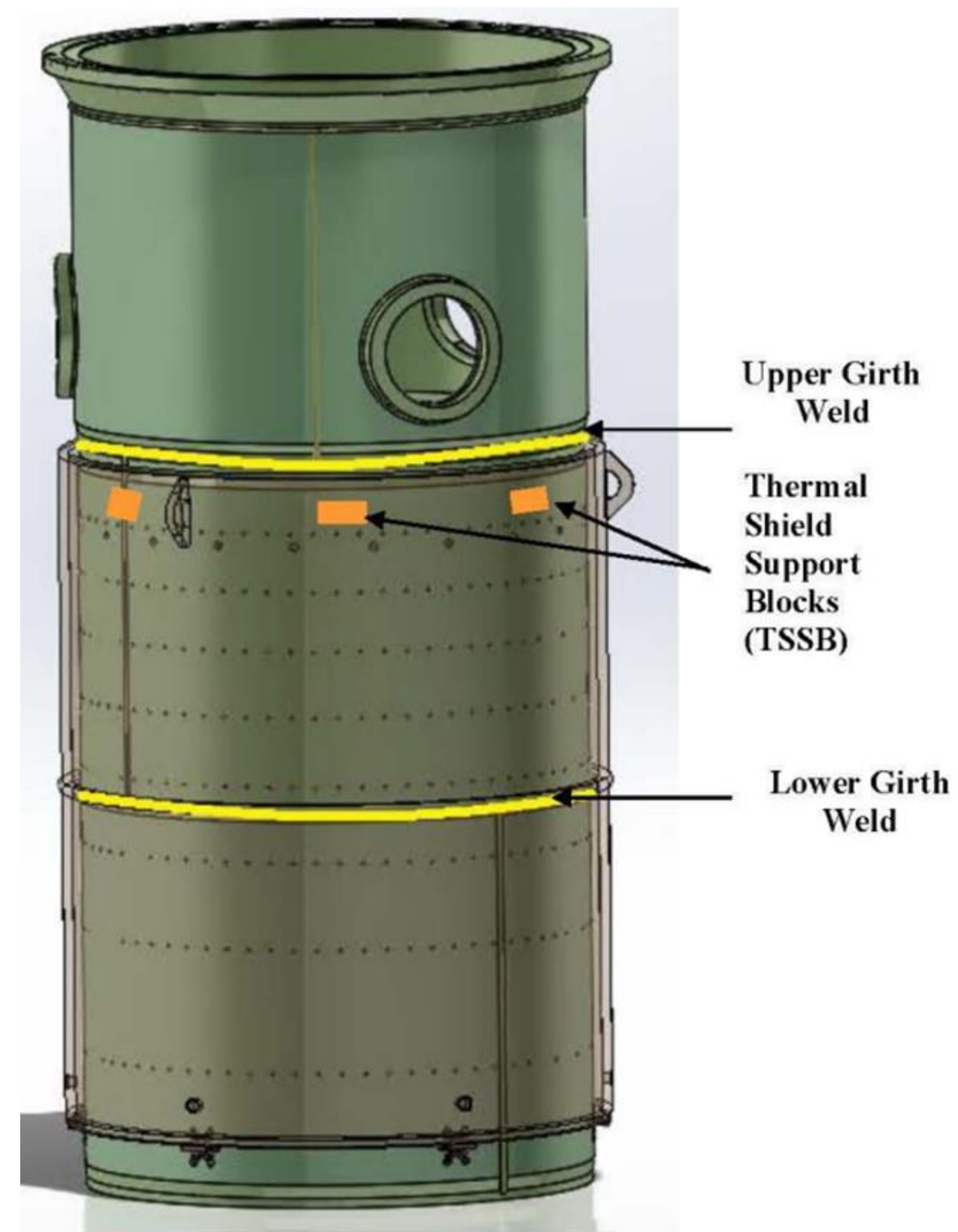
Background

- The primary function of the core barrel is to support the core
 - It also directs coolant through the fuel
- In the event of failure of a circumferential weld and a complete separation of the core barrel, a secondary core support structure is in place to protect the core and support maintaining alignment for safe shutdown
 - Downward movement of the lower portion of the core barrel is limited to ensure continued engagement of the fuel alignment pins with the fuel as well as engagement of the control rods within the fuel.
 - The lower radial keys maintain alignment of the lower portion of the core barrel with the top portion to ensure the control rods can still be inserted and maintain fuel alignment.
- While design features are in place to support shutdown when initiated, separation of the core barrel is treated as a potential safety significant condition since prolonged operation with a barrel in a separated condition is an unanalyzed condition in the plants design basis.



