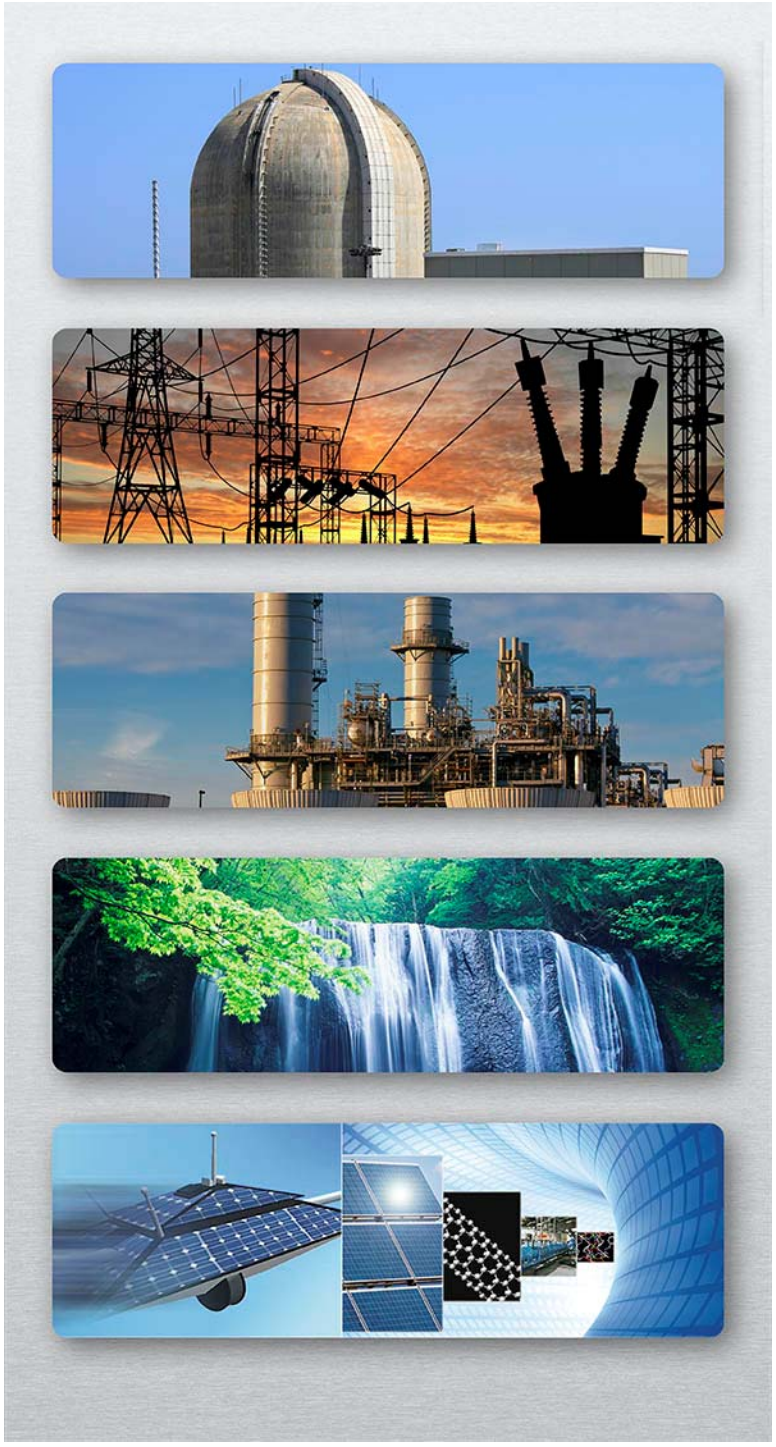


ELECTRIC POWER RESEARCH INSTITUTE

BWR Vessel and Internals Project Update

Drew Odell, Exelon

BWRVIP Integration Committee Technical Chairman

EPRI-NRC Technical Exchange Meetings

June 2-4, 2015

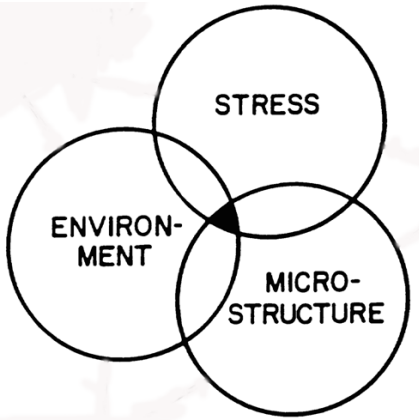
Overview Outline

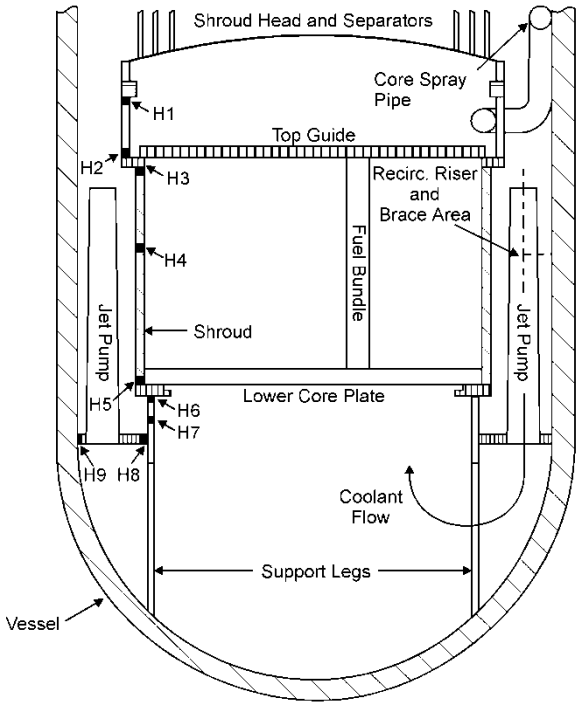
- Background
- Current Members and Organization
- BWRVIP Guidelines and Implementation
- Strategic Plan and Current Research Gaps
- BWRVIP Major Tasks
- Status of Key Topics with NRC
- Submittals to the NRC
- Contact Information

Background

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

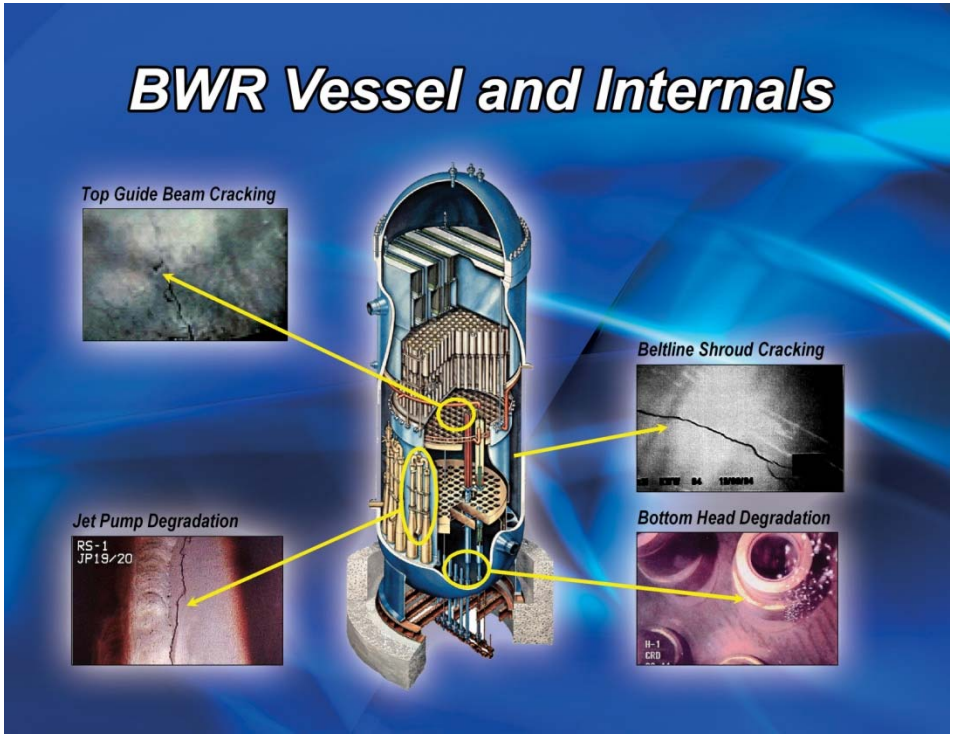




- Shroud cracking in 1993-1994 confirmed that IGSCC of internals is a significant issue for BWRs
- BWR utility executives formed the BWRVIP in mid-1994 to proactively address BWR reactor vessel and internals material condition issues
- The goal was to lead industry toward proactive generic resolution of vessel and internals material condition issues with generic, cost-effective strategies

BWRVIP Objectives

- Lead industry toward proactive generic resolution of vessel and internals material condition issues
- Identify or develop generic, cost-effective strategies from which each operating plant will select the alternative most appropriate to their needs
- Serve as a focal point for the regulatory interface with the industry in BWR vessel and internals material condition issues (including license renewal)
- Share information among members to obtain useful data from many sources

