BWR Vessel and Internals Project Update

Drew Odell, Exelon
BWRVIP Integration Committee Technical Chairman

Andy McGehee, EPRI
BWRVIP Program Manager

EPRI-NRC Technical Exchange Meetings
May 22-24, 2018

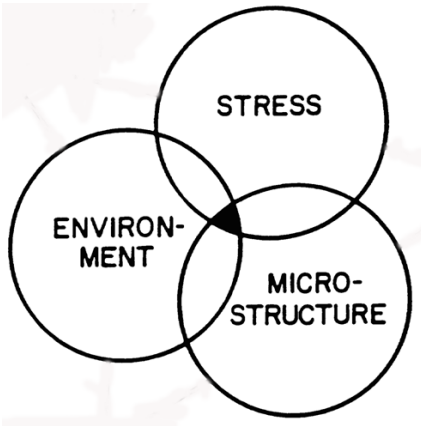
Overview Outline

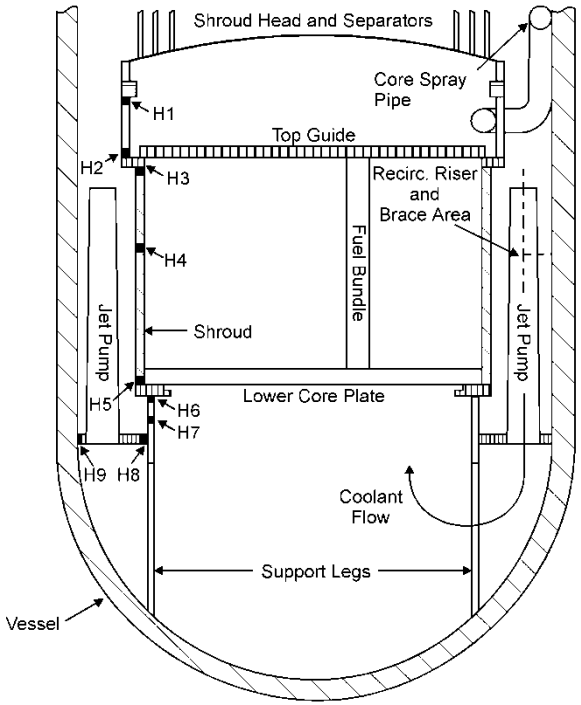
- Background
- Current Members and Organization
- BWRVIP Guidelines and Implementation
- Strategic Plan and Current Research Gaps
- BWRVIP Major Tasks
- NRC Interactions
- Training Opportunity for the NRC
- Contact Information

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

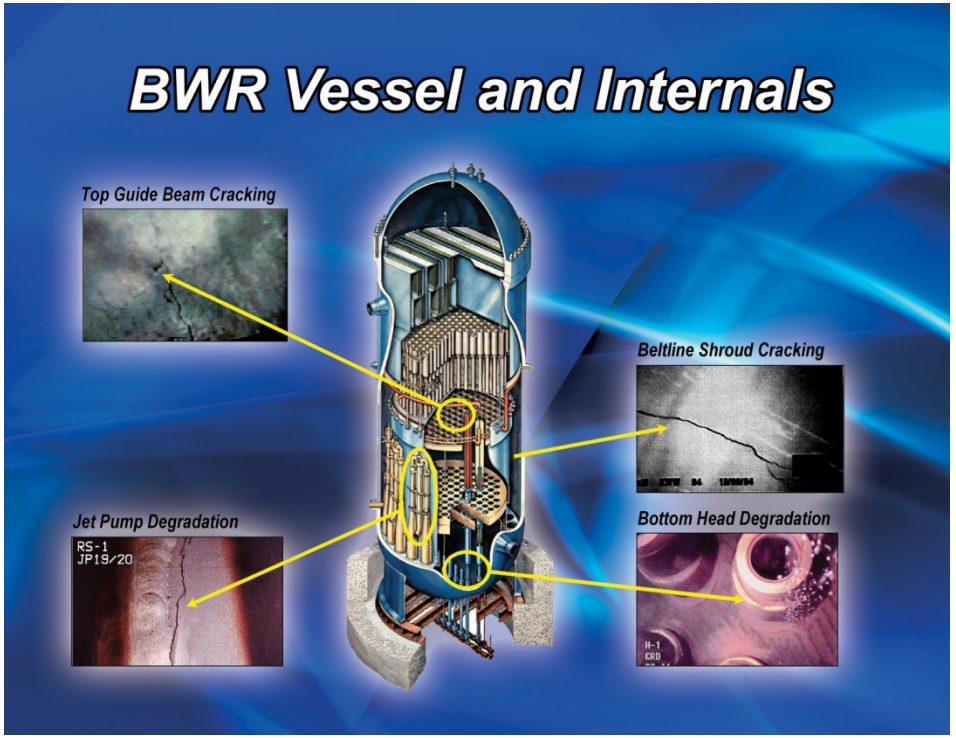




- Shroud cracking in 1993-1994 confirmed that IGSCC of internals is a significant issue for BWRs
- BWR utility executives formed the BWRVIP in mid-1994 to proactively address BWR reactor vessel and internals material condition issues
- The goal was to lead industry toward proactive generic resolution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