Background: OE

- An indication was detected during a general visual VT-3 ASME Section XI B-N-3 exam of a 3-loop core barrel in fall 2022:
 - Linear indication at the upper girth weld (UGW) identified on the core barrel inner diameter (ID) surface
 - Indication was circumferential and approximately 12” in length
- Extent of condition VT-1/EVT-1 was performed at the UGW:
 - 100% coverage of the UGW ID and OD surfaces
 - Identified four additional indications on the ID and no relevant indications on the OD
- UT was performed on all five indications:
 - The five indications ranged from 1.1” to 17.76” in length and 37% to 92% in through-wall depth



Background: MRP-227

- The UGW cracking OE observed in Fall of 2022 has several aspects that indicate the need to enhance the current MRP-227 examination requirements:
 - Cracking that could not be dispositioned by analysis alone was observed in the UGW
 - The UGW is designated as an Expansion component in MRP-227 Revision 1-A rather than as a Primary component
 - This cracking would have been missed if a one-sided surface inspection (as permitted by MRP-227) had been conducted from the other surface
- From review of 2012 10-year ISI video there is evidence that at least one of the cracks was present prior to the end of the plant's original 40-year operating license. The crack length and generally accepted crack growth rates would also suggest that the other cracks were also likely present at that time but could not be identified visually.

Industry Core Barrel Focus Group

- A joint core barrel focus group was set up to coordinate industry activities related to:
 - Understanding technical issues associated with recent core barrel cracking
 - Coordinating an agreed upon industry approach to resolving issues
 - The goal is generic applicability and overarching recommendations
- Membership includes PWROG, EPRI, NSSS Vendors, and utility personnel

Interim Guidance^(1/5)

- A key topic of discussion for the core barrel focus group was the need to promptly address revisions to the MRP-227 Revision 1-A guidance
- MRP-227 Interim Guidance was issued on May 19, 2023 as MRP 2023-005
 - ❑ Addresses Westinghouse and Combustion Engineering (CE) designs
 - ❑ NEI 03-08 “Needed” guidance to be implemented at the next planned core barrel removal coinciding with MRP-227 examinations
 - ❑ The guidance is effective as of May 1, 2024
 - ❑ Expansion inspections triggered by the UGW examination to components that require a core barrel removal are not required to implement the Expansion exam changes until the first outage after May 1, 2026
 - ❑ This guidance was discussed with the NRC-NRR on May 31, 2023

Interim Guidance^(2/5)

- Noteworthy changes in MRP 2023-005 include:
 - ❑ Promote UGW to a Primary component
 - ❑ Perform enhanced visual (EVT-1), eddy current (ET), examination of both surfaces (ID surface and OD surface) or volumetric (UT) examination of one surface when performing examinations on UGW, upper flange weld (UFW), or upper axial weld (UAW)
 - ❑ Address Primary and Expansion relationships
- Revision 1 issued on March 15, 2024 which addresses the following:
 - ❑ Inaccessibility of the inner diameter (ID) surface of the UGW in CE-design plants with welded core shrouds assembled from two vertical sections and the different layout of core barrel welds present in the CE-design plants with welded core shrouds with full-height shroud plates
 - ❑ The volumetric UT was clarified to require a full thickness/full volume examination
 - ❑ Corrections have been made to the tables to address these recently recognized issues along with a few typos in the original interim guidance tables

Interim Guidance^(3/5)

- Supplemental Guidance to MRP-227 was issued on February 15, 2024 as MRP 2024-004
 - Addresses Westinghouse designs and supplements MRP 2023-05 and does not supersede it
 - Serves to fill a gap in inspection coverage among a certain group of PWRs which have already performed MRP-227 examinations. Once these new required examinations are performed, the gap will be closed, and the guidance will no longer be applicable.
 - All Westinghouse-design PWR units that have not completed core barrel weld examinations required by MRP-227 and have not previously performed an enhanced visual (EVT-1) or surface (ET) examination of the ID surface, or volumetric (UT) examination of the Core Barrel UFW and UGW are requested to implement the following NEI 03-08 'NEEDED' interim guidance in one of their next two (2) planned refueling outages after the after June 1, 2024.
 - Perform an enhanced visual (EVT-1) or surface (ET) examination of the ID surface, or volumetric (UT) examination of the Core Barrel UFW and UGW (Items W3 and W3a in MRP-227). Examinations shall be conducted in accordance with MRP-228.
 - This guidance will be included in the RAI response letter to US NRC

Interim Guidance^(4/5)

