Boiling Water Reactor Vessel and Internals Project (BWRVIP) Report

Industry/NRC Materials Technical Exchange Meeting

Steve Richter
Research Integration Committee Chairman (Energy Northwest)

Nathan Palm, PE
EPRI-BWRVIP Program Manager

June 17, 2025

Contents

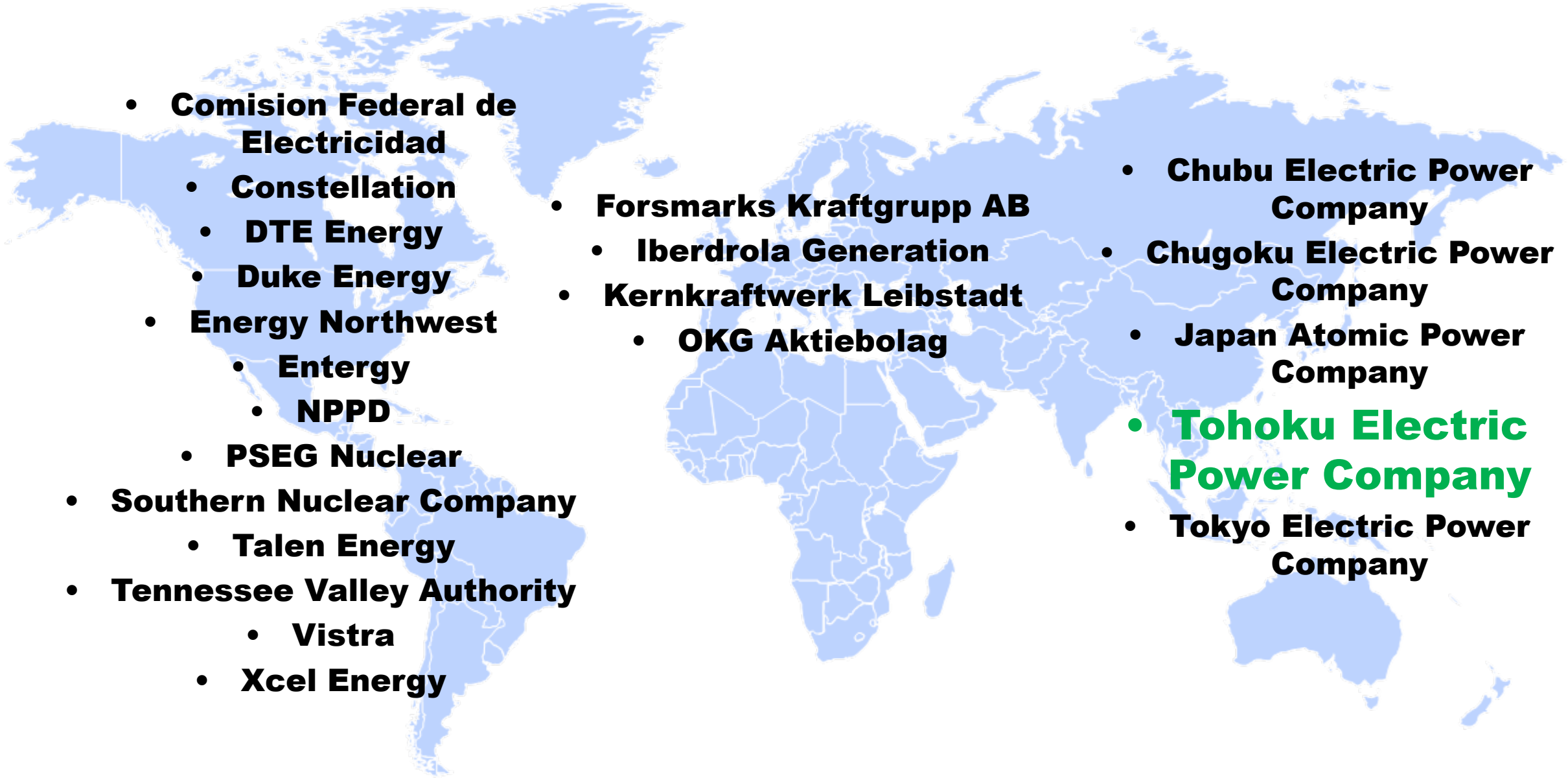
- BWRVIP Overview
- Operating Experience
- 2025 BWRVIP Technical Activities
- Summary of BWRVIP Report Submittals