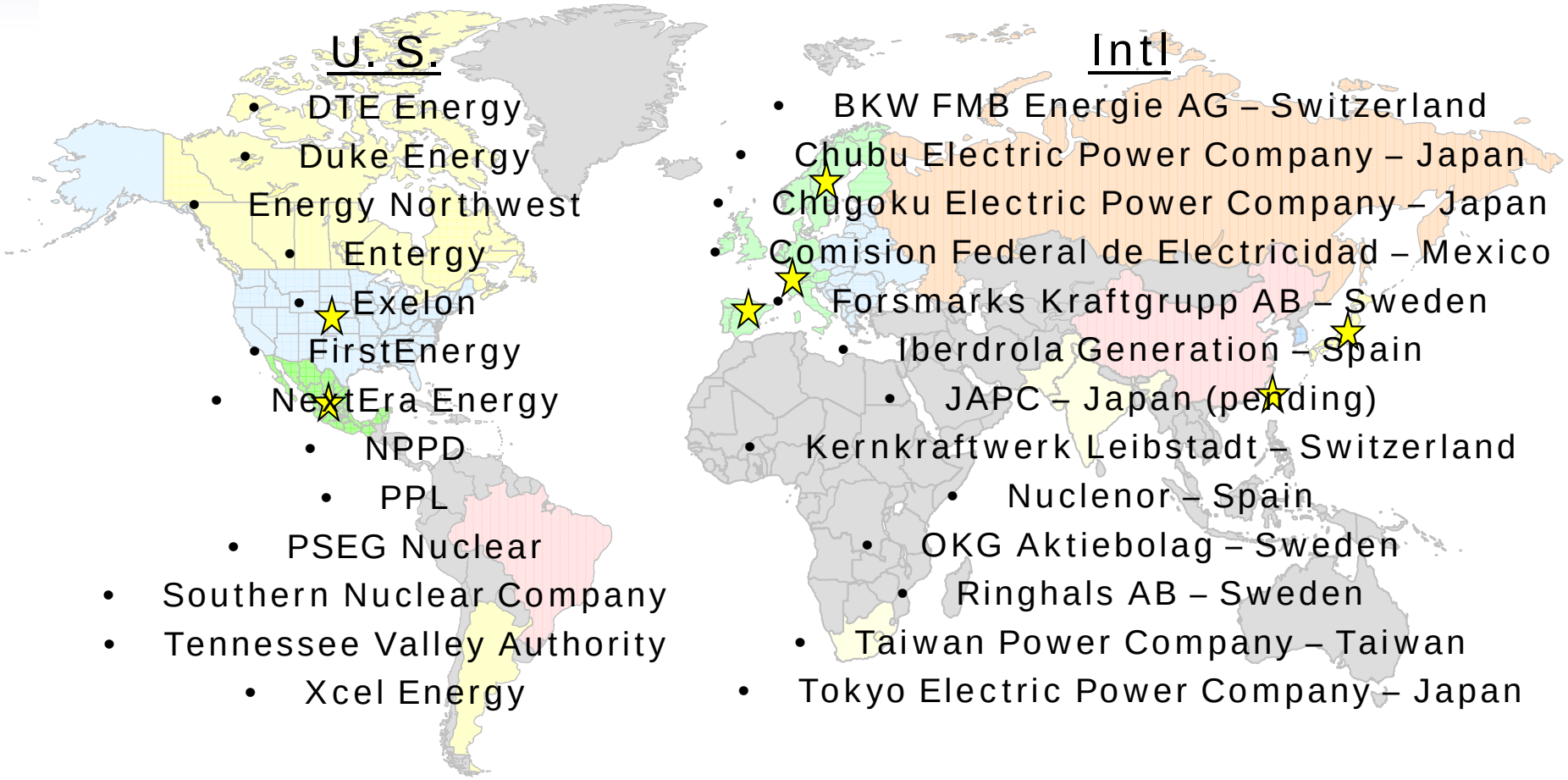


BWRVIP & NEI 03-08

- In 2003, the industry established the NEI 03-08 Materials Initiative to pro-actively address Reactor Coolant System (RCS) materials issues in the United States for both PWRs and BWRs.
- The BWRVIP became one of six EPRI programs that was brought under the initiative. The six EPRI programs are:
  - Boiling Water Reactor Vessel and Internals Project
  - Materials Reliability Project (PWRs)
  - Nondestructive Examination
  - Steam Generators Project
  - Primary Systems Corrosion Research
  - Water Chemistry
- The implementation guidance for NEI 03-08 is largely patterned after the implementation guidance previously established by the BWRVIP.