- Phase 3 Guidance (MRP 2024-008) In-Process
 - ❑ Addresses Westinghouse and Combustion Engineering (CE) designs
 - ❑ NEI 03-08 “Needed” guidance to be implemented at the next planned core barrel removal coinciding with MRP-227 examinations
 - ❑ Current plan is to have this guidance be effective as of January 1, 2026
- Noteworthy changes in MRP 2024-008 include:
 - ❑ Core barrel or CSB welds that are only accessible from one surface must be inspected volumetrically (UT)
 - ❑ Primary Components:
 - Westinghouse-design plants: LGW
 - CE-designed plants with welded core shrouds assembled from two vertical sections: UGW and MGW
 - CE-designed plants with welded core shrouds assembled from full-height shroud plates: upper MGW and lower MGW
 - ❑ Expansion Components:
 - Westinghouse-design plants: MAW, LAW, and LFW.
 - CE-designed plants with welded core shrouds assembled from two vertical sections: MAW, LAW, and LGW/LFW.
 - CE-designed plants with welded core shrouds assembled from full-height shroud plates: upper MAW, lower MAW, LAW, and LGW/LFW.

Interim Guidance^(5/5)

■ Phase 3 Guidance (MRP 2024-008) – Endorsement Plan:

- ❑ CB FG Members Endorse NEI 03-08 Needed Guidance by 5/21/24 (Complete)
- ❑ TAC / RIC Members Endorse Needed Guidance by 6/7/24 (Complete)
- ❑ PMMP EC Members Endorse Needed Guidance by 6/24/24 (In-Process)
- ❑ EPRI promulgate MRP 2024-008 to utility members by 7/2/24

Ongoing Site-Specific Work at 3-Loop Plant with OE

- Re-inspection (UT) of unmitigated UGW indications planned for Fall 2024 outage.
- Performing an EVT-1 on the ID of the UAW (Item W3.2) in accordance with MRP-227, Rev 1-A (See Table 5-3, Item W3b). (the rest of the expansion items in MRP 2023-005 will be addressed in the following outage)
- Analysis updates to accept the open crack arrest holes for the life of the plant.
- Preparation of contingencies for hole plugging if additional mitigation is needed.
- Preparations for capturing a boat sample (or equivalent) for metallurgical exams.

Industry Completed Work

- PWROG - Development of Fault Tree for Potential Causes of Cracking
- PWROG - Investigation of the Effect of Manufacturing Process on the Potential for Flaws Adjacent to the Core Barrel Outlet Nozzles
- PWROG - Utilization of Neutron Noise Data to Monitor for Active Core Barrel Cracking and Separation

- EPRI - Investigation of Weld Residual Stress and Presence of Outlet Nozzle in Vicinity of the UGW
- EPRI - Issuance of interim guidance, MRP 2023-005 and R1 for Westinghouse and CE Plants
- EPRI - Issuance of Supplemental guidance, MRP 2024-004 for Westinghouse Plants

Industry Ongoing Work

- PWROG/EPRI - Development of core barrel interim guidance
- PWROG/EPRI - Development of interim guidance for B&W Plants

- PWROG - PWR Core Barrel Lower Girth Weld (LGW) Failure Operability Feasibility Assessment
- PWROG - B&W Core Barrel Circumferential Weld Failure Operability Feasibility Assessment
- PWROG - Investigation and Exploration of Core Barrel Repair Options
- PWROG - Investigation of the Effect of Manufacturing Process and Flow-Induced Vibration on the Potential for Flaws Adjacent to the Core Barrel Outlet Nozzles – Additional Work

- WRTC and ORNL - Research for the feasibility of welding irradiated stainless steel which could support future Core Barrel repair options
- EPRI - Continued collaboration with PWROG on irradiated SS weld and base metal fracture toughness guidance EPRI - Development of a Detailed Thermal Stress Profile on the Core Barrel ID

Possible Future Industry Work

■ 2024

- ❑ PWROG - Development of a Standard Set of Welded Inspection Specimen Designs for UT Technique Development and Demonstration Purposes.

■ 2025-2026

- ❑ PWROG - Core Barrel Focus Group Support and Investigations – Additional Work
- ❑ PWROG - PWR Core Barrel LGW Failure Operability Feasibility Assessment
- ❑ PWROG / EPRI - Harvesting, Transport, and Laboratory Testing of H.B. Robinson Core Barrel Sample
- ❑ PWROG - Fault Tree for Core Barrel Cracking – for B&W Plants

■ EPRI Future Work

- ❑ Analysis of Thermal Fluctuations on Core Barrel UGW
- ❑ Fabricate a standard set of inspection specimens (per PWROG supplied bounding design drawings) containing representative flaw types that industry use for UT technique development and demonstration purposes.

Questions?

The Materials Committee is established to provide a forum for the identification and resolution of materials issues including their development, modification and implementation to enhance the safe, efficient operation of PWR plants.