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Material Degradation / Aging MAPC Report

Mike Robinson,

Duke Energy

Industry/NRC Executive Meeting on Materials Programs
July 17, 2013

Contents

- Program Business
- Selected Technical Highlights
  - Support Committees
  - WRTC – welding
  - PSCR – fundamental materials science

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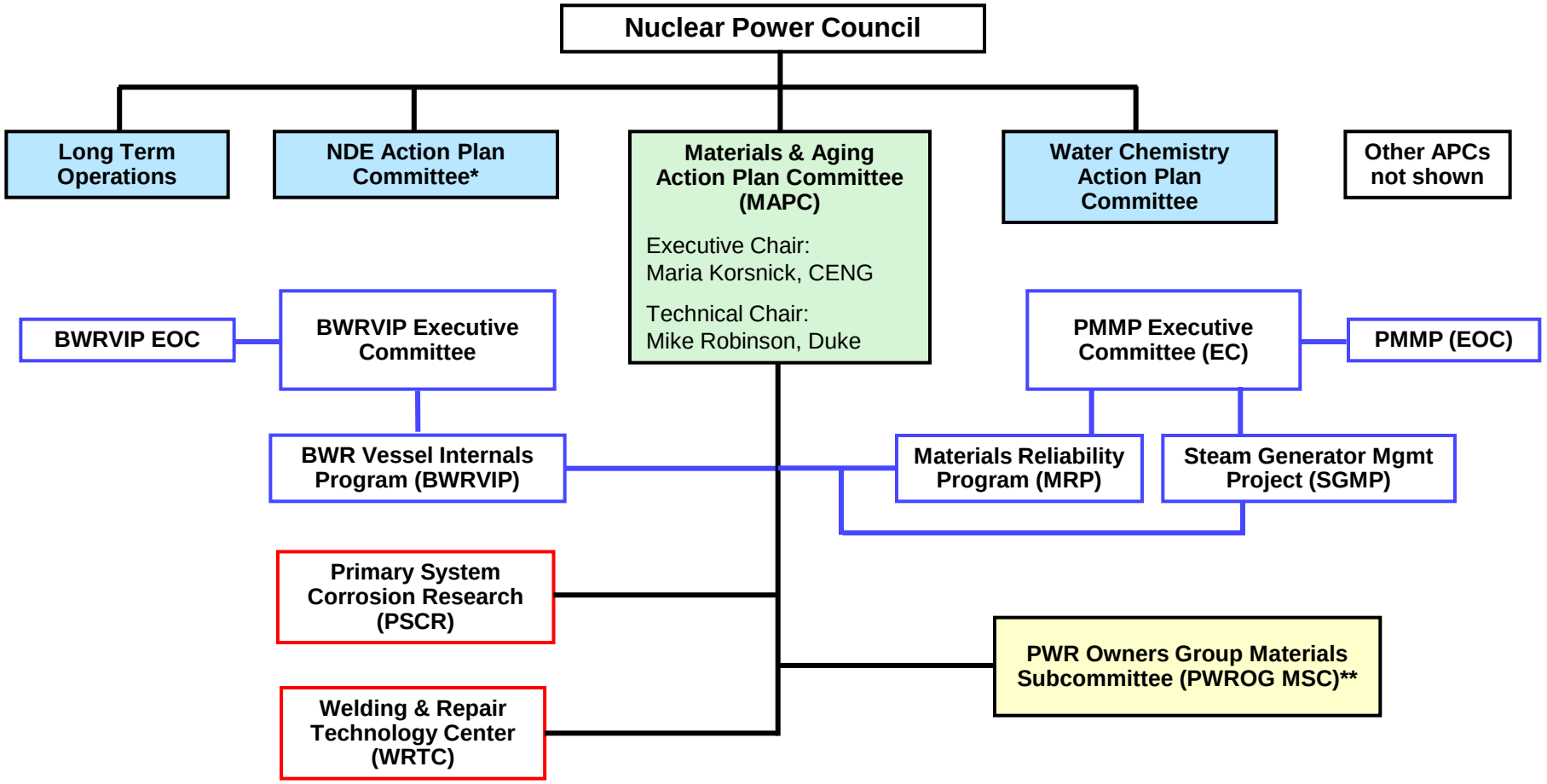
Program Business

Materials Support Committees



**NDE APC coordinates with Materials APC and PWR Owners Group*
***Materials Subcommittee has a representative on Materials APC*

Program Business

- Industry commitment to Materials Initiative (NEI 03-08) remains strong from executives to individual advisory level
  - 100% participation by all US nuclear utilities
  - IP leadership significant factor in continued successes of MAPC
  - Engaged participation from INPO and NEI
  - Funding relatively stable in this important area
- IPs performing industry's work on new guidelines and refreshing existing guidelines with new information/insights
- Strategic Plan – Safe and reliable plant operations
  - Aligned industry priorities
  - Common goals and objectives
  - Support for Long Term Operation and Subsequent License Renewal

Program Business (cont'd)

- Annual update to Nuclear Strategic Issues Advisory Committee (NSIAC):
  - Background of Materials Initiative (approach, coordination, budget, metrics, etc.)
  - Recent operating experience
  - Near-term industry challenges (welding irradiated materials, jet pump OE, NDE reliability, etc.)
  - Longer-term industry challenges (IASCC in BWRs, RPV embrittlement in PWRs, SCC of nickel based alloys, component fatigue life & effects of environment, etc.)
  - Assures strategic alignment at the CNO level

Key Issue Program Topics

- BWR Jet Pump Testing
- Optimizing BWR inspections
- PWR Bottom mounted nozzles
- Zorita materials testing
- PWR Reactor Internals
- Doel 3 follow-up
- NDE Improvements
- SG Channel Head assessments
- SG Thermal Hydraulics
- Materials Integration with Long Term Operation

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Welding & Repair Technology Center (WRTC)

Welding & Repair Technology Center – Key Activities

- Alloy 52 technical welding issues and solutions for DMW
  - Weldability improvements and understanding of material interactions
  - New high Cr alloy development
- Support of Weld Residual stress activities
  - Repair/mitigation processes for DMW locations
  - Process development for minimizing stress profile
- Advanced welding process and techniques for welding on irradiated materials (demonstrated at recent WRTC TAC)
    - Friction stir welding
    - Hybrid laser welding
- ASME Code Cases – repair and mitigation applications
  - Section XI Code Case support (Example: N754, N740, N770, N666)

Advanced Welding Technology

- MAPC leadership has increased strategic content of Welding and Repair Technology Center (WRTC)
  - Support current field welding issues
  - Investigate advanced techniques as long-term approach
  - Increased annual for advanced techniques to $1M/year

Advanced Welding Technology White Papers Drafted to Guide the Way

Advanced Welding Processes

- Techniques
  - Laser, Hybrid Laser
  - Friction Stir
  - Magnetic Stir
  - Electron Beam
  - Hot wire TIG
  - Thermal / Metal Spray
- Control / Automation
  - Programmable process controls
  - Track-based robotics, other robotics
  - Additive Manufacturing
  - Real-time NDE

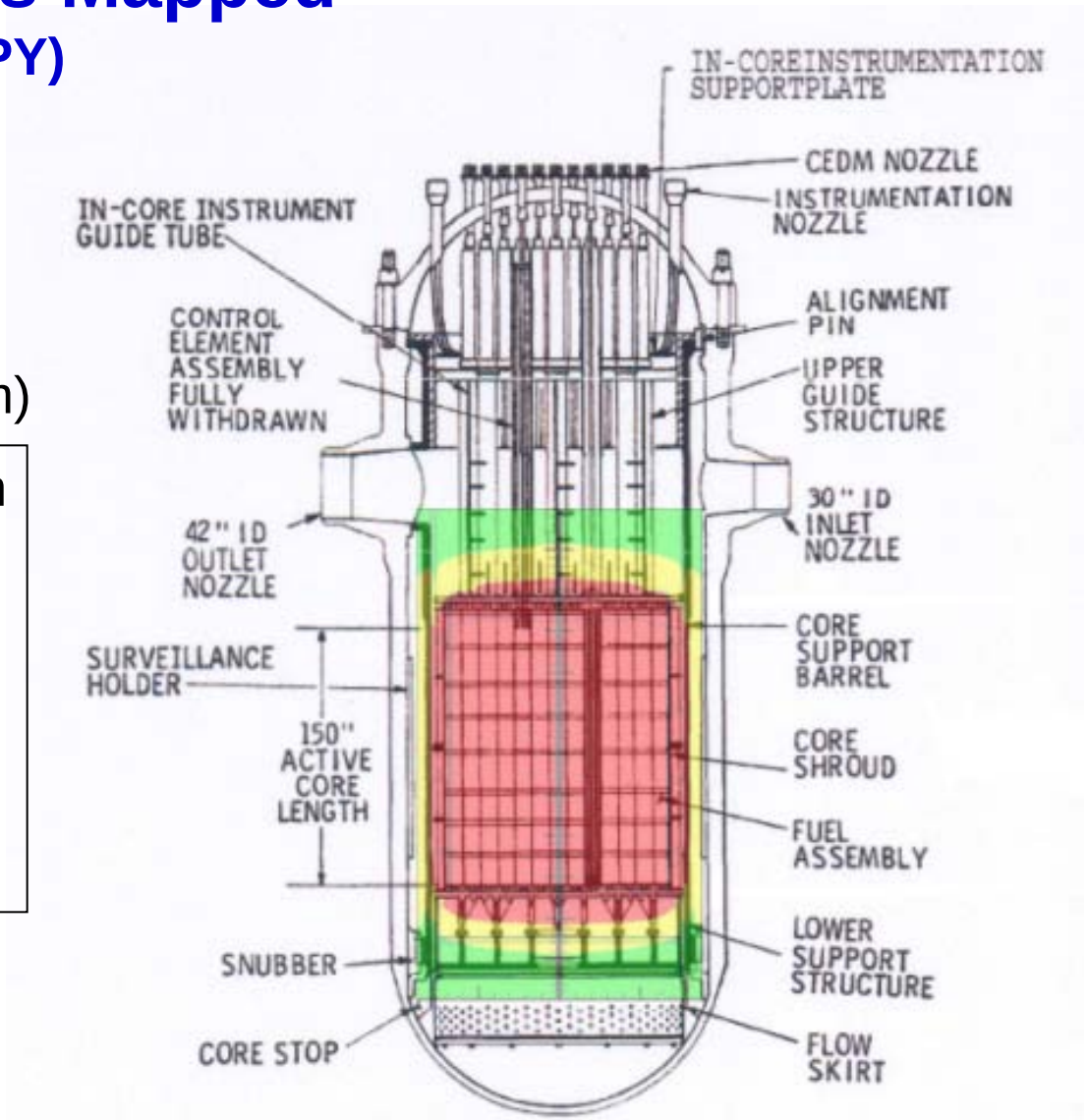
Applicability of Advanced Welding Systems

- Weldability Issues
  - Alloy 52/690
  - Irradiated Materials
  - Welding fit-up issues
  - Dissimilar metal welds
  - Underwater welding
  - Hardfacing
- Primary Nuclear Applications
  - Thick section plate
  - Narrow groove pipe & plate
  - Tube and tubesheet
  - Pipe weld overlays
  - Etc.