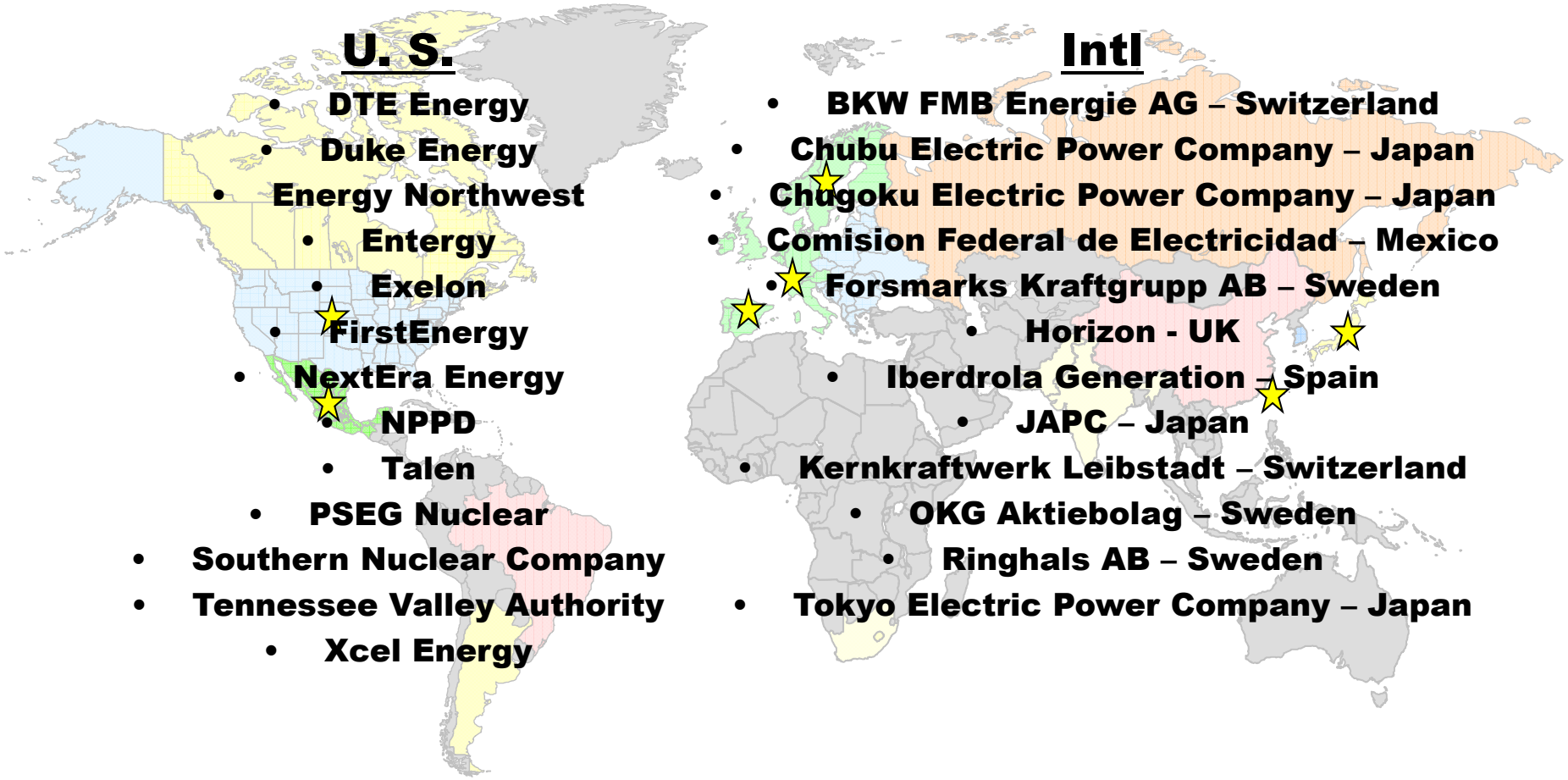


BWRVIP & NEI 03-08

- 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

2018 BWRVIP Member Utilities



U. S.

- DTE Energy
- Duke Energy
- Energy Northwest
- Entergy
- Exelon
- FirstEnergy
- NextEra Energy
- NPPD
- Talen
- 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
- Horizon - UK
- Iberdrola Generation – Spain
- JAPC – Japan
- Kernkraftwerk Leibstadt – Switzerland
- OKG Aktiebolag – Sweden
- Ringhals AB – Sweden
- Tokyo Electric Power Company – Japan