Current Members and Organization

2015 BWRVIP Member Utilities



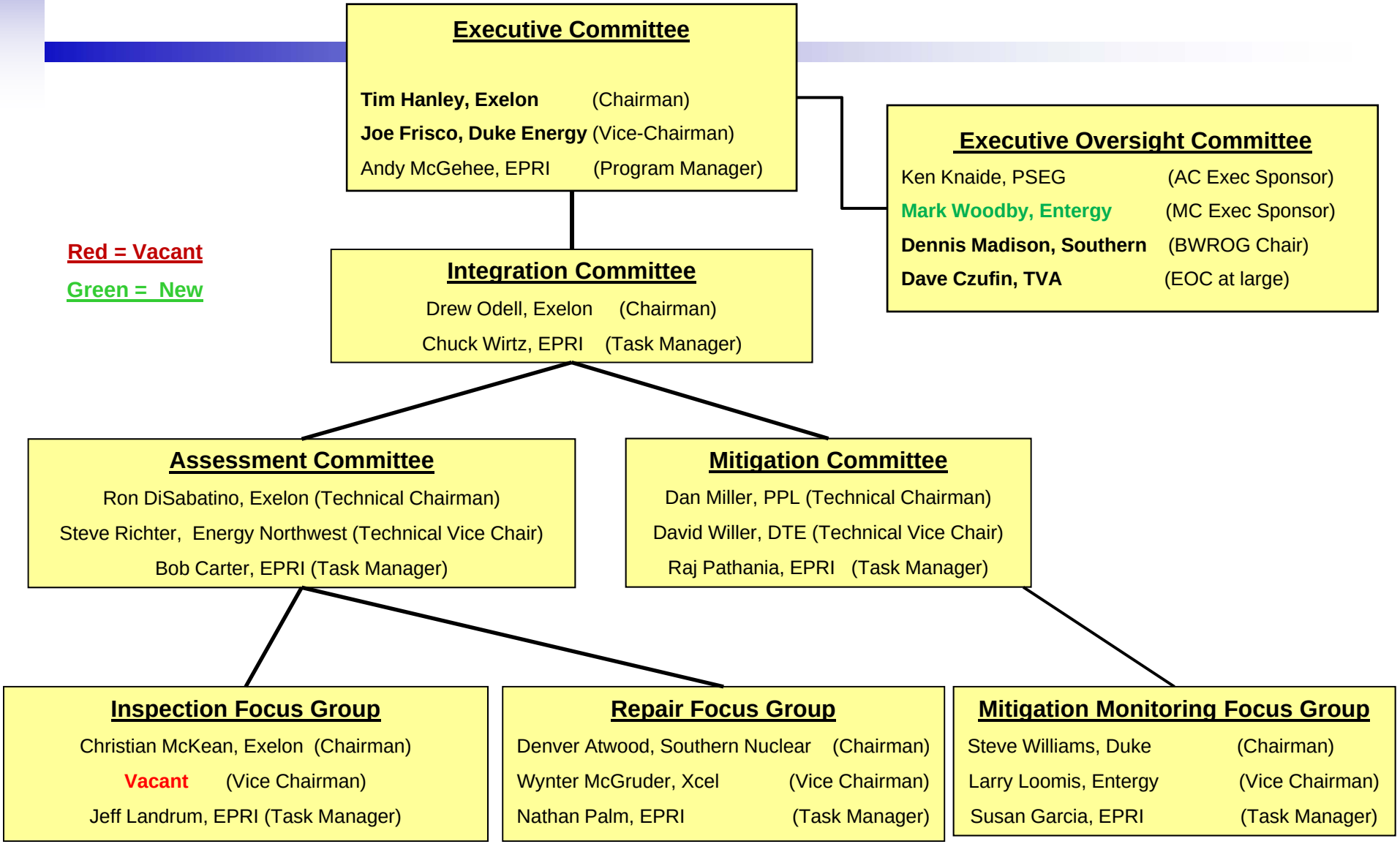
U. S.

- DTE Energy
- Duke Energy
- Energy Northwest
- Entergy
- Exelon
- FirstEnergy
- NextEra Energy
- NPPD
- PPL
- PSEG Nuclear
- Southern Nuclear Company
- Tennessee Valley Authority
- Xcel Energy

Intl

- BKW FMB Energie AG – Switzerland
- Chubu Electric Power Company – Japan
- Chugoku Electric Power Company – Japan
- Comision Federal de Electricidad – Mexico
- Forsmarks Kraftgrupp AB – Sweden
- Iberdrola Generation – Spain
- JAPC – Japan (pending)
- Kernkraftwerk Leibstadt – Switzerland
- Nuclenor – Spain
- OKG Aktiebolag – Sweden
- Ringhals AB – Sweden
- Taiwan Power Company – Taiwan
- Tokyo Electric Power Company – Japan

2015 BWRVIP Organization



EPRI ELECTRIC POWER RESEARCH INSTITUTE

Technical Committee Responsibilities

Assessment --	What needs to be inspected, when it needs to be inspected, inspection options, how to disposition observed degradation
Inspection --	How to inspect, what equipment and techniques are available, what are the associated uncertainties
Repair/replace --	What repair/replacement techniques are available and what are the associated requirements that must be met
Mitigation --	How can SCC degradation be prevented or reduced

BWRVIP Guidelines and Implementation

BWRVIP Guidelines to Manage Degradation

Component	Assessment (I&E) Guidelines	Inspection Guidelines	Repair/Replace Design Criteria	Mitigation Recommendations
Core shroud	BWRVIP-76, R1-A	BWRVIP-03	BWRVIP-02-A/-04-A	BWRVIP-62, R1/-190, R1
Core spray	BWRVIP-18, R1-A	BWRVIP-03	BWRVIP-16-A/-19-A/-34-A	N/A
Shroud support	BWRVIP-38	BWRVIP-03	BWRVIP-52-A	BWRVIP-62, R1/-190, R1
Top Guide	BWRVIP-26-A	BWRVIP-03	BWRVIP-50-A	N/A
Core Plate	BWRVIP-25	BWRVIP-03	BWRVIP-50-A	BWRVIP-62, R1/-190, R1
SLC	BWRVIP-27-A	BWRVIP-03	BWRVIP-53-A	BWRVIP-62, R1/-190, R1
Jet pump assembly	BWRVIP-41, R3	BWRVIP-03	BWRVIP-51-A	BWRVIP-62, R1/-190, R1
CRD guide/stub tube	BWRVIP-47-A	BWRVIP-03	BWRVIP-17/-55-A/-58-A	BWRVIP-62, R1/-190, R1
In-core housing/dry tube	BWRVIP-47-A	BWRVIP-03	BWRVIP-17/-55-A	BWRVIP-62, R1/-190, R1
Instrument penetrations	BWRVIP-49-A	BWRVIP-03	BWRVIP-57-A	BWRVIP-62, R1/-190, R1
LPCI coupling	BWRVIP-42, R1	BWRVIP-03	BWRVIP-56-A	N/A
Vessel ID brackets	BWRVIP-48-A	BWRVIP-03	BWRVIP-52-A	BWRVIP-62, R1/-190, R1
Reactor pressure vessel	BWRVIP-74-A	N/A	N/A	N/A
Primary system piping	BWVIP-75-A	N/A	N/A	BWRVIP-62, R1/-190, R1
Steam dryer	BWRVIP-139-A	BWRVIP-03	BWRVIP-181-A	N/A
Access hole cover	BWRVIP-180	BWRVIP-03	N/A	BWRVIP-62, R1/-190, R1
Top guide grid beam	BWRVIP-183	BWRVIP-03	BWRVIP-50-A	N/A
Bottom head drain line	BWRVIP-205	N/A	BWRVIP-208	N/A