Welding Thresholds Mapped
(example is BWR at 60 EFPY)

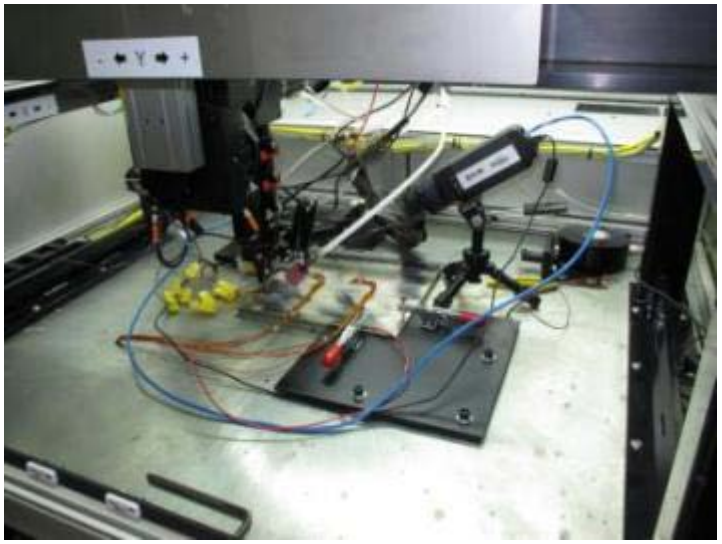
Welding Thresholds
(Zone He generation in appm)

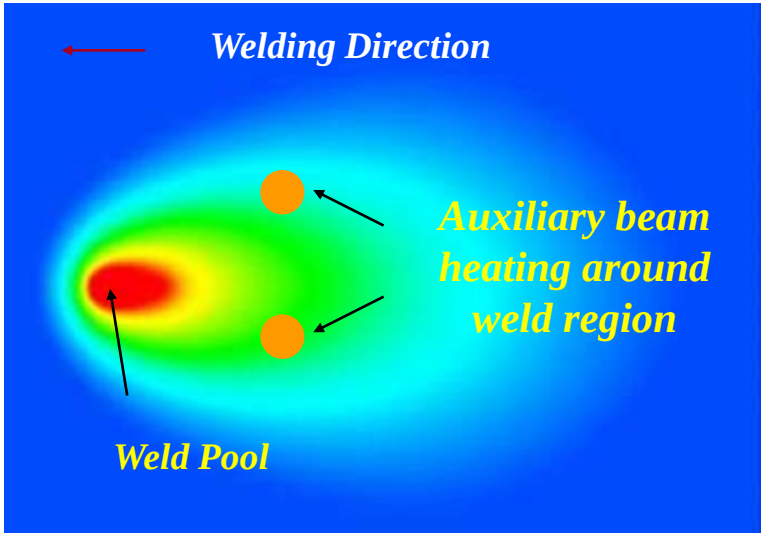
- Red >10: Not weldable with current welding processes
- Yellow 0.1 – 10: Weldable with heat input control
- Green <0.1: No special process control is needed



Potential Solution for Red Zone – Hybrid Laser

- Modeling indicates stress reversal can be achieved
- Advanced computational modeling will enable beam manipulation to control local stress/strain fields that interact with helium bubbles
  - Beam intensity
  - Spot size
  - Placement





Establish Weldability of High Cr Filler Metal (52/152)

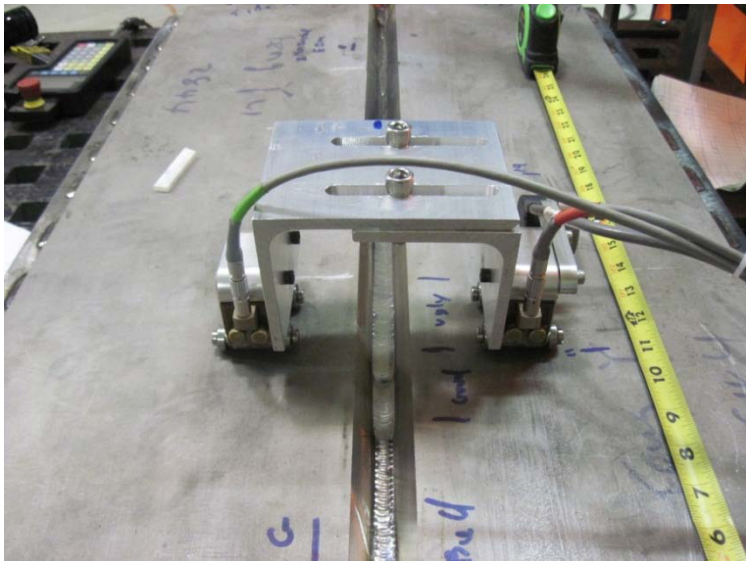
- Motivation
  - Cracking and general weldability problems with high Cr nickel-base filler metals (52 and 152 alloys)
  - Weldability varies widely with small changes in composition
- Objectives
  - Develop weldability performance data
  - Standardize approach for testing weldability of filler materials
  - Investigate influence of dilution of high Cr nickel-base filler metals by austenitic stainless steels

Example of hot cracking with 52M on CF8A pipe

Real-Time NDE – Collaborative NDE/WRTC/TI

- Real-time, online NDE method for flaw detection during welding could:
  - Avoid residual stresses during flaw repair
- Methods being evaluated include electromagnetic acoustic transducer (EMAT) and laser ultrasonic
- Includes collaborative work with INL

Example of EMAT Evaluation of Weld Integrity (Performed after each Weld bead)



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Primary Systems Corrosion Research (PSCR) – Fundamental Research

PSCR Support of Strategic Objectives

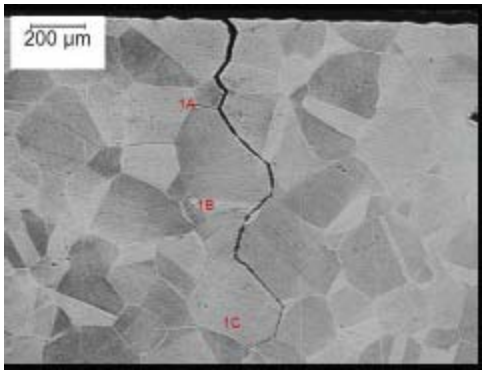
- PSCR program provides fundamental R&D in support of NEI 03-08 Materials Initiative
  - Proactively address RCS material performance knowledge gaps
  - Establishing technical basis for
    - physically based predictive models
    - identifying mitigation, repair or replacement options
  - Support for long term operation (LTO)

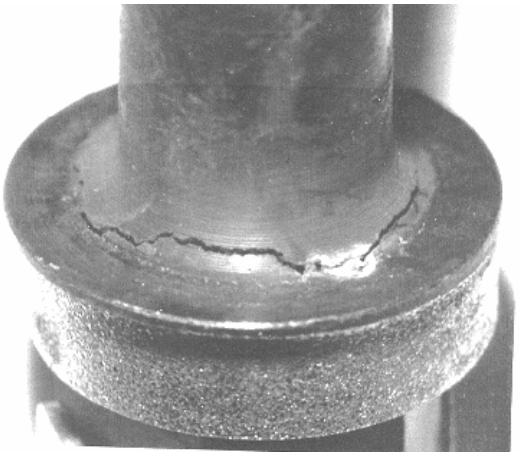
PSCR Strategies

- Conduct fundamental R&D to address key degradation issues identified in Material Degradation Matrix (MDM)
  - IASCC of SS and Ni-base alloys in BWR and PWR environments
  - Environmental effects on fracture resistance.
  - Environmental effects on fatigue life
- Collaboration: coordinate PSCR research with the materials issue programs and stakeholders
- Leverage: develop alliances with DOE and international partners to leverage research funds and knowledge

Major Challenges

- **Enhance prediction of the occurrence of environmentally assisted cracking for pressure boundary components:**
  - PWSCC of Ni-based alloys and welds
- **Enhance prediction of occurrence of irradiation assisted cracking for reactor internal components:**
  - Cracking of baffle bolts, shrouds, top guides…
- **Radiation resistant materials for repair and replacement of reactor internal components**
  - All current materials crack under irradiation





2013 PSCR Key Projects

- **Irradiated Materials Testing & IASCC Degradation Mechanism Studies**
  - Study of compositional effects on IASCC (EPRI-DOE co-funding)
  - APT study of microstructural effects on IASCC
  - CT specimen size and orientation effects on IASCC
  - Mechanistic study of localized deformation and IASCC (cause-&-effect)
  - **Expert panel on IASCC data compilation & CGR model**
  - **Development of IASCC resistant alloys (EPRI-DOE co-funding)**

- **SCC of Non-irradiated Stainless Steels and Ni-Base Alloy**
  - Japanese POLIM program on SCC mechanisms and prediction models
  - Oxide film and oxidation kinetics study on Ni-alloys and stainless steels
  - Role of creep and creep crack growth in EAC of austenitic materials
  - SCC initiation of Alloy 690 and SCC susceptibility of Ni alloy welds
  - Theoretical model for SCC/IASCC propagation
  - SCC initiation model for cold worked stainless steels

2013 PSCR Key Projects (cont'd)

- **Environmental Effects on Fracture Resistance**
  - Fracture resistance of irradiated stainless steel and non-irradiated Ni welds in LWR operating environments.
  - Scoping study of low temperature fracture property on thermally aged cast austenitic stainless steels
- **Environmental Fatigue**
  - Mechanistic understanding and modeling of EAF enhancement and retardation in BWR and PWR environments
- **Synergistic Effects in Degradation**
  - Synergetic effects of thermal aging and irradiation aging on degradation of stainless steel welds in reactor internals
- **MDM , Materials Information Portal and Materials Handbook**
  - MDM Revision-3 has been published in May 2013 *(EPRI Report - 3002000628)* Living document routinely updated to reflect change in knowledge and OE
  - Referenced by NRC EMDA

Recently Completed Works

- **PWSCC propagation models for Ni-Alloys**
  - Developed more accurate and mechanistically based PWSCC propagation models for Ni-base alloys and welds in PWR environment
  - Ready to be utilized for improvement of MRP-55 and MRP-115 disposition curves for PWSCC of Ni-based alloys and welds, and as an input to the xLPR program
- **Investigation of “rapid fracture” phenomenon**
  - Resolved one degradation mechanism gap that would potentially have severe impact to safety evaluation
  - The observed degradation was due to mechanical overloading, and was not caused by the effects of LWR environments

EPRI IASCC Data Compilation & Analysis
Objectives and Scope

Compile crack growth rate data on irradiated stainless steels

CIR-fast reactor irradiated materials Halden-LWR irradiated materials & in-reactor tests	BWRVIP and MRP irradiated materials Literature data (ANL NUREG reports, JNES reports)

Convene an Expert Panel

Review, screen and categorize the available data using consensus screening criteria	Panel includes principle investigators, selected industry experts, and vendors.