BWRVIP Overview

BWRVIP Background and Objectives

- Background
  - Intergranular Stress Corrosion Cracking (IGSCC) in austenitic piping was a major issue for Boiling Water Reactors (BWRs) in the 1980s – susceptibility of reactor internals to IGSCC was also recognized
  - Shroud cracking in 1993-1994 confirmed that IGSCC of internals is a significant issue for BWRs
  - BWR utility executives formed the BWRVIP in mid-1994
- Objectives
  - Lead industry toward proactive generic resolution of vessel and internals material condition issues with generic, cost-effective strategies
  - Identify or develop generic, cost-effective strategies
  - Serve as a focal point for the regulatory interface with the industry in BWR vessel and internals material condition issues
  - Share information among members to obtain useful data from many sources

2025 BWRVIP Member Utilities



- Comision Federal de Electricidad
- Constellation
- DTE Energy
- Duke Energy
- Energy Northwest
- Entergy
- NPPD
- PSEG Nuclear
- Southern Nuclear Company
- Talen Energy
- Tennessee Valley Authority
- Vistra
- Xcel Energy

- Forsmarks Kraftgrupp AB
- Iberdrola Generation
- Kernkraftwerk Leibstadt
- OKG Aktiebolag

- Chubu Electric Power Company
- Chugoku Electric Power Company
- Japan Atomic Power Company
- **Tohoku Electric Power Company**
- Tokyo Electric Power Company

2025 BWRVIP Organization

Red = Vacant

Green = New (since 2024 Tech Exchange

Blue = Tentative

Executive Committee

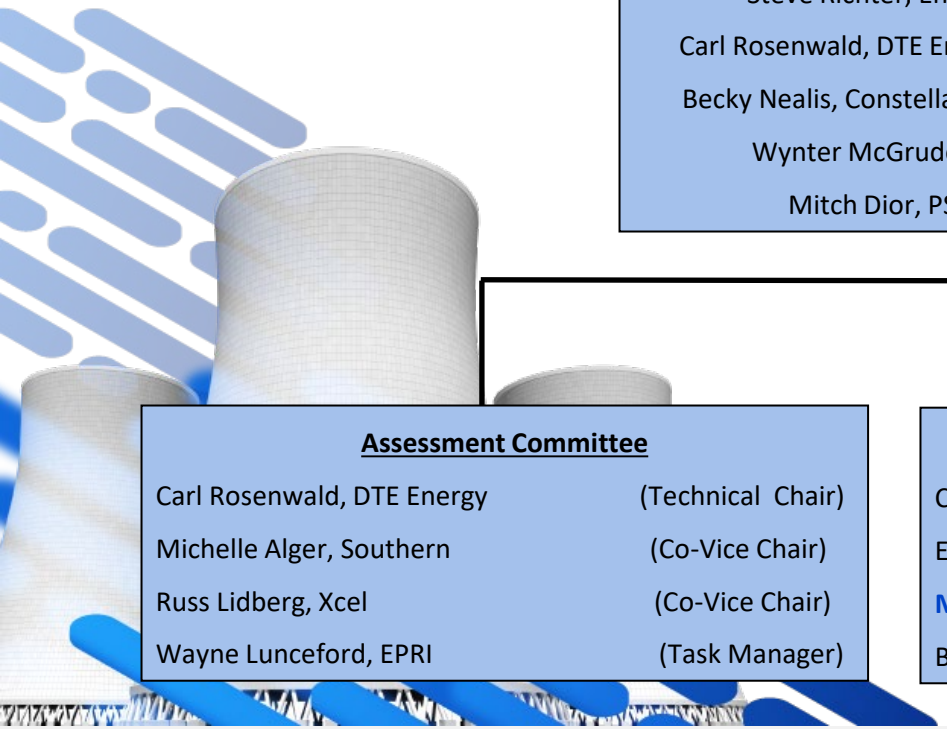
Barry Davis, Entergy	(Chair)
Ron DiSabatino, Constellation	(Vice Chair)
Nathan Palm, EPRI	(Program Manager)

Executive Oversight Committee

Barry Davis, Entergy	(EC Chair)
Ron DiSabatino, Constellation	(EC Vice Chair)
Bill Kopchick, PSEG	(AC/IC Exec Sponsor)
Jeremiah Hill, Xcel	(MC Exec Sponsor)
Andrew Barritt, KKL	(International Sponsor)
Troy Barker, NPPD	(EOC at large)