Utility Implementation of BWRVIP Guidelines

- Utilities have voluntarily committed to implement BWRVIP guidelines:
  - BWRVIP letters to NRC
  - Consistent with Nuclear Energy Institute (NEI) 03-08 Guideline for Management of Materials Issues
- BWRVIP-94 establishes framework for implementing BWRVIP guidance:
  - Requires that utilities develop/strengthen their inspection programs consistent with BWRVIP guidelines
  - Implement BWRVIP guidelines (as approved by Executive Committee) within two refueling outages
  - Deviations from BWRVIP guidelines require a NEI 03-08 deviation disposition (i.e., Executive level approved technical justification)
  - Notify NRC within 45 days of deviations from NRC-approved guidelines

Strategic Plan and Current Research Gaps

NEI 03-08 Integrated Materials Issues Strategic Plan

- Provides Systematic Approach to Managing Materials Issues
  - Identify vulnerabilities
  - Assess condition (inspect & evaluate)
  - Mitigate degradation initiation and propagation mechanism
  - Repair or replace as required
- Approach Used:
  - Degradation Matrix and Issue Management Tables
    - Degradation Matrix and Issues Management Tables to be maintained as living documents with periodic updates

Issue Management Tables

- BWRVIP Prepares the BWR Issue Management Tables (IMTs)
  - Initial version utilized BWRVIP-06, Safety Assessment
  - Identifies and prioritizes “gaps”
  - Information reflects current state of the BWRVIP Program
  - First published as BWRVIP-167 in March 2007 and then updated 2 to 3 years thereafter
  - Current version is BWRVIP-167NP, Revision 3, published in 2013

Current IMT High Priority Gaps (as of 12/12/2014)

GAP	Description	2015 BWRVIP Tasks ( )=Unfunded	2016 BWRVIP Tasks ( )=Unfunded
B-AS-07	Environmental Effects on Fatigue Resistance: Pressure Boundary Components [LTO - Direct]	(2.11), 2.31	2.11, 2.31
B-AS-09	Assess the Impact of High Fluence on Fracture Toughness [LTO - Indirect]	2.7, 2.34	2.7, 2.34
B-AS-10	Assess the Impact of High Fluence and HWC Mitigation Tech on SCC Crack Growth Rates [LTO - Indirect]	2.5, 2.6, (2.39)	2.5, 2.6, (2.39)
B-AS-18	Jet Pump Degradation Management	2.17	2.17
B-AS-26	High Strength Alloys [LTO - Indirect]	2.15	2.15
B-AS-30	Material Surveillance Program Implementation for 80-Year Service Lives [LTO - Direct] **(M to H)**	2.38	2.38
B-AS-32	Assessment of Core Plate Rim Hold Down Bolts	2.18	2.18
B-AS-34	Assess Impact of Shallow Surface Breaking Flaws on Rx Vessel Integrity During Leak Test **(New)**	2.40	2.40
B-AS-35	Estimation of Initial Fracture Toughness Properties for Low Alloy Pressure Vessel Steels (BTP 5-3) **(New)**	2.42	N/A
B-MT-02	ECP Measurement, Estimation, and Validation	(3.15), (3.20)	(3.15), 3.20
B-MT-04	On-Line NMCA Deposition Effectiveness and Implementation	3.1, 3.5, 3.8, 3.14, 3.17, (3.20), (3.21), (3.22)	3.1, 3.5, 3.8, 3.17, 3.20, (3.22), (3.23), (3.24)
B-MT-05	Water Chemistry Optimization for Power Operation, Startup and Shutdown	3.1, 3.10	3.1, 3.10, (3.23), (3.24)
B-I&E-03	Inspection of Shroud & Shroud Support Weld Locations	2.27	2.27
B-RR-02	Welding Processes for Repair of Irradiated Material [LTO - indirect]	2.21	2.21
B-RG-05	Evaluation of Remote EVT-1	2.27, 2.28	2.27, 2.28
B-RG-09	Management of License Renewal Issues [LTO - Indirect]	Many	Many

Current IMT Medium Priority Gaps (as of 12/12/2014)