2018 BWRVIP Organization

Red = Vacant

Green = New

Executive Committee

Tim Hanley, Exelon (Chairman)

Paul Davison, PSEG (Vice-Chairman)

Andy McGehee, EPRI (Program Manager)

Executive Oversight Committee

Tim Hanley, Exelon	(EC Chairman)
Paul Davison, PSEG	(AC Exec Sponsor)
Vacant	(MC Exec Sponsor)
Michael Kessler, KKL	(International Sponsor)
Dennis Madison, Southern	(BWROG Chair)
Dave Czufin, TVA	(EOC at large)

Integration Committee

Drew Odell, Exelon (Chairman)

Chuck Wirtz, EPRI (Task Manager)

Assessment Committee

Steve Richter, Energy Northwest (Technical Chair)

Wynter McGruder, Xcel (Assessment Vice Chair)

Denver Atwood, Southern Nuclear (Repair Vice Chair)

Bob Carter, EPRI (Task Manager)

Inspection Committee

Christian McKean, Exelon (Chairman)

Shane Charbonnet, NPPD (Vice Chairman)

Jeff Landrum, EPRI (Task Manager)

Mitigation Committee

Vacant (Technical Chair)

David Willer, DTE (Technical Vice Chair)

Susan Garcia, EPRI (Task Manager)

Technical Committee Responsibilities

Assessment --	What needs to be inspected, when it needs to be inspected, inspection options, how to disposition observed degradation. Repair/replacement techniques are available including the associated requirements.
Inspection --	How to inspect, what equipment and techniques are available, what are the associated uncertainties.
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, R2-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
  - Update will be published 2019.

Current IMT High Priority Gaps (reflects 2018 approved budget)

GAP	Description	2017 BWRVIP Tasks ( )=Unfunded	2018 BWRVIP Tasks ( )=Unfunded	2019 BWRVIP Tasks ( )=Unfunded
B-AS-07	Environmental Effects on Fatigue Resistance: Pressure Boundary Components [LTO - Direct]	2.11, 2.31	2.11, 2.31	2.11, 2.31
B-AS-09	Assess the Impact of High Fluence on Fracture Toughness [LTO - Indirect]	2.7,	2.7	2.7
B-AS-10	Assess the Impact of High Fluence and HWC Mitigation Technologies on SCC Crack Growth Rates [LTO - Indirect]	2.5, 2.6, 2.39, 2.43	2.5, 2,6, 2.39, 2.43	2.5, 2,6, 2.39, 2.43, (2.51)
B-AS-18	Jet Pump Degradation Management **(funded through 2018, closed out in 2019)**	2.17	2.17	**Complete**
B-AS-26	High Strength Alloys [LTO - Indirect]	2.15	2.15	2.15 (2.46)
B-AS-30	Material Surveillance Program Implementation for 80-Year Service Lives [LTO - Direct]	2.38	2.38	2.38
B-AS-32	Assessment of Core Plate Rim Hold Down Bolts	2.18	**Complete**	N/A
B-AS-34	Assess Impact of Shallow Surface Breaking Flaws on Rx Vessel Integrity During Leak Test	2.40	2.40*	2.40*
B-AS-35	Estimation of Initial Fracture Toughness Properties for Low Alloy Pressure Vessel Steels (BTP 5-3)	Completed	N/A	N/A
B-AS-37	Atypical Core Shroud Cracking	2.41	2.41 **	2.41
B-MT-02	ECP Measurement, Estimation, and Validation	(3.15), 3.20, 3.27	(3.15), 3.20	3.20, (3.26), (3.27)
B-MT-04	On-Line NMCA Deposition Effectiveness and Implementation	3.1, 3.5, 3.8, 3.20, 3.22, (3.24), (3.25)	3.1, 3.5, 3.8, 3.20, 3.22, (3.24), (3.25)	3.1, 3.5, 3.8, 3.20, 3.22, (3.24), (3.25), (3.26), (3.27)
B-MT-05	Water Chemistry Optimization for Power Operation, Startup and Shutdown	3.1, 3.10, (3.23), (3.24)	3.1, 3.10, 3.23, (3.24)	3.1, 3.10, 3.23, (3.24)
B-I&E-03	Inspection of Shroud & Shroud Support Weld Locations	2.27	2.27	2.27
B-RR-02	Welding Processes for Repair of Irradiated Material [LTO - indirect]	2.21	2.21	2.21
B-RG-05	Evaluation of Remote EVT-1	2.27, 2.28	2.27, 2.28	2.27, 2.28
B-RG-09	Management of License Renewal Issues [LTO - Indirect]	Many	Many	Many