Research Integration Committee

Steve Richter, Energy Northwest	(Chair)
Carl Rosenwald, DTE Energy	(Co-Vice Chair)
Becky Nealis, Constellation	(Co-Vice Chair)
Wynter McGruder, EPRI	(Task Manager)
Mitch Dior, PSEG	(BWROG Chair)



Assessment Committee

Carl Rosenwald, DTE Energy	(Technical Chair)
Michelle Alger, Southern	(Co-Vice Chair)
Russ Lidberg, Xcel	(Co-Vice Chair)
Wayne Lunceford, EPRI	(Task Manager)

Inspection Committee

Christian McKean, Constellation	(Technical Chair)
Eddie Goss, Energy Northwest	(Co-Vice Chair)
Mike Swartz, Constellation	(Co-Vice Chair)
Bob Grizzi, EPRI	(Task Manager)

Mitigation Committee

Becky Nealis, Constellation	(Technical Chair)
Mike Shobe, Energy Northwest	(Vice Chair)
Taryn Barber, EPRI	(Task Manager)

BWRVIP Membership at a Glance

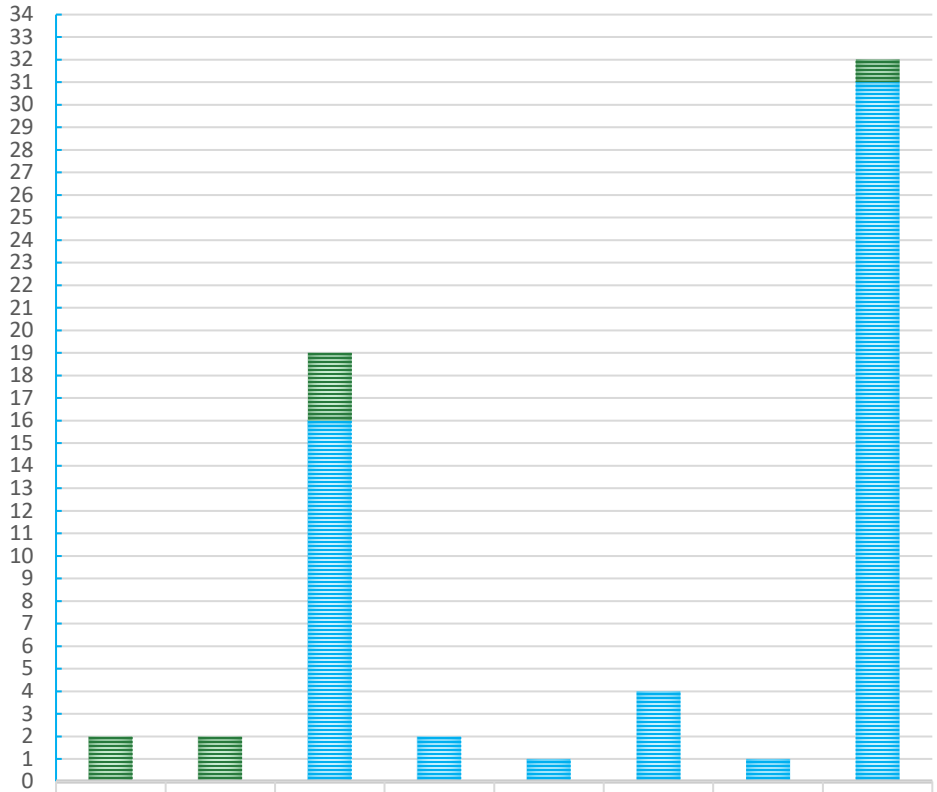
- 22* of 26 BWR licensees are BWRVIP members
  - 55* of 63 BWR units are BWRVIP members
  - One ABWR under construction
  - Chugoku's Shimane 2 restarted December 2024
- Two OEMs of 9 different BWR types
- 1,909** combined operating years
- 15% of worldwide nuclear capacity
- Youngest operational unit: 19 years (Dec. 2005)
- Oldest operational unit: 55 years (Dec. 1969)

Added Tohoku Electric Power Co.; Onagawa unit 2 restarted October 29th, 2024

**13.8 years were removed from each BWR in Japan to account for extended shutdown*

Duane Arnold added as a non-member within the chart given their announced plans to restart in 2028

BWRVIP MEMBERS & NON-MEMBERS BY COUNTRY



	Finland	India	Japan	Mexico	Spain	Sweden	Switzerland	U.S.A.
Non-Member	2	2	3	0	0	0	0	1
Member	0	0	16	2	1	4	1	31