GAP	Description	2015 BWRVIP Tasks ( ) = Unfunded	2016 BWRVIP Tasks ( ) = Unfunded
B-DM-06	Environmental Effects on Fracture Resistance		
B-DM-07	Chloride Transient Effects on Low Alloy Steel Crack Growth Rates	3.10, (2.36),	3.10, 2.36, (3.23)
B-AS-05	Assess Neutron Dose Rate Effects on Embrittlement of C&LAS [LTO - Indirect]	DOE	DOE
B-AS-11	Assess Non BWR Reactor Irradiated Materials Data Applicability to the BWR Environment [LTO - Indirect]	2.6	2.6
B-AS-15	FIV and High Cycle Fatigue Assessment: Reactor Internals		
B-AS-22	High-Cycle Thermal Fatigue: Piping Locations	(2.12)	(2.12)
B-AS-27	Alloy 182 / Creviced Alloy 600 SCC Susceptibility & Irradiation Effects [LTO - Indirect]		
B-AS-28	Impact of BWR Nozzle Penetrations on Pressure-Temperature Limit Curves [LTO - Indirect]		
B-AS-33	Equivalent Margins Analysis for BWR Nozzles [new gap] [LTO - Direct]	(2.35)	(2.35)
B-AS-36	Fluence Attenuation and Cavity Streaming Effects Outside the RPV Beltline **(New)**		
B-MT-01	Alternative Mitigation Technologies	(2.24), MRP	(2.24), MRP
B-I&E-01	Inspection of Core Plate Rim Hold Down Bolts	2.18	2.18
B-I&E-02	Inspection of Hidden Weld Locations (Thermal Sleeves & Piping)	2.27	2.27
B-I&E-10	UT of Group 3 Jet Pump Beams **(New)**		2.27
B-RR-05	Alternate High-Strength Materials	PSCR, ARRM	PSCR, ARRM
B-RR-08	Availability of Laser Welding for Repairs to Highly Irradiated Components [LTO - indirect]	2.21	2.21
B-RG-10	R.G. 1.161 and ASME Section XI Appendix K Stress Intensity Factor Equation Non-conservatisms [new gap]		

Current IMT Low Priority Gaps (as of 12/12/2014)

GAP	Description	2014 BWRVIP Tasks ( ) = Unfunded	2015 BWRVIP Tasks ( ) = Unfunded
B-DM-03	Low Temperature Crack Propagation	PSCR	PSCR
B-DM-08	Long-Term Neutron Fluence Effect on Low Alloy Steel Cracking Susceptibility [LTO - Indirect]		
B-DM-09	Long-Term SCC Susceptibility (Late Life SCC Initiation) [LTO - Indirect]		
B-AS-12	Thermal & Irradiation Embrittlement: Synergistic Effects (on CASS BWR Reactor Internals) [LTO - Indirect]		
B-AS-14	Environmental Effects on Fatigue Resistance: Reactor Internals [LTO - Direct]	2.31	2.31
B-AS-20	Assess Non-Safety Locations		
B-AS-29	Steam Dryer Evaluation Methodology	(2.8)	(2.8)
B-AS-31	BWRVIP-47-A (CRGT) Re-Inspection Requirements		
B-I&E-06	NDE Capability: CASS Components	NDEC	NDEC
B-I&E-08	Inspection and Evaluation Guidance for Repairs		
B-I&E-09	Examination Techniques for Detection of Loss of Preload in Reactor Internals Components		
B-I&E-11	UT of BWR/6 Top Guide Grid Beams **(New)**		2.27

2015 BWRVIP Major Tasks

2015 BWRVIP Major Tasks

- Evaluation of Shroud Cracking (NDE & Boat Sample Analysis at a BWR-4)
  - This topic will be presented later during the Technical exchange meeting.
- Core Spray Inspection and Evaluation Guidelines Optimization (BWRVIP-18 rev. 2)
  - Currently the Core Spray I&E guideline has been submitted to NRC with a meeting held on May 27th 2015.
- Jet Pump Inspection and Evaluation Guideline Optimization (BWRVIP-41 rev. 4)
  - This topic will be presented later during the Technical exchange meeting.

2015 BWRVIP Mitigation Committee Tasks

- Platinum Modeling Efforts using the modeling engine from the BWRVIA model.
- Laboratory Testing of Low Alloy Steel (LAS) when exposed to low levels of chloride such as 5 ppb or less. Impacts to the BWRVIP Water Chemistry guidelines are under review.
- Fleet wide chemistry data collection continues to support chemistry reports and data evaluation and assessment.

Status of Key NRC Topics

Status of Key Topics with NRC

- Remote VT Round Robin
- BWRVIP-62, Rev 1 - Inspection Relief with OLNC & HWC
- BWRVIP-234 - Evaluation of CASS in BWR Internals
- Integrated Surveillance Program (ISP) for BWRs

Involvement in Industry Wide Projects

- Remote VT Round Robin
  - BWRVIP co-funds the project
  - There is extensive use of remote VT by the BWRVIP Inspection & Evaluation Guidelines (I&EGs) so the BWRVIP is a major stakeholder in the project
  - A Phase 3 planning meeting was held August 5 & 6, 2014 in Charlotte. NRC and PNNL attended.
  - Phase 3 Round Robin testing begins 3rd quarter 2015.