Recommend crack growth models and disposition curves

Crack growth models and disposition curves for irradiated stainless steels in BWR and PWR environments	Final report will be issued after review by PSCR, MRP, and BWRVIP

PSCR: Mechanistic understanding on IASCC

Objectives

- Identify the key factors influencing IASCC initiation and crack growth.
- Understand the linkage between irradiated microstructures and IASCC
- Confirm the processes that lead to occurrence of IASCC

Gaps

- Lack of understanding on IASCC
- No mitigation strategies available
- Uncertainty on reliability of components for LTO

ARRM Project

Advanced Radiation Resistant Materials (ARRM)

- EPRI and the U.S. Department of Energy (DOE) are initiating a global, collaborative research effort to develop the next generation of materials for in-core structural components and fasteners.
- The two primary research goals are:
  - By 2021, to develop and test a degradation-resistant alloy that is within current commercial alloy specifications
  - By 2024, to develop and test a new advanced alloy with superior degradation resistance
- 10-year project, estimated $12 -15 M work-scope
- Project work-scope defined by sponsors and managed by EPRI as was done in the CIR and NFIR programs

Summary

- RCS materials aging continues as a strategic focus area with broad support, commitment, and teamwork
- Continuing to support near-term and longer-term needs
- Making real technical and strategic progress in a number of key areas
- Committed to ongoing interchanges with NRC to share knowledge gained

Together…Shaping the Future of Electricity

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Boiling Water Reactor Vessel & Internals Project (BWRVIP)

Dennis Madison, Southern Company
BWRVIP Executive Chairman

Industry/NRC Executive Meeting on Materials Program
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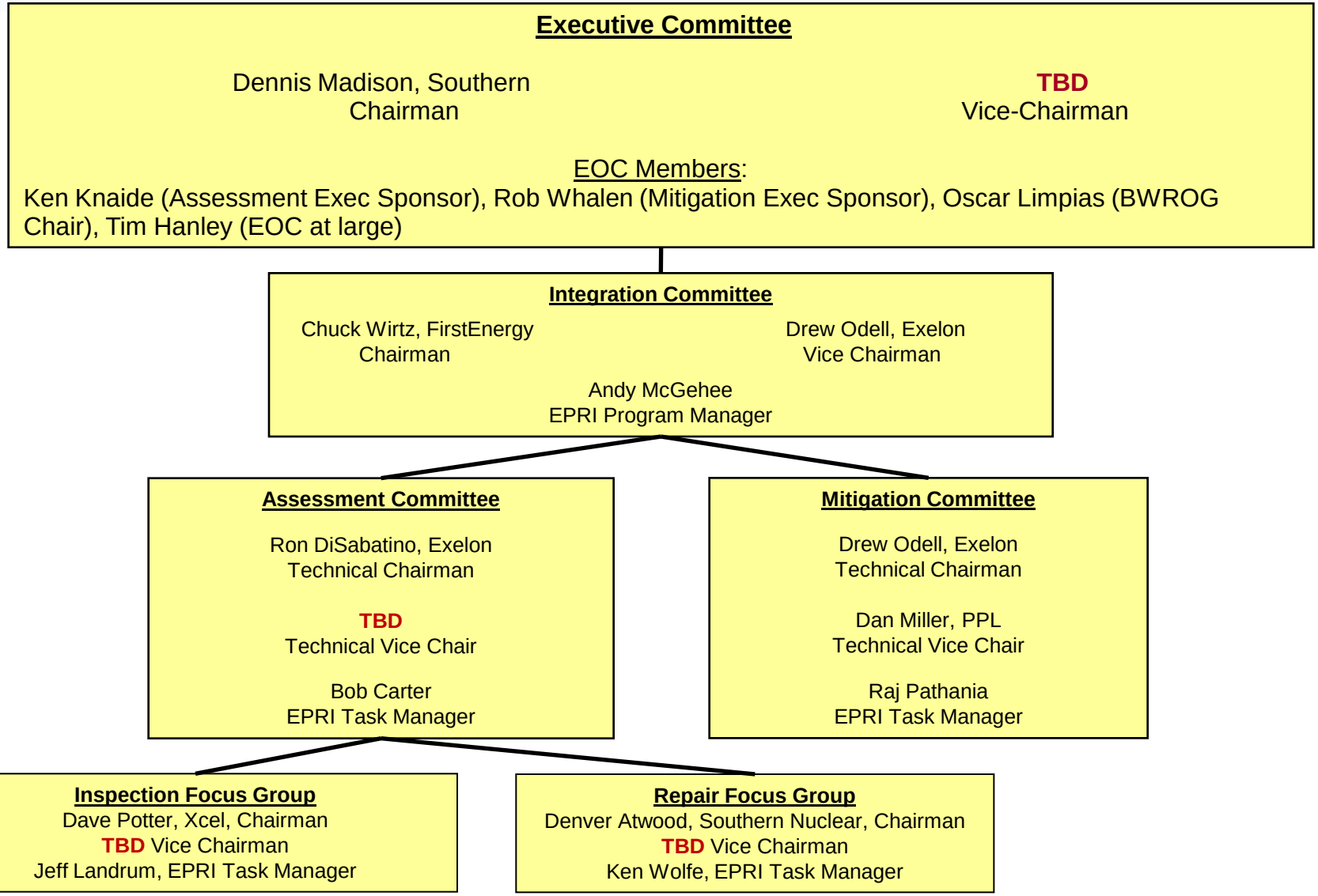
Presentation Outline

- BWRVIP Organization
- Key 2013 BWRVIP Activities
- FY 2014 Submittals to the NRC
- Topical Report Review Challenges

BWRVIP Organization



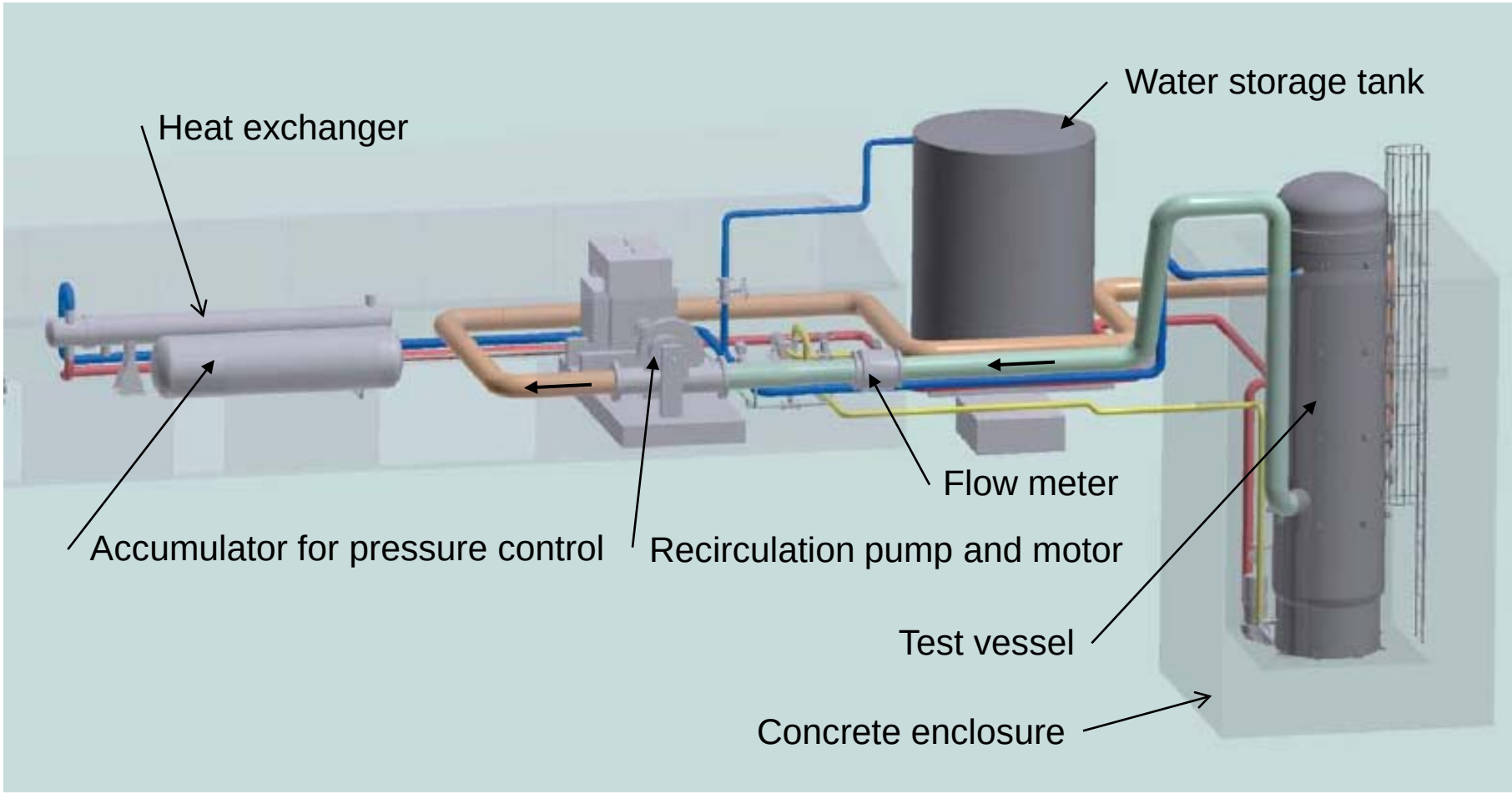
Key 2013 BWRVIP Activities

Key 2013 BWRVIP Activities

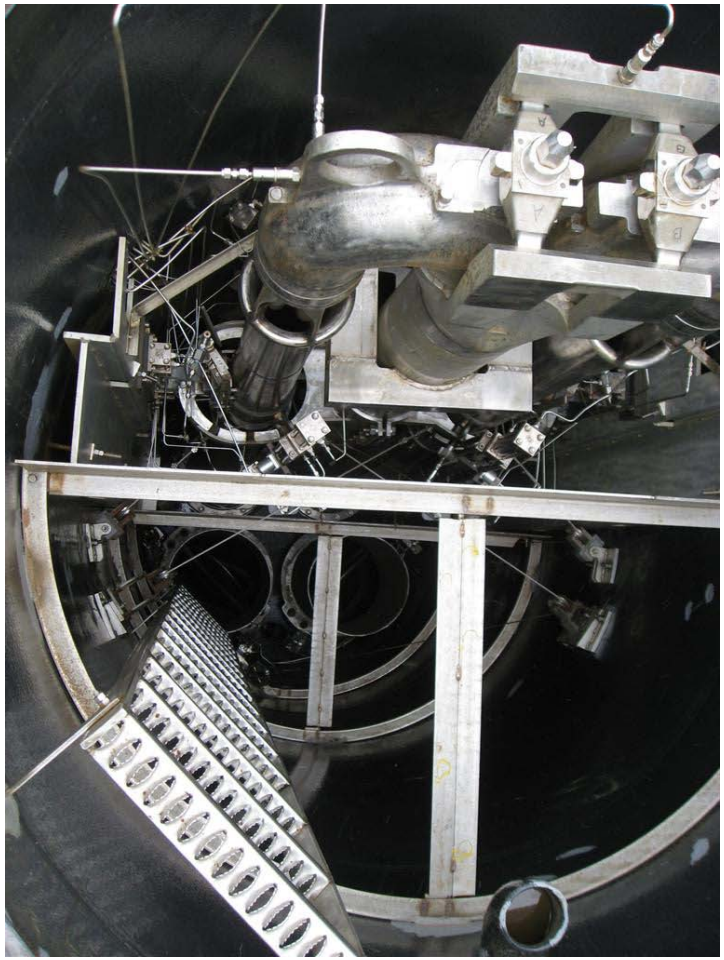
- Impacts of irradiation on BWR materials
  - Ongoing work at Studsvik looking at shroud material taken from Barseback plant
  - Ongoing study of X-750 & XM-19 material that we are working with Idaho National Labs
- 2013 Water Chemistry Guidelines Revision
  - Revision to the current BWR Water Chemistry Guidelines, which are BWRVIP-190
- Address Jet Pump Flow Induced Vibration Issues*
- Optimization of BWR internals inspection guidelines*
- General Electric-Hitachi (GEH) Recirculation Line Break loads Safety Communications*