2025 BWRVIP EPRI Staff

Taryn Barber	Mitigation	865-218-8120	tbarber@epri.com

Bret Flesner	Inspection	704-595-2601	bflesner@epri.com
Bob Grizzi	Inspection	704-595-2511	rgrizzi@epri.com

Ryan Hosler	Assessment	410-397-1490	rhosler@epri.com
Jennifer Jarvis	Mitigation	980-495-7481	jejarvis@epri.com

Chris Joffe	Inspection	704-595-2944	cjoffe@epri.com
Wayne Lunceford	Assessment/Mitigation	650-855-8566	walunceford@epri.com

Wynter McGruder	Research Integration	704-595-2205	wmcgruder@epri.com
Nathan Palm	Program Manager	704-595-2855	npalm@epri.com

Debbie Rouse	Communications	704-595-2520	drouse@epri.com
Daniel Sommerville	Assessment	650-855-8633	dsommerville@epri.com
Matt Walter	Assessment	972-556-6518	mwalter@epri.com

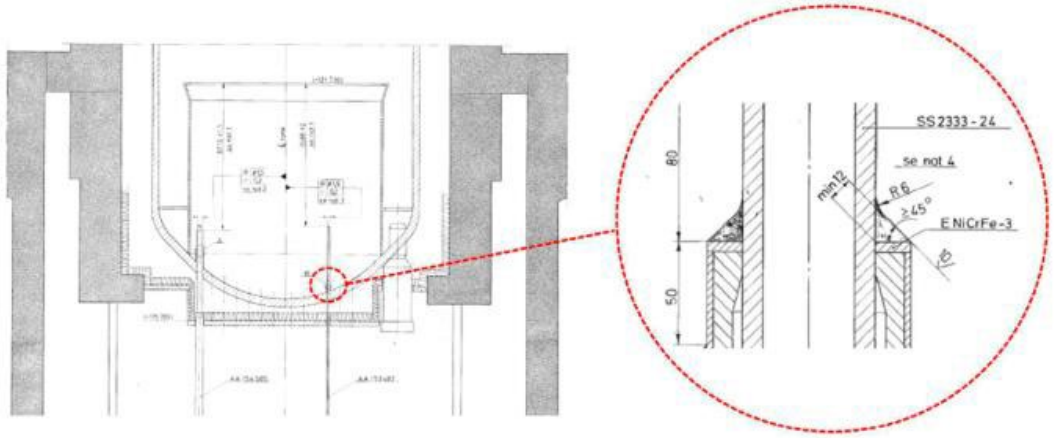
Operating Experience

Operating Experience

- No operating experience (OE) has occurred since the 2024 technical exchange meeting that triggered the initiation of the emergent issues protocol
- One noteworthy piece of international OE (next slide)
  - Erosion corrosion of RPV bottom head nozzle welds at two Swedish BWRs
  - First identified in 2020 but recently brought to the attention of BWRVIP
  - No similar OE identified in rest of U.S. or international BWR fleet
  - Issue is being added to BWR Issue Management Tables (IMTs)
- Some other OE trends exist that represent non-safety challenges (subsequent slide)

Bottom Nozzle Erosion Corrosion at Two Swedish BWRs

- Identified in all bottom head nozzles to a varying degree
- The main part of the socket weld is A82 but A182 has been used for the root, some weld reparation and the upper part towards the housing.
- Current corrosion rates challenge plants' ability to operate to 60 years
- Research and inspections being performed by Swedish utilities to:
  - Better understand causes and rates of degradation
  - Reduce unnecessary conservatism (in the structural calculations)
  - Develop mitigative strategies
- BWRVIP, IMR and WRTC providing assistance



Ongoing OE Trends

- Jet Pump Vibration Issues
  - Wedge and rod wedge wear, failure of anti-vibration hardware, etc.
  - Several instances resulting from loose parts / foreign objects
- Dry tube spring relaxation and engagement issues
  - Some plants are implementing proactive replacement strategies
  - Many plants facing challenges due to lack of available replacement parts
- Discovery of “new” flaws / additional cracking due to improved NDE (better cleaning, attention to lighting, use of HD cameras, etc.)
  - Results in subsequent examination per conditions in SEs for BWRVIP-18 R2-A and BWRVIP-41 R4-A
  - Often, with benefit of hindsight, flaws can be seen in prior NDE images
  - Conversely, many instances exist of previously identified flaws being determined to be non-relevant (e.g., crud lines, scratches, etc.)