Topical Report Reviews

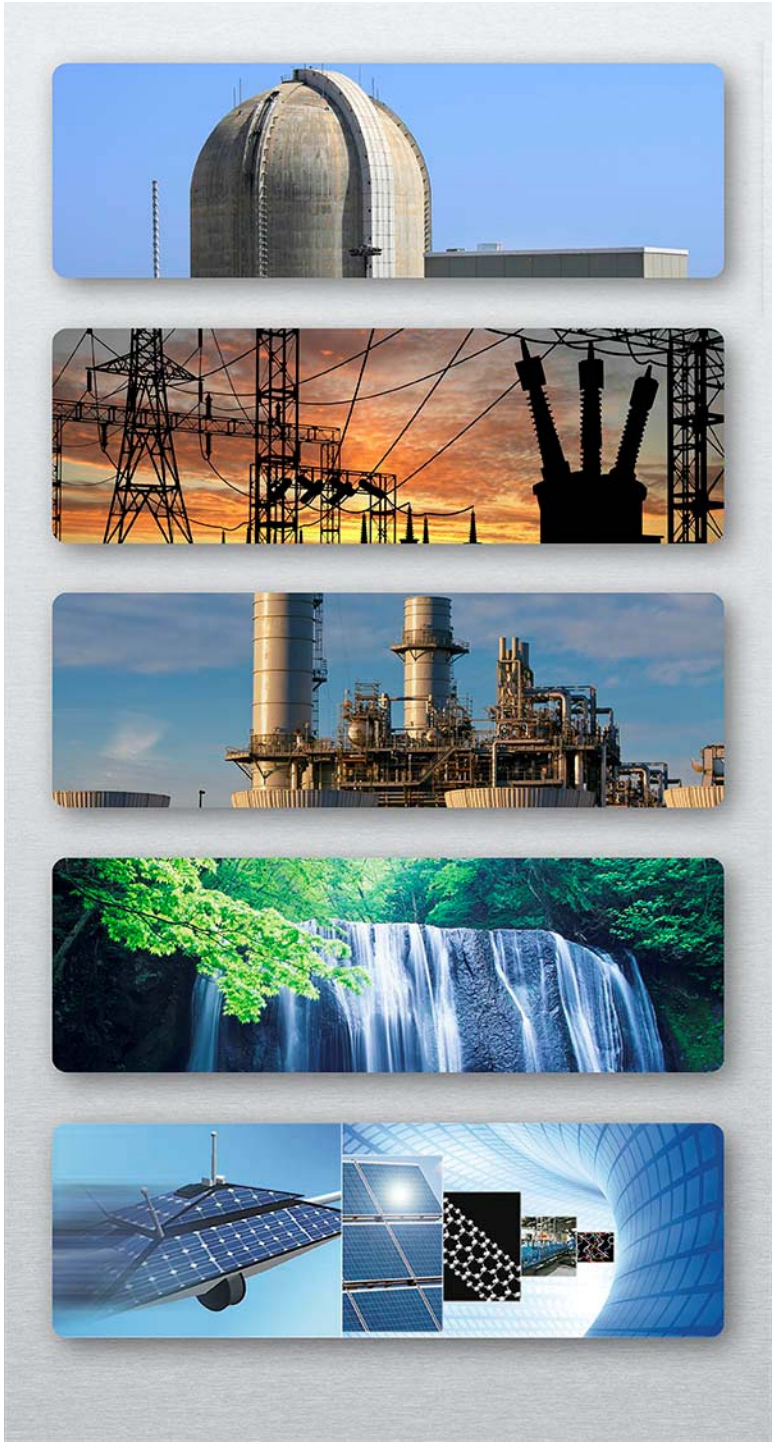
- BWRVIP-62, Rev 1 (Inspection Relief with OLNC & HWC)
  - Submitted to the NRC March 7, 2012
  - NRC requested review of many of the reference documents for BWRVIP-62, Rev 1
  - Good communications between Industry and Staff with several teleconference and a face-to-face meeting (March 28, 2013) held to outline the issues and work toward resolution
  - RAIs received from the staff in March 2014.
  - A meeting with the staff was held July 18, 2014 to discuss potential responses to the RAI's.
  - The BWRVIP is performing additional research activities to fully address the questions raised by the RAI's.

Topical Report Reviews Cont.

- BWRVIP-234 (Evaluation of CASS in BWR Internals)
  - Technical report submitted to the NRC in September 2010
  - 1st RAI was received in September 2011 and response provided in September 2012
  - 2nd RAI was received in April 2013 and response provided in May 2014
- Industry (MRP and BWRVIP) and the Staff held meeting in May 2013 to discuss issues related to developing a common industry approach for TE and IE of CASS
- BWRVIP/MRP Industry position on TE and IE issued in May 2014 as part of 2nd RAI response
- NRC position issued on June 2014
- Follow-up meeting
  - July 2014 public meeting at NRC Headquarters
  - Additional technical bases to support industry position informally submitted to NRC in Oct 2014
  - Conference call held with NRC in November 2014 to discuss additional industry technical bases
    - NRC feedback indicated that the industry revised position may not be acceptable in that the staff remains favoring their June 2014 position
  - Industry formally transmitted additional technical bases to NRC in March 2015
- BWRVIP has requested NRC to disposition the BWRVIP-234 RAI responses and issue a Safety Evaluation

Integrated Surveillance Program (ISP) for BWRs

- Due to the BWRVIP's capsule testing process, which includes BWRVIP Committee review and approval of the capsule reports because they can affect not only the host plant, but other plants in the US BWR fleet, ISP capsule reports cannot be completed within one-year. Thus, extensions of the 10CFR50, Appendix H, reporting requirement from 12 to 18 months are necessary.
- An ISP surveillance capsule was pulled from Hope Creek in April of 2015.
- The extension request for the Hope Creek capsule report was submitted by the BWRVIP to the staff on May 11th, 2015 to the Division of Operating Reactor Licensing (DORL).
- The BWRVIP expects that review of the extension request and communication of the results to the licensee will be completed prior to the 1 year anniversary date of the capsule pull.



EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Submittals to the NRC

Topical Report Reviews

Recent Safety Evaluations or Approvals of “-A” Reports

- BWRVIP-86, Revision 1-A, Integrated Surveillance Program (“-A” approval 03/26/14)
- BWRVIP-76, Revision 1, Core Shroud Inspection and Evaluation Guidelines (Final SE 11/12/2014)

Topical Report Reviews

Submittals for Review and Approval that are Still in Process (continued):

- BWRVIP-183, Top Guide Grid Beam Inspection and Evaluation Guidelines (submitted 01/15/2008). In BWRVIP's house to address conditions in draft SE with the draft SE response currently in committee review and to be submitted in the near future.
- BWRVIP-234, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels for BWR Internals (submitted 9/10/2010). In NRC's house for Final SE.
- BWRVIP-100, Revision 1, Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds (submitted 02/07/2012). In BWRVIP's house for RAI response with RAI response currently in committee review and to be submitted in the near future.

Topical Report Reviews

Submittals for Review and Approval that are Still in Process (continued):

- BWRVIP-62, Revision 1, Technical Basis for HWC Inspection Relief, Including OLNC (submitted 03/07/2012). In BWRVIP's house for RAI response with submittal expected by 12/31/2015.
- BWRVIP-18, Revision 2, Optimized Core Spray Inspection and Evaluation Guidelines (submitted 05/09/2012). In NRC's house for final SE with draft SE provided by NRC on 02/23/2015.
- BWRVIP-241 License Renewal Appendix, LR Appendix for Probabilistic Fracture Mechanics Evaluation for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii (submitted 10/12/2012). In NRC's house for initial review.

Topical Report Reviews

Submittals for Review and Approval that are Still in Process (continued):

- BWRVIP-42, Revision 1, Low Pressure Core Injection Coupling Inspection and Evaluation Guidelines (submitted 11/06/2012). In BWRVIP's house for RAI response with RAI response currently in committee review and to be submitted in the near future.
- BWRVIP-84, Revision 2, Guidelines For Selection and Use of Materials for Repairs to BWR Internal Components (submitted 03/13/2013). In NRC's house for Final SE.
- BWRVIP-139-A License Renewal Appendix, LR Appendix for Steam Dryer Inspection and Evaluation Guidelines (submitted 02/21/2014). In BWRVIP's house for RAI response with RAI response currently in committee review and to be submitted in the near future.
- BWRVIP-41, Revision 4, Optimized Inspection and Evaluation Guidelines for Jet Pump Assemblies (submitted 09/24/2014). In the NRC's house for initial review.

Topical Report Reviews

Safety Evaluations Expected in the Near Term:

- BWRVIP-18, Revision 2, Core Spray Inspection & Evaluation Guidelines
  - Draft SE provided on 02/23/2015.
- BWRVIP-234, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels for BWR Internals
  - RAI response provided to NRC May 23, 2014.
- BWRVIP-84, Revision 2, Guidelines For Selection and Use of Materials for Repairs to BWR Internal Components
  - RAI response provided to NRC February 17, 2015.

Topical Report Reviews

BWRVIP Report Submittals Expected in 2015:

- BWRVIP-25, Revision 1, Core Plate Inspection and Flaw Evaluation Guidelines. Revision to address inspection of core plate bolts and updates to address GEH Safety Communications (SCs).
  - Note: The revision addresses the inability to inspect core plate bolts under the current guidance, for which there are currently 17 Deviations. The duration of all the Deviations is through 2015 because it was anticipated that BWRVIP-25, Rev. 1 would be submitted and approved by the NRC by that time. However, addressing the GEH SCs delayed completion of the report. The affected plants will be processing extensions for their deviations before the end of the year.

BWRVIP Contact Information

- Drew Odell – BWRVIP Integration Chairman .
  610-765-5483 (w), 610-212-1155 (c), andrew.odell@exeloncorp.com

- EPRI BWRVIP Committee Contacts
  - Inspection: Jeff Landrum 704-595-2553 jlandrum@epri.com
  - Assessment: Bob Carter 704-595-2519 bcarter@epri.com
  - Repair: Nathan Palm 724-288-4043 npalm@epri.com
  - Mitigation: Raj Pathania 650-855-8762 rpathani@epri.com
  - Integration: Chuck Wirtz 440-346-7124 cwirtz@contractor.epri.com
  - MAPC-NRC: Robin Dyle 205-426-5371 rdyle@epri.com
  - General BWRVIP Comms: Amardeep Mehat 650-855-2046 amehat@epri.com
  - Program Manager: Andy McGehee 704-502-6440 amcgehee@epri.com

NRC BWRVIP training opportunities

- San Jose IVVI class available – 3 years remain on existing contract.
- In years past a one day training class has been provided.
- The BWRVIP is open to discuss training support.

Together…Shaping the Future of Electricity

Background Information

- Additional slides follow if needed.