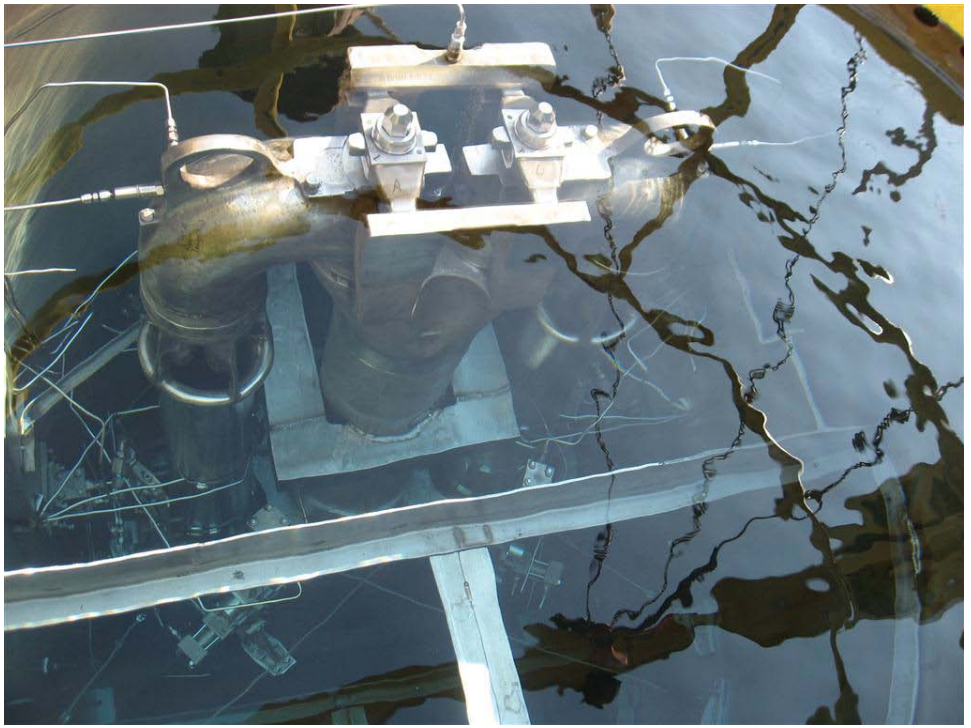
* Additional information provided in the following slides

Full Scale Jet Pump Test Facility



View from Top of Pressure Vessel





Filled with water

Status of Full Scale Jet Pump Testing

- Testing of the facility in the BWR/5 jet pump configuration was completed in Fall of 2012 and demonstrated that the test facility met all flow, temperature and pressure requirements, and was able to replicate the flow induced vibration (FIV) phenomena. The testing provided a significant amount of knowledge on the causes of jet pump FIV
- The first vendor demonstrations for FIV repair hardware were performed in Nov-Dec 2012
- No other vendors have performed demonstration testing, but vendors and utilities are using the facility for hardware fix developmental testing
- Currently evaluating need and design requirements to reconfigure test facility for BWR/4 testing

Optimization of Reactor Internals Inspection Guidelines

Optimize inspection programs based on:

- Latest field inspection data and fleet operating experience
- Evaluation of credit for benefits of HWC
- Current NDE capabilities

Key inputs include:

- Inspection database and survey results
- Crack growth studies
- Application of fracture mechanics

Current status:

- BWRVIP-18, Rev 2 with NRC for review
- Submittals of other optimized guidelines to await NRC feedback on BWRVIP-18, Rev 2
- BWRVIP-41, Rev 3 prepared
- Optimized version of BWRVIP-76 in progress

#	I&E Guideline	Bin
1	Core Spray (BWRVIP-18R1)	High
2	Jet Pump (BWRVIP-41R2)	
3	Shroud (BWRVIP-76)	
4	Shroud Support (BWRVIP-38)	
5	CRD Guide Tubes (BWRVIP47-A)	
6	Vessel ID Brackets (BWRVIP-48-A)	Medium
7	Top Guide Rims / Pins (BWRVIP26-A)	
8	SLC / Core DP Piping (BWRVIP-27-A)	
9	LPCI Coupling (BWRVIP-42-A)	
10	Access Hole Cover (BWRVIP-180)	
11	Jet Pump Beam (BWRVIP-138 R1)	
12	Top Guide Grid Beam (BWRVIP-183)	Low
13	Core Plate Bolts (BWRVIP-25)	
14	Steam Dryer (BWRVIP-139-A)	
15	Bottom Head Drain Piping (BWRVIP-205)	

GEH Recirculation Line Break (RLB) Loads Safety Communications

- GEH recently (early June) issued three Safety Communications (SCs) that deal with RLB loads
  - 09-03, Rev 1: Core Shroud Screening Reports (consideration of RLB acoustic loads in the reports)
  - 11-07, Rev 0: Impact of Inertial Loading and Potential New Load Combination from Recirculation Suction Line Break Acoustic Loads
  - 12-20, Rev 0: Error in Method of Characteristics Boundary Conditions Affecting Acoustic Loads Analyses
- SCs are an output of GEH's 10 CFR Part 21 evaluation program and all three of these SCs conclude that the issues do not present substantial safety concerns and are not reportable under Part 21

BWRVIP Actions regarding the GEH RLB Loads SCs

- Evaluate the impact of the SCs on existing BWRVIP Inspection and Evaluation Guidelines for BWR Vessel Internals
  - The scope of the SC's only affects core shrouds, core support plates, access hole covers and jet pump assemblies
- Utilize survey information recently collected for the Core Shroud I&E guidelines optimization project to identify the status of core shroud weld flaws across the US BWR fleet
- Consider whether generic action on the part of the BWRVIP to address the issues is feasible
- Further actions yet to be determined

FY 2014 Submittals to the NRC

FY 2014 Submittals to the NRC for Review & Approval

- BWRVIP-25, Rev 1: BWR Core Plate Bolt Inspection and Flaw Evaluation Guidelines …revision to address inability to perform inspections per current guidelines
- BWRVIP-41, Rev 4, BWR Jet Pump Assembly Inspection and Flaw Evaluation Guidelines …optimized version of the guidelines and will also incorporate BWRVIP-138-A jet pump beam requirements and hidden weld requirements
- BWRVIP-99, Rev 1, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components …revision to incorporate latest research results
- BWRVIP-181, Rev 1, Steam Dryer Repair Design Criteria …revision to incorporate operating experience
- "-A" versions of BWRVIP-100, Rev 1, BWRVIP-139, Rev 1, BWRVIP-194, BWRVIP-234 and BWRVIP-241

Topical Report Review Challenges

Topical Report Reviews

- The BWRVIP proactively develops inspection, assessment and repair guidance that primarily covers non-pressure boundary components (no ASME Code guidance) and thus submits a large number of topical reports to the NRC for review and approval.
- Historically, these submittals received an efficient review resultant from staff continuity and technical familiarity with the topics of the guidance being submitted.
- Turnover with the NRC staff (i.e., new reviewers) and an increased emphasis on the license renewal aspects of BWRVIP guidelines are providing challenges for some of the current reviews.
- Examples are provided on the following slides.

Topical Report Reviews

- BWRVIP-194, Methodology for Demonstrating Steam Dryer Integrity for Power Uprate
  - Submitted to the NRC October 31, 2008
  - RAI response submitted in September 2011 provided a complete update to the Acoustic Model (ACM 4.1) that is the model used for Nine Mile Point 1's approved License Renewal approval
  - BWRVIP-194 does not specifically address Westinghouse dryers, NRC questions whether it should
  - NRC aware of a Westinghouse update to the ACM 4.1 acoustic model and wanted BWRVIP to update BWRVIP-194 to reflect the newer acoustic model
  - Good communications between industry and Staff with several teleconference and a face-to-face meeting on March 27, 2013 being held to outline the issues and work toward resolution
  - BWRVIP position is no further revision of BWRVIP-194 and the NRC agreed to provide RAI on the current version

Topical Report Reviews

- BWRVIP-62, Rev 1, Inspection Relief with Online HWC
  - Submitted to the NRC March 7, 2012
  - NRC requesting review of many of the reference documents for BWRVIP-62, Rev 1 …BWRVIP is facilitating the reviews by making copies of the references, which contain proprietary information, available for the NRC's review at EPRI's Washington DC offices
  - NRC questioning some aspects of the already approved technology for classic Noble Metals Chemical Addition HWC
  - Good communications between industry and Staff with several teleconferences and a face-to-face meeting March 28, 2013 being held to outline the issues and work toward resolution

Topical Report Reviews

- BWRVIP-139 Appendix B, Steam Dryer Inspection and Evaluation Guidelines License Renewal Appendix
  - Submitted to the NRC July 27, 2009
  - Not prepared and submitted to the NRC at the same time as the parent I&E guidelines, which is atypical and was an oversight on the BWRVIP's part
  - Since submittal, RAI received and responded to and additional draft RAI received
  - Some RAI suggest changes to the NRC approved parent I&E guidelines (i.e., BWRVIP-139-A), and actions that would normally be addressed as licensee actions in the licensee's License Renewal application
  - Teleconference held with Staff on April 16, and going forward actions to address the RAI issues were agreed upon

Topical Report Reviews

- 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
  - NRC was headed towards issuance of SE with conditions and limitations related to screening criteria for evaluation of combined effects of thermal embrittlement and irradiation
  - Based on discussions with BWRVIP, NRC agreed to issue a 2nd RAI and it was issued on April 24, 2013
  - May 21, 2013 meeting with industry (MRP and BWRVIP) and the Staff to discuss issues related to evaluation of CASS
  - BWRVIP and MRP are now working closely together on this issue to respond to Staff concerns

Topical Report Reviews

- BWRVIP-42, Rev 1, Low Pressure Coolant Injection Coupling Inspection and Flaw Evaluation Guidelines
  - Submitted to the NRC December 10, 2012
  - Sole purpose of the revision was to incorporate requirements to address hidden welds, which was an open item from the NRC Safety Evaluation for Rev 0
  - Revision 1 uses same methodology to address hidden welds is used for Core Spray piping hidden welds and that was approved by the NRC (i.e., BWRVIP-18, Rev 1-A)
  - Draft RAI, received from the NRC June 12, 2013, questions some aspects from Rev 0 that were unchanged and aspects of the hidden weld methodology that were approved for the Core Spray hidden welds
  - A productive teleconference was held on July 2, 2013 in which the BWRVIP agreed that some clarifications to the unchanged portions of BWRVIP-42 would be helpful and the Staff agreed that a number of the RAI questions could be deleted

General Observations with Recent Topical Report Reviews

- In order to facilitate some of the reviews, the industry is spending more time/resources than in the past to brief the Staff on the background and technical bases for the reports.
- In some instances, the Staff is questioning previously approved technical positions or guidance.
- On both the industry and the NRC side, the review process is often taking more time and requiring more resources than either side had anticipated.
- Communications between the NRC and the BWRVIP have been open and productive.
- The BWRVIP looks forward to continuation of our good communications and working relationship in resolving these issues.