* Task 2.40 funding complete and now going through ASME Code. ** Task is working in 2018 (i.e., fleet implementation), but no funding is actually budgeted for 2018

Current IMT Medium Priority Gaps (reflects 2018 approved budget)

GAP	Description	2017 BWRVIP Tasks ( ) = Unfunded	2018 BWRVIP Tasks ( ) = Unfunded	2019 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, (3.23)	3.10, 2.36, 3.23	3.10, 2.36, 3.23
B-DM-10	Chloride Transient Effects on Stainless Steel and Nickel Alloys Crack Growth Rates	3.10	3.10	3.10
B-AS-05	Assess Neutron Dose Rate Effects on Embrittlement of C&LAS [LTO – Indirect]	DOE		
B-AS-11	Assess Non BWR Reactor Irradiated Materials Data Applicability to the BWR Environment [LTO – Indirect]	2.6	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	2.12
B-AS-27	Alloy 182 / Creviced Alloy 600 SCC Susceptibility & Irradiation Effects [LTO – Indirect]	2.53*	2.53*	2.53*
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	2.35
B-AS-36	Fluence Attenuation and Cavity Streaming Effects Outside the RPV Beltline			
B-MT-01	Alternative Mitigation Technologies	(2.24), MRP	2.24	2.24
B-I&E-01	Inspection of Core Plate Rim Hold Down Bolts	2.18	Complete	N/A
B-I&E-02	Inspection of Hidden Weld Locations (Thermal Sleeves & Piping)	2.27		
B-I&E-10	UT of Group 3 Jet Pump Beams	2.27		
B-RR-05	Alternate High-Strength Materials	PSCR, ARRM		
B-RR-08	Availability of Laser Welding for Repairs to Highly Irradiated Components [LTO – indirect]	2.21	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]			

* Task 2.53, Alloy 82 CGR Expert Panel, funded with reserve funds as authorized by the BWRVIP EOC on 8/23/17.

Current IMT Low Priority Gaps (reflects 2018 approved budget)

GAP	Description	2017 BWRVIP Tasks ( ) = Unfunded	2018 BWRVIP Tasks ( ) = Unfunded	2019 BWRVIP Tasks ( ) = Unfunded
B-DM-03	Low Temperature Crack Propagation	PSCR	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]			2.48
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	2.31
B-AS-20	Assess Non-Safety Locations	(2.9)	(2.9)	
B-AS-29	Steam Dryer Evaluation Methodology	Complete	N/A	N/A
B-AS-31	BWRVIP-47-A (CRGT) Re-Inspection Requirements		2.13	2.13
B-I&E-06	NDE Capability: CASS Components	NDEC	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	2.27	2.27	2.27

2018 BWRVIP Major Tasks

2018 BWRVIP Major Tasks

- IASCC research and inspection guidance
- Environmental effects on fatigue properties and fatigue crack growth curves for BWRs (EPRI TR# 3002012326 to be published in 2018)
- Crack growth testing, fracture toughness evaluations, and metallurgical examinations of highly irradiated materials (2019 Technical Report)
- Development of leakage evaluation guidance for reactor vessel internals (2019 Technical Report)
- Quantification of the effect of chemistry transients on stress corrosion cracking of low-alloy reactor pressure vessel steels and updated associated guidance (To be published in 2018 as BWRVIP-233, Rev 2, EPRI TR# 3002013026)

2018 BWRVIP Major Tasks

- Development of technical basis on BWRVIP materials aging to inform decisions regarding second license renewal in the United States and license extension outside the United States (To be published in 2018 as BWRVIP-316, EPRI TR# 3002012536)
- Development of a fleet-wide inspection results database and analysis tool that can be used to inform continued maintenance and optimization of BWRVIP inspection and evaluation guidelines (2019 Software Release)
- Continued optimization of guidance using inspection results and operational experience from the global fleet
- Continued updating of the MDM and BWR Issue Management Tables to ensure the highest priorities are being addressed (To be published in 2019 as BWRVIP-167, Revision 4, EPRI TR# TBD)
- Extension of the BWR Integrated Surveillance Program from 60 years to 80 years (To be published in 2018 as BWRVIP-321, EPRI TR# 3002013097)