No Safety Issues – Issues represent challenges but are being managed

2025 BWRVIP Technical Activities

2025 Key BWRVIP Technical Activities

- Optimization of the BWR ISP withdrawal schedule
- Updating of core shroud inspection and evaluation guidance
- Evaluation of passive noble metal injection technology
- Completion of a platinum characterization round robin
- Reevaluation of stainless steel and low alloy steel SCC growth rates
- Update to BWR Issue Management Tables (IMTs) (BWRVIP-167, Revision 5)
- Publication of methods for dispositioning remnant flaws after an instrument penetration repair (BWRVIP-362, June 2025)
- Continued efforts on stainless steel fracture toughness (next slide)

Stainless Steel Fracture Toughness

- Updated Z-factors for simplified elastic-plastic analysis published in BWRVIP-364, March 2025
- Version 4.0 of the Distributed Ligament Length (DLL) software issued February 2025
- BWRVIP-100, Revision 2 Draft SE received – Publication of “-A” version scheduled by end of 2025
- International cross-program focus group established to evaluate options for future research
  - Set of recommendations issued to materials issues programs (BWRVIP, MRP, IMR, PWROG MSC)
  - Recommendations currently being considered by IPs

Summary of BWRVIP Report Submittals

Submittals in the NRC Review Process

- BWRVIP-100, Revision 2, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds
  - Submitted for review and approval July 2023
  - Draft SE Received March 2025; BWRVIP Response to Draft SE Planned for June 30, 2025
  - Final SE Expected October 2025
- BWRVIP-138, Revision 2, Updated Jet Pump Beam Inspection and Evaluation Guidelines
  - Submitted for review and approval October 2023
  - Draft SE received February 2025 with significant conditions
    - Public meeting scheduled for June 13, 2025 to discuss conditions
    - Conditions removed by NRC after review of EPRI meeting materials
    - Public meeting canceled
  - Remaining schedule: TBD

Planned Submittals

- BWRVIP-316, Reactor Pressure Vessel Aging Management Evaluation for Extended Operations
  - Publication planned for Q1 2026
  - NRC Submittal for Review and Approval planned for Q2 2026
  - Fee waiver will be requested
- BWRVIP-368, Technical Basis for Optimization of the U.S. BWR Fleet Integrated Surveillance Program (ISP)Capsule Withdrawal Schedule
  - Initial public meeting with NRC held on April 23, 2024
  - Publication planned for Q4 2025
  - NRC Submittal for Review and Approval planned for Q1 2026

Use of the NEI 03-08 Appendix C Screening Process

- BWRVIP Letter 2025-024 (NRC Notification Letter; May 15, 2025)
  - BWRVIP-38, Revision 1: BWR Shroud Support Inspection and Flaw Evaluation Guidelines (Published 2024)
    - NRC Accession #s: ML25134A292, ML25134A293, ML25134A294, ML25134A295

- BWRVIP Letter 2025-022 (NRC Notification Letter; May 13, 2025)
  - BWRVIP-48, Revision 1: Vessel ID Attachment Weld Inspection and Flaw Evaluation Guidelines
  - BWRVIP-48, Revision 2: Vessel ID Attachment Weld Inspection and Flaw Evaluation Guidelines
  - BWRVIP-49, Revision 1: Instrument Penetration Inspection and Flaw Evaluation Guidelines
  - BWRVIP-57, Revision 1: Instrument Penetration Repair Design Criteria
  - BWRVIP-62, Revision 2, Volume 1: Implementation Criteria for Inspection Relief for BWR Internal Components with Hydrogen Injection
  - BWRVIP-84, Revision 3: Guidelines for Selection and Use of Materials for Repairs to BWR Internal Components
  - BWRVIP-303: Load Definitions and Combinations for Use in BWR Internals Repair/Replacement and Flaw Evaluations
    - NRC Accession #s: ML25133A213, ML25133A214, ML25133A215,ML25133A216, ML25133A217, ML25133A218, ML25133A219, ML25133A220, ML25133A221, ML25133A222
  - This letter contains the report revisions details (where applicable) and the complete Appendix C screening for each of the above listed reports.
  - Utilities should reference the above submittals when implementing screened reports and referencing them in licensing submittals.

- The NRC will be notified via letter of any reports screened, published, and issued for generic implementation in 2025. The letter will be submitted in 2026 and will include the report revision details (where applicable) and the complete Appendix C screening.

TOGETHER…SHAPING THE FUTURE OF ENERGY®

www.epri.com