BWRVIP Key Contact Information

- BWRVIP Executive Chairman

  Dennis Madison, Southern Company
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Materials Reliability Program

Scot Greenlee, Exelon
MRP Executive Sponsor

Industry/NRC Executive Meeting on Materials Program
July 17, 2013

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- Key 2013 Deliverables and Research Areas
- Key ASME Code and NRC Interactions
- T_{cold} RPV Closure Head and BMN Discussion
- Quasi-Laminar Indications in RPV Beltline Ring Forgings
- Reactor Internals guideline support and irradiated materials testing

Membership

New members in 2013:

- ***EDF Energy***
- ***Ringhals/Vattenfall***

Hokkaido Electric Power Co., Inc.

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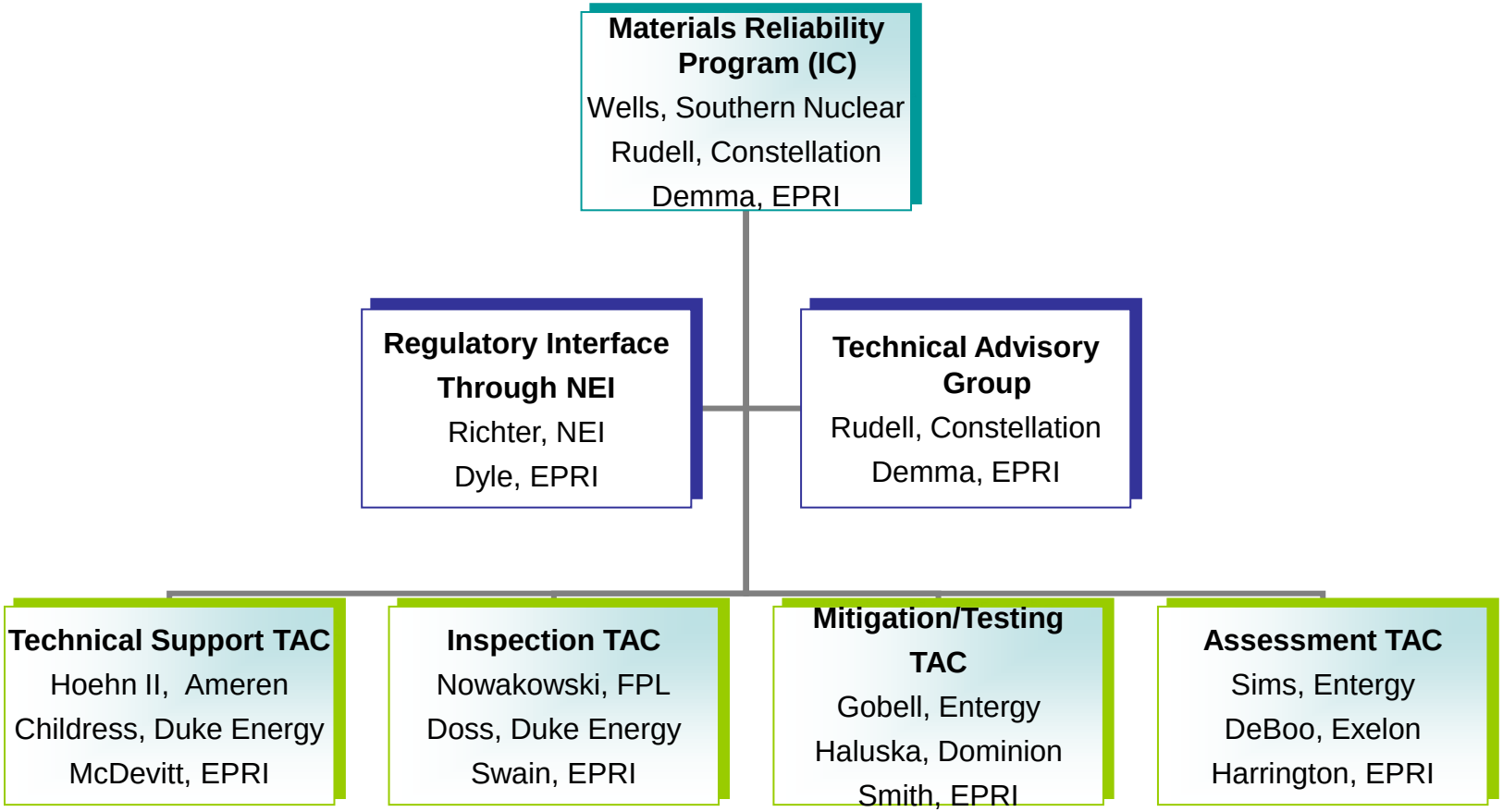
2013 MRP Organization



Key 2013 Deliverables and Research Areas

- **2013 Key Deliverables**
  - Topical Report for Primary Water Stress Corrosion Cracking Mitigation by Surface Stress Improvement (MRP-335, Rev. 1)
  - Resistance of Alloys 690, 152 and 52 to Primary Water Stress Corrosion Cracking (MRP-237, Rev. 2)
  - Probabilistic Fracture Mechanics (PFM) Analysis of Reactor Vessel Shell Forgings with Quasi-Laminar Indications
  - PWR Issue Management Tables report (MRP-205, Rev. 3)
  - RMSe Requirement Change Technical Basis
- **2013 Research Areas**
  - xLPR – largest MRP project, reconcile approved LBB with existence of PWSCC mechanism
  - Reactor Internals guideline support and irradiated materials testing
  - Replacement Materials – Alloy 690 and its weld metals
  - RPV Integrity – develop appropriate analytical tools & correlations for ensuring vessel integrity through 80 years
  - EAF – resolve differences between lab test results and plant experience

MRP- ASME Code Support and Interactions

- Basis for modifying ASME Code Section XI Appendix VIII RMSe requirement for thick-wall RPV DM weld locations (ASME and NRC)
- Code Case N-770 revision for 10 year cold leg DM Weld inspection interval (basis is MRP-349)
- Code Case N-770 revision for PWSCC mitigation by surface stress improvement (parallel with MRP-335 review)
- Quasi-laminar indications OE and issue presented to ASME Code Section III Sub-Group Materials, Fabrication & Examination in May and Section XI Executive Committee

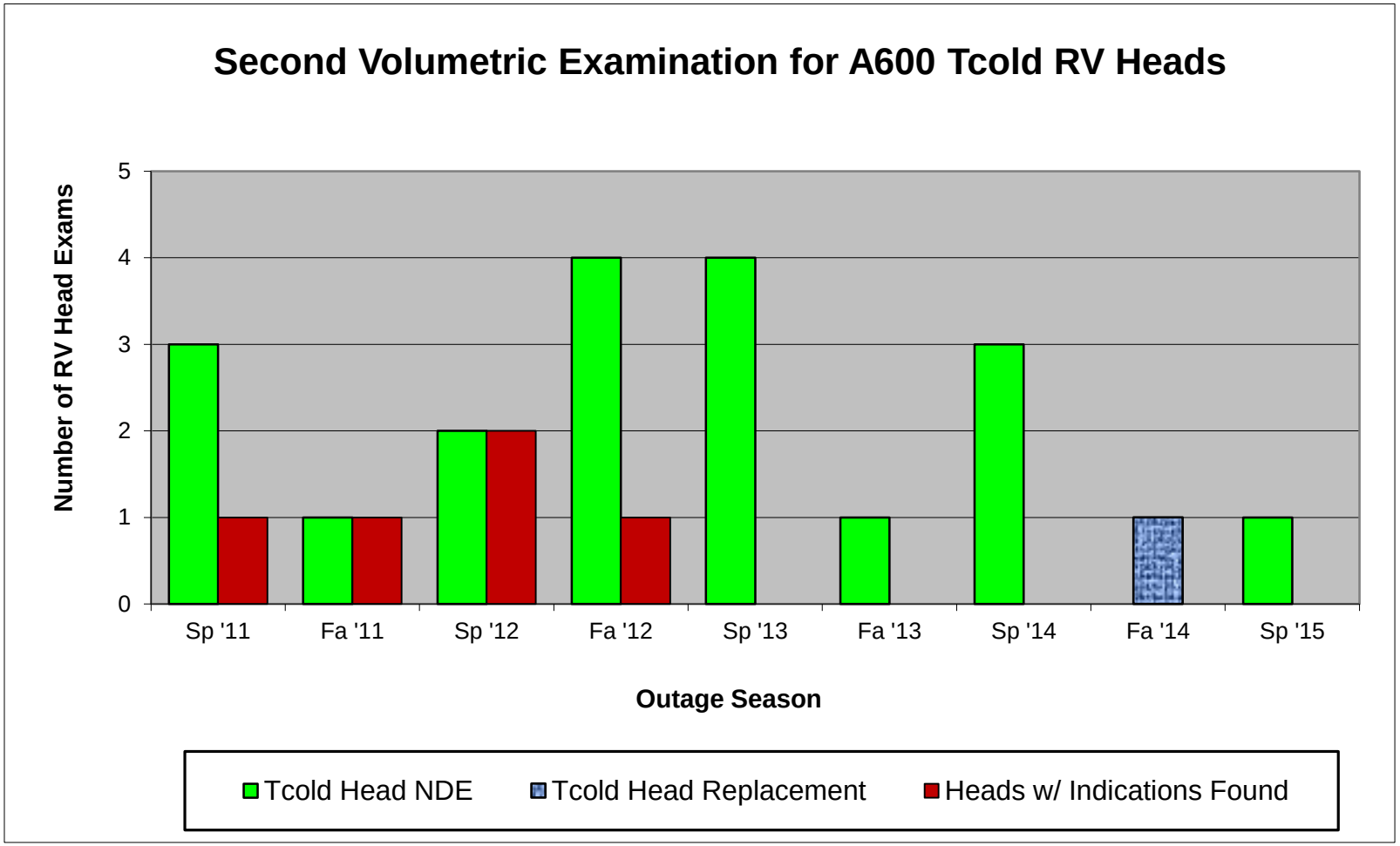
Key MRP-NRC Interactions

- Continue with xLPR
- Address quasi-laminar indications detected in non-US reactor core forged rings (future ASME Code Section III interaction?)
- Address staff concerns with Appendix G PT limits (future Code interaction)
- Address MRP-227-A Licensee action item 1 for generic applicability of guidance to the Westinghouse fleet
- Address MRP-227-A Licensee action item 7 for CASS reactor internals components (collaborating with BWRVIP)
- Topical report for PWSCC mitigation by surface stress improvement (MRP-335)
- Irradiated materials testing collaboration

T_{cold} RPV Experience and Analysis

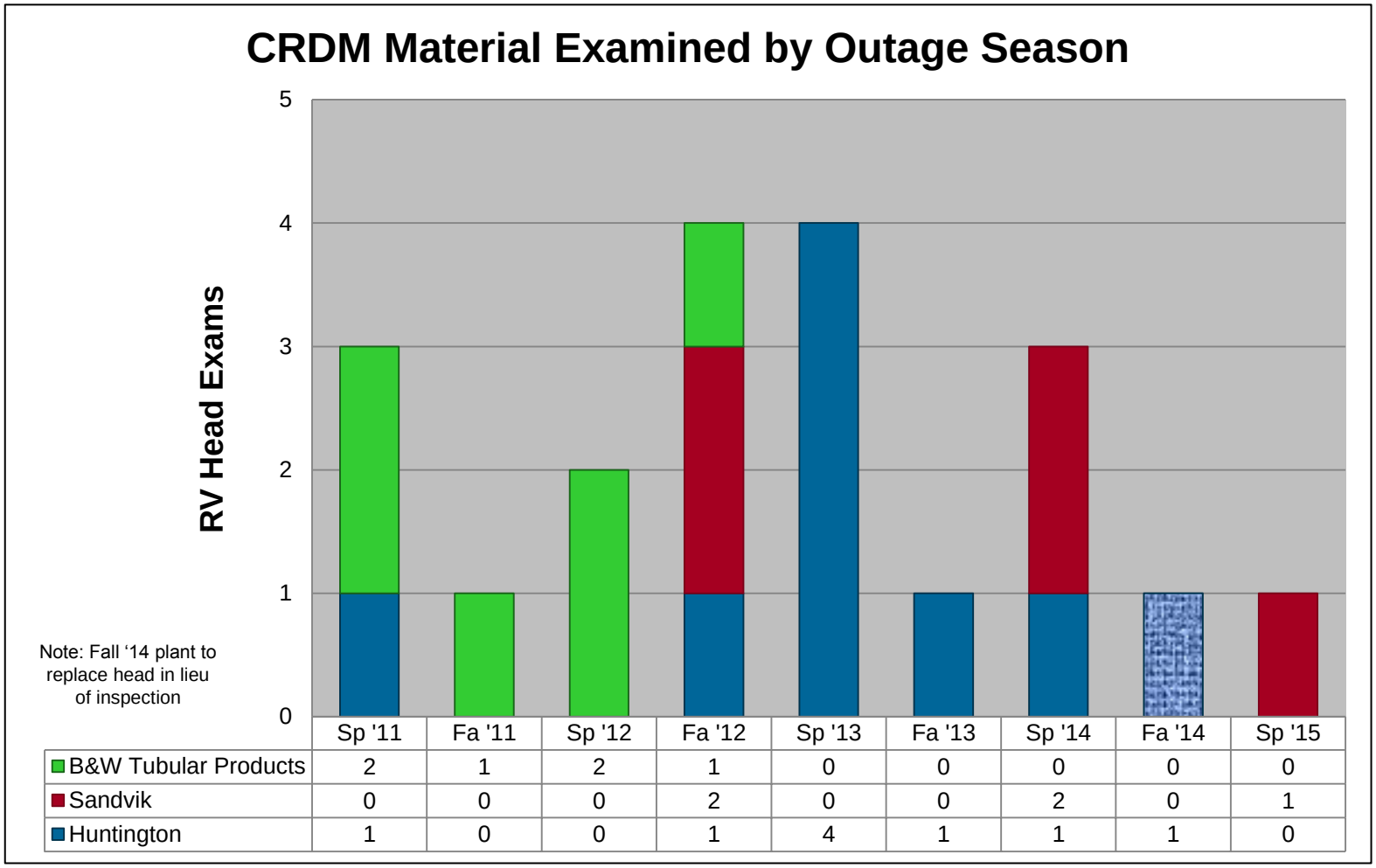
- Closure Head Penetrations (20 US plants)
- Bottom Mounted Penetrations (58 US plants)

2nd CRDM Exam Schedule - US T_{cold} Heads



20 US plants currently operate A600 RV heads at T_{cold}; 5 with reported PWSCC

2nd Exam Schedule by CRDM Material Supplier



	Sp '11	Fa '11	Sp '12	Fa '12	Sp '13	Fa '13	Sp '14	Fa '14	Sp '15
B&W Tubular Products	2	1	2	1	0	0	0	0	0
Sandvik	0	0	0	2	0	0	2	0	1
Huntington	1	0	0	1	4	1	1	1	0

PWSCC to date limited in T_{cold} heads to one material supplier

CRDM Inspection Basis Margin Analysis

- MRP-117, "*Inspection Plan for Reactor Vessel Closure Head Penetrations in U.S. PWR Plants*"
  - Provides technical basis for ASME Code Case N-729
- A 2011 qualitative analysis considering initial confirmed T_{cold} head PWSCC OE demonstrated margin in analysis
  - Six subsequent exams, three with flaws, exceeded range of sensitivity case assumptions
- Analysis update to include spring 2013 inspection results
  - *Includes four additional 2nd exam data points (no indications)*
  - *Broader material suppliers represented*
- Detection of only part-depth cracks indicates present exams are effective

BMN Safety Assessment

- BMN Safety Assessment (MRP-206; 2009) included;
  - Nozzle Structural Integrity,
  - Head Wastage (MRP-167),
  - Inspection Options.
- Code Case N-722 Technical Basis
- Subsequent BAC Wastage Evaluations
  - Contained in MRP BAC Test Program and BAC Implication reports (MRP-288, MRP-308)
- BAC Program leakage & monitoring NEI requirements
- Overall assessment of PWSCC Experience at Tcold
- BMN NDE Capability

Quasi-Laminar Indications in RPV Beltline Ring Forgings: Update on Industry Activities

Current Status and Schedule

- Probabilistic Fracture Mechanics analyses have been completed and are being reviewed
- A draft report (MRP-367) is in preparation
- Plant responses to MRP 2013-012 (request for fabrication NDE records review) are due to MRP on July 26
- Current intention is to include a generic summary of the results from the MRP 2013-012 records review in MRP-367
- A draft of MRP-367 will be submitted for MRP review by the end of August and expected to be available for information by the end of the year

Reactor Internals Guideline Support and Irradiated Materials Testing

Generic Applicability of MRP-227-A (A/LAI 1)

- Industry discussions/meetings with staff in late 2012 identified that NRC needed more proprietary design information regarding assumptions regarding to verify generic applicability of MRP-227
- Unease with B&W generic applicability promptly addressed via these discussions
- MRP, Westinghouse and NRC held proprietary meetings in May 2013 to present requested information to staff. Outcome of these discussions was positive.

Generic Applicability of MRP-227-A

- Westinghouse provided a proprietary Technical Design Basis document to NRC on 7/1,
  - No more related RAIs expected on these issues
- MRP will issue a letter to reflect Westinghouse technical basis
  - To include a ‘checklist’ for these responses for individual utilities to utilize for their submittal
- *See ADAMs ML13042A048; ML13043A062*

MRP-227-A SER A/LAI #7, Plant Specific Evaluations

- MRP-227-A SER A/LAI #7, Plant Specific Evaluations
  - '…applicants/licensees of B&W, CE, and Westinghouse reactors are required to develop plant-specific analyses to be applied for their facilities'
  - '…analyses shall also consider the possible loss of fracture toughness in these components due to thermal and irradiation embrittlement'
- Evaluation of CASS in BWR Internals, BWRVIP-234 submitted for SER
- Recent BWRVIP-234 RAIs have relevance to PWRs (*ML13079A210)*
- Prompted public meeting in May (joint BWR/PWR participation)

MRP-227-A SER A/LAI #7, Plant Specific Evaluations

- MRP and BWRVIP Working Group formed in May 2013
  - WG includes Westinghouse, AREVA, Anatech/Structural Integrity, utility representatives, and EPRI.
- Plans being developed for technical basis for TE for CASS
  - Will be an enhancement upon previous assumptions used in Grimes letter.
  - The May meeting with Staff identified need to revise this GALL reference.
- BWRVIP and MRP working closely to respond to Staff in a consistent manner
- Will establish with Staff preferred path(s) for documenting technical basis and review/acceptance
- Need for patience on review of A/LAI 7 submittals to be reiterated during July 2013 MRP-TAG meeting

2013-2014 MRP Projects on Reactor Internals

Reactor Internals Guidelines - Planning MRP-227, Rev. 1

- Revision currently scheduled for publication by end of 2014
  - MRP likely to submit for NRC review with SER tentatively anticipated late-2015 to early 2016.
- MRP beginning process of collecting and consolidating needed changes from MRP-227-A
- Revision motivated by need to incorporate:
  - Utility Inspection experiences through the past 3 years,
  - Industry work that generically addresses several MRP-227 SER conditions and licensee action items
  - Industry generic acceptance criteria as approved by NRC (WCAP 17096), and
  - Anticipated guidance from PWROG guide card project.