Updates on BWRVIP Major Tasks and OE

- Updates on the following will be presented later in these meetings:
  - BWRVIP Mitigation activities
  - BWRVIP progress concerning Second License Renewal (SLR)
  - BWRVIP Integrated Surveillance Program (ISP) for SLR
  - Significant BWR Operating Experience (OE)

NRC Interactions

Outline for NRC Interactions

- Status of BWRVIP Report Submittals
  - Recently Received Safety Evaluations
  - Recent Approvals of “-A” Reports
  - Submittals Still in the Review Process
  - Expected 2018 Submittals

Recently Received Safety Evaluations

- No final safety evaluations (SEs) issued for BWRVIP reports since last year's Tech Exchange meetings
- Draft SE for BWRVIP-41, Revision 4, BWR Vessel and Internals Project, Jet Pump Assemble Inspection and Evaluation Guidelines, issued 4/23/2018
- BWRVIP verified the identification of proprietary information in the draft SE and requested some clarifications

Recent Approvals of "-A" Reports

- No "-A" report approvals issued for BWRVIP reports since last year's Tech Exchange meetings
- Approvals of the following BWRVIP "-A" reports that were recently submitted to NRC are expected in the near future:
  - BWRVIP-183-A, BWR Vessel and Internals Project, Top Guide Grid Beam Inspection and Evaluation Guidelines (submitted 1/19/2018)
  - BWRVIP-234-A, BWR Vessel and Internals Project, Thermal and Aging Neutron Embrittlement of Cast Austenitic Stainless Steels for BWR Internals (submitted 2/7/2018)
  - BWRVIP-42, Rev. 1-A, BWR Vessel and Internals Project, Low Pressure Coolant Injections (LPCI) Coupling Inspection and Evaluation Guidelines (submitted 2/28/2018)
  - BWRVIP-139, Rev. 1-A, BWR Vessel and Internals Project, Steam Dryer Inspection and Evaluation Guidelines (submitted 4/4/2018)

Submittals Still in the Review Process

(in submittal date order)

- BWRVIP-41, Rev 4, Optimized Jet Pump Inspection and Evaluation Guidelines, Submitted 09/24/2014
  - RAI for BWRVIP-41, Rev. 4 issued on 04/25/2016
  - BWRVIP response to RAI submitted on 02/19/2017
  - Draft SE issued on 4/23/2018
- BWRVIP-25, Revision 1, BWR Core Plate Inspection and Flaw Evaluation Guidelines, Submitted 09/26/2016 with a fee waiver request
  - NRC approved the fee waiver request on 11/7/2016
  - Acceptance for review letter issued on 12/14/2016
  - RAI for BWRVIP-25, Rev. 1 issued on 7/24/2017
  - BWRVIP response to RAI targeted for 9/30/2018

Expected 2018 Report Submittals

Submittal of Reports for Review and Approval:

- None

Submittal for Information Only:

- BWRVIP Fall 2018 Inspection Summary Report
- BWRVIP Spring 2019 Inspection Summary Report
- BWRVIP-03, Revision 20, RPV and Internals Examination Guidelines
- BWRVIP-307NP, BWR Vessel and Internals Project, Testing and Evaluation of the Dresden Unit 3 245º Surveillance Capsule
- BWRVIP-318NP, BWR Vessel and Internals Project, Testing and Evaluation of the Cooper 120º Surveillance Capsule
- BWRVIP-319NP, BWR Vessel and Internals Project, Testing and Evaluation of the Hatch Unit 2 120º Surveillance Capsule

Expected 2018 Report Submittals

Submittal of “-A” Reports:

- BWRVIP-41, Revision 4-A, BWR Vessel and Internals Project, Jet Pump Assembly Inspection and Evaluation Guidelines (late 2018 or early 2019)
- No others

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.

BWRVIP Contact Information

- Drew Odell – BWRVIP Integration Chairman .
  267-533-1444 (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
  - Assessment: Wayne Lunceford 650-855-8566 walunceford@epri.com
  - Assessment: Daniel Summerville 425-231-5903 dsommerville@epri.com
  - Assessment: John Hosler (704) 595-2720 jhosler@epri.com
  - Assessment & Repair: Nathan Palm 724-288-4043 npalm@epri.com
  - Mitigation: Susan Garcia 650-855-2731 sgarcia@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: Debbie Rouse 704-595-2520 drouse@epri.com
  - Program Manager: Andy McGehee 704-502-6440 amcgehee@epri.com

Together…Shaping the Future of Electricity