Zorita Internals Research Project (ZIRP)

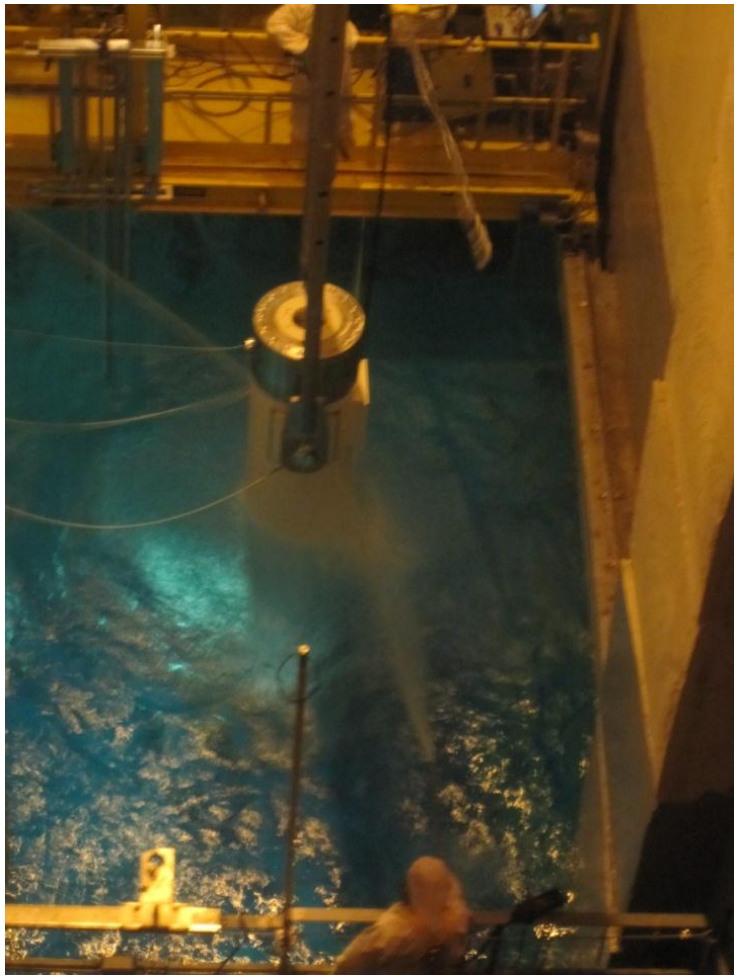
- Tests conducted on materials irradiated under service conditions to increase understanding of fluence effects on:
  - *Mechanical properties*: tensile strength, fracture toughness, crack initiation and growth
  - *Microscopic properties*: grain boundary chemistry and size, void formation, and hydrogen and helium production
  - Project uses Zorita baffle plate material

Jose Cabrera NPP "Zorita"
Westinghouse design
1968 – 2006 (~26 EFPY)

Participants: U.S. NRC, Tractebel, AXPO, VTT (pending)
- Additional in-kind contribution from Japanese utilities/MHI
- BWRVIP, PSCR, and U.S. NRC co-funding material extraction and analysis for use in additional research projects

Zorita Internals Research Project
Current Status

- Specimens have been loaded into the shipping cask; decon and prep for shipping continues
- All approvals have been granted for the transportation of the materials (Spain, Sweden, Barbados)
- Radiation and temperature analyses are complete



Specimens in shipping cask being lifted from the spent fuel pool

MRP Projects Using Additional Zorita Materials

Thermal and Irradiation Embrittlement and Environmental Effects Testing of Stainless Steel Welds (2012 – 2016)

- Determine combined effects of irradiation & elevated temperature on embrittlement of stainless steel welds and characterize environmental effect on fracture toughness in irradiated stainless steel welds
- ***Project uses Zorita core barrel weld material***
- P-AS-13 (high): Thermal & Irradiation Embrittlement Synergistic Effects on CASS and Stainless Steel Welds

CGR Testing of Irradiated SS Weld and HAZ Materials (2012 – 2016)

- Develop IASCC CGR data in irradiated stainless steel weld and HAZ materials for comparison to existing data for base materials
- ***Project uses Zorita core barrel weld material***
- P-AS-14 (high): Fluence Impact on SCC of Stainless Steels (IASCC)

Determination of IASCC CGR, Initiation Rate, and Void Swelling in Zorita Material after Post-Reactor Irradiation (2012 – 2018)

- Evaluate IASCC crack initiation and crack growth rates and degree of void swelling in highly-irradiated (near end-of-life conditions) stainless steel base metal and welds
- ***Project uses Zorita baffle plate & core barrel weld material***
- P-AS-14 (high): Fluence Impact on SCC of Stainless Steels
  P-AS-15 (medium): Void Swelling of Stainless Steels

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Together…Shaping the Future of Electricity

Industry Executive - NRC Management Meeting
Materials Programs

PWROG Materials Subcommittee Overview

Mike Robinson, Duke Energy

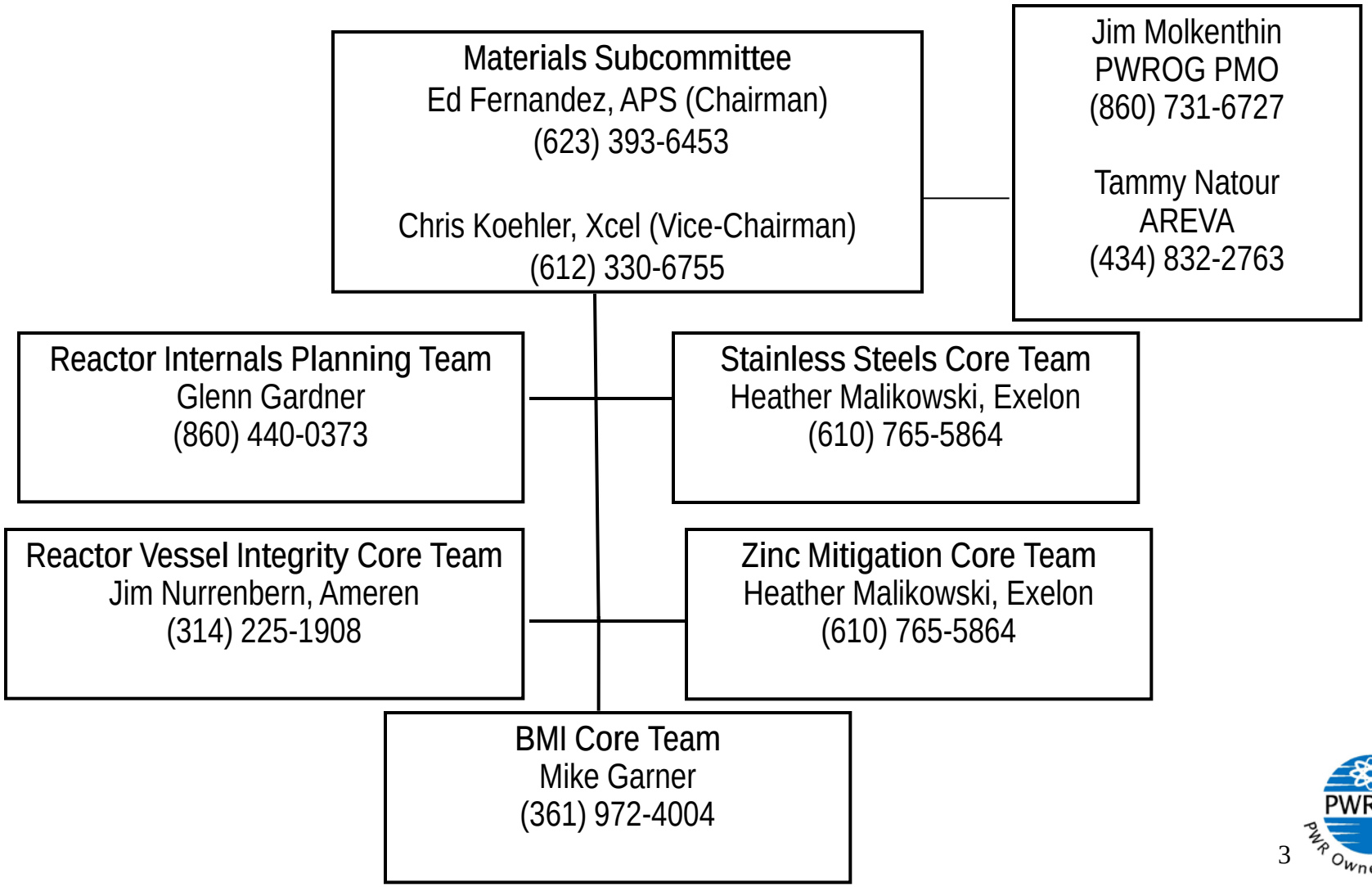
July 17, 2013

NRC/Industry Executive Management Meeting
PWR Owners Group MSC Agenda

- PWROG MSC Key Strategic Areas & Core Teams
- PWROG MSC Key Deliverables Completed to Date in 2013
- PWROG MSC Key Focus Activities for 2013-2014
- Emerging Issues/Recent Interactions
- MSC – NRC Interactions Summary

NRC/Industry Executive Management Meeting

PWROG MSC Key Strategic Areas & Core Team Organization



NRC/Industry Executive Management Meeting
PWROG MSC Key Deliverables Completed to Date in 2013

Reactor Internals

- Support for Applicant Action Items 1, 2, and 7 from the Final Safety Evaluation on MRP-227, Revision 0 (PA-MSC-0983) – Generic Work Complete
  - The purpose of the program was twofold:
    - Develop a methodology and provide a generic guideline for applicant/licensee susceptibility evaluation of MRP-227-A reactor internals components (Generic to the fleet).
    - Compile plant-specific reactor internals data to support utility responses on Applicant/Licensee Action Items 1, 2, and 7 from the final Safety Evaluation (SE) on MRP-227, Revision 0 (Cafeteria, plant specific).
- Key Deliverables – WCAP-17638-P, "Generic Methodology for Addressing Applicant/Licensee Action Item 7 from the Final Safety Evaluation on MRP-227, Revision 0".
- Current Work – Performing plant specific work to support Applicant Action Items 1, 2 and 7. This work will continue through 2014.

NRC/Industry Executive Management Meeting
PWROG MSC Key Deliverables Completed to Date in 2013

Reactor Internals (continued)

- Reactor Vessel Internals MRP-227 Implementation Manual and Training Workshop (PA-MSC-0562) – Complete
  - The purpose of the program is to support effective plant specific implementation of the industry requirements to manage aging in reactor internals.
  - Benefits:
    - Direction and instructional tools for the utilities to effectively implement reactor internals aging management programs that are compliant with the "Mandatory" and "Needed" aspects of MRP-227-A and the SE on MRP-227 Rev. 0,
    - Consistent response to regulatory requirements for managing aging in reactor vessel internals,
    - Starting point for outage planning.
- Key Deliverables – WCAP-17485-P, Revision 0 and WCAP-17484-P, Revision 1, "Reactor Vessel Internals MRP-227 Implementation Manual and Training Session" (W/CE Fleet) and 47-9184607-000, "MRP-227-A Implementation Manual for Reactor Vessel Internals Aging Management Operating B&W 177-Fuel Assembly Designs" (B&W Fleet).

NRC/Industry Executive Management Meeting
PWROG MSC Key Focus Activities for 2013-2014 (1/2)

Reactor Internals Programs:

- ✓ PA-MSC-0784 - Development of Generic Acceptance Criteria for W and CE Reactor Internals
- ✓ PA-MSC-0473 - Reactor Internals Acceptance Criteria Methodology & Data Requirements
- ✓ PA-MSC-0562 – RV Internals MRP-227 Implementation Manual and Training Workshop
- ✓ PA-MSC-0942 - Dynamic Response Model of Westinghouse Internals
- ✓ PA-MSC-0983 - Support for Applicant Action Items 1, 2, and 7 from the Final Safety Evaluation on MRP-227, Revision 0
- ✓ PA-MSC-1103 - FMEA Decision Matrix for Westinghouse and Combustion Engineering Reactor Internals (to be proposed in 2013)
- ✓ PA-MSC-0833 – Assess Acceptable Bolting Pattern Operating Experience (to be proposed in 2013)
- ✓ PA-MSC-0688 – Westinghouse Upper Internals Guide Tube Card Wear – Fleet-wide Operational Projections

The program above are designed to support utility implementation of MRP-227.

NRC/Industry Executive Management Meeting
PWROG MSC Key Focus Activities for 2013 – 2014 (2/2)

Reactor Vessel Integrity

- PA-MSC-0783 - Archival of Westinghouse and CE Unirradiated Reactor Vessel Materials
- PA-MSC-1172 - Support of Electric Power Research Institute (EPRI) Materials Reliability Program (MRP) 2013-012 Regarding Doel Unit 3 Inspection Results
- PA-MSC-0440 – ISI Interval Extension for Non- Alloy 82/182 RV Nozzle to Piping Welds (just completed)

Stainless Steel

- PA-MSC-0551 - Development of I&E Guidelines for ID and OD-Initiated SCC of PWR SS Pressure Boundary Components – Phase II
- PA-MSC-0918 – SCC of SS Issues, Industry Participation and Strategic Planning Support
  - ✓ PWROG has overall industry lead for this issue

Other

- PA-MSC-0257 - PWSCC Crack Initiation Testing of Farley Unit 2 Alloy 600 CRDM Penetrations
- PA-MSC-1068 - Pressurizer Heater Sheaths: Acceptance Methodology

NRC/Industry Materials Programs Technical Exchange
Emerging Issues/Recent Interactions (1/2)

Update on PWROG Efforts to Support the Doel-3 Inspection Results

- Background
  - In June 2012, a UT examination was conducted at Doel Unit 3, to identify the presence of under-clad cracks. No such cracks were found, but during this new type of inspection, conducted for the first time in Belgium, several thousands of flaw indications were detected in the base metal of the Doel 3 reactor pressure vessel, located mainly in the upper and lower core shells.

  - This issue has raised questions regarding the possibility that U.S. forged-ring vessels may also have such indications. There are 21 PWR vessels with forged core shells currently operating in the U.S.

  - The PWROG has been working with the EPRI MRP to address the issue.

NRC/Industry Materials Programs Technical Exchange
Emerging Issues/Recent Interactions (2/2)

Update on PWROG Efforts to Support the Doel-3 Inspection Results(continued)

- Latest Activities
  – The PWROG program is currently evaluating the original fabrication records and performing an ultrasonic modeling simulation of the inspection sensitivity. The modeling report has been sent to the participants as a draft (June 2013) and the intent is:

  1. To demonstrate the laminar flaw detection capability throughout the vessel thickness using the typical US inspection practices employed to satisfy the American Society of Testing and Materials (ASTM) requirements at the time of fabrication. For comparison, the inspection technique described by Doel Unit 3 was benchmarked in order to provide a direct comparison.
  2. To provide background information on UT exams, ASTM A388, under clad cracking, and the equipment specifications (E-Specs) for the individual reactor vessels. Finally, the report provides detailed discussion of how flaws discovered during the original UT examinations were handled and provides clear technical input as to whether they pose any further issue related to the Doel-like indications.

NRC/Industry Executive Management Meeting
MSC – NRC Interactions Summary

- PWROG MSC Interactions with the NRC have been valuable
  - NRC informed about PWROG projects,
  - PWROG becomes aware of NRC issues,
  - Benefits to both PWROG members and NRC,
  - Facilitates utility submittals and NRC reviews,
    - ✓ Significantly contributed to success of RPV ISI Interval Extension from 10 to 20 years and complementary program to extend ISI Interval for non-Alloy 82/182 RPV nozzle welds.
    - ✓ OE on ODSCC of stainless steels lead to interim strategy that was communicated and provided to the NRC.
    - ✓ OE on Seal Encapsulation strategy was communicated to the NRC. Guidance in line with the NEI 03-08 initiative implemented at all affected sites.

Questions?

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Steam Generator Management Program (SGMP)

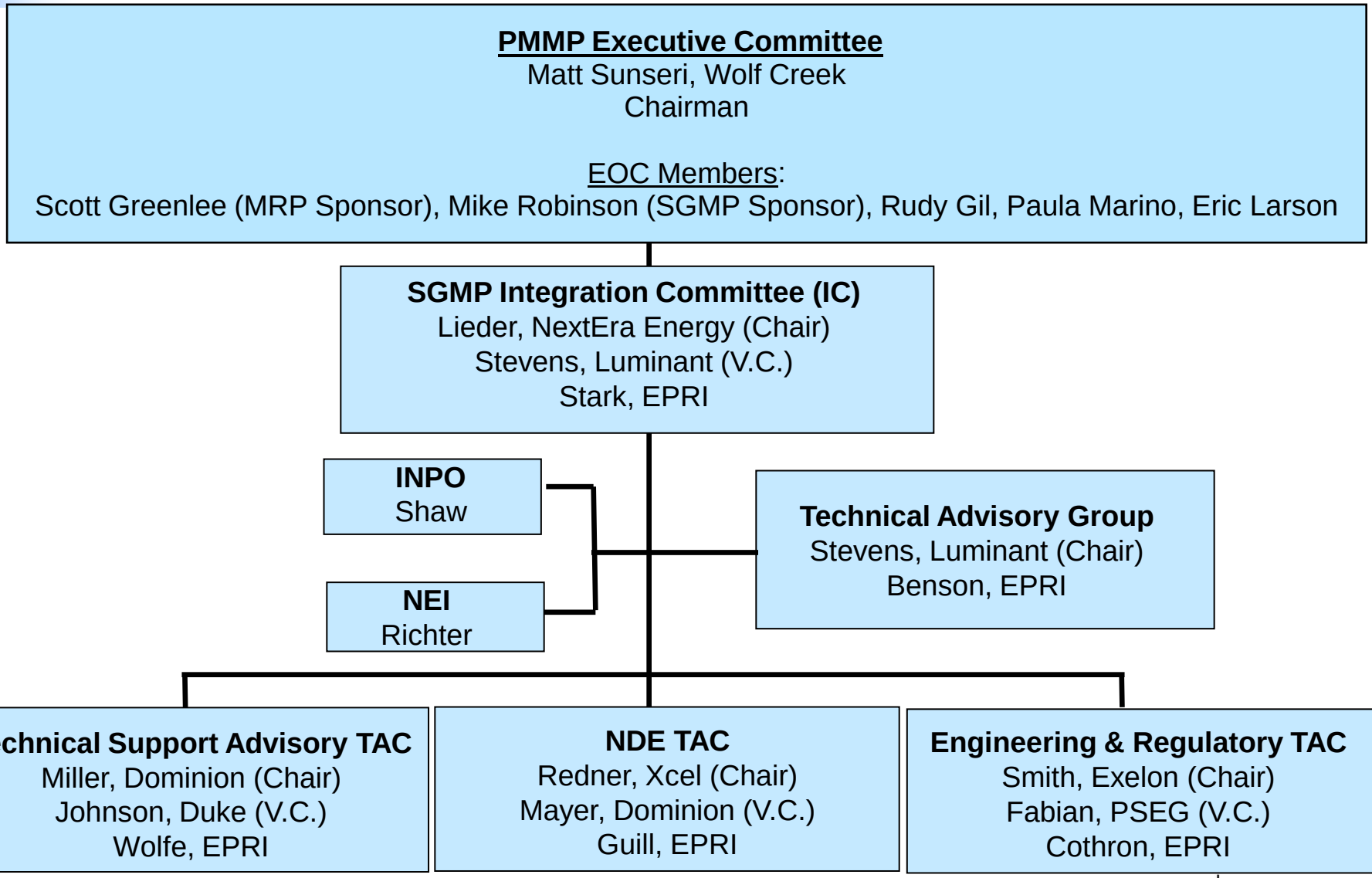
Mike Robinson, Duke Energy
SGMP Executive Chairman

Industry/NRC Executive Meeting on Materials Program
July 17, 2013

Presentation Outline

- SGMP Organization
- Current SGMP Guidelines Revision Status
- Key 2013-2014 SGMP Activities
- Open SG Task Force Issues

SGMP Organization



SGMP Guidelines Status and Revision Schedule
(Page 1 of 2)

Guideline Title	Current Rev #	Report #	Last Pub	Implementation	Interim Guidance	Review Date	Comments
Steam Generator Integrity Assessment Guidelines	3	1019038	Nov 2009	9/1/2010	SGMP-IG-10-01 SGMP-IG-12-01		Rev 4 in progress
EPRI Steam Generator In Situ Pressure Test Guidelines	4	1025132	Oct 2012	10/10/2013	none	2015	
PWR Steam Generator Examination Guidelines	7	1013706	Oct 2007	9/1/2008	SGMP-IG-08-04 SGMP-IG-12-01		Rev 8 in progress
PWR Steam Generator Primary-to-Secondary Leak Guidelines	4	1022832	Sep 2011	4/11/2012 7/11/2012	none	2014	

SGMP Guidelines Status and Revision Schedule
(Page 2 of 2)

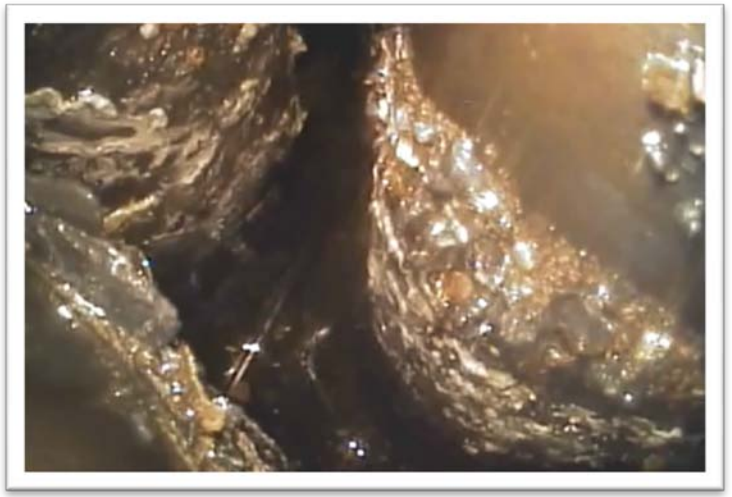
Guideline Title	Current Rev #	Report #	Last Pub	Implementation	Interim Guidance	Review Date	Comments
PWR Primary Water Chemistry Guidelines	6	1014986	Dec 2007	6/17/2008 9/17/2008	SGMP-IG-09-01 SGMP-IG-11-02		Rev 7 in progress
PWR Secondary Water Chemistry Guidelines	7	1016555	Feb 2009	8/20/2009 11/20/2009	SGMP-IG-13-01	2014	
Steam Generator Management Program Administrative Procedures	3	1022343	Dec 2010	9/1/2011 12/31/2011	none	n/a	
Steam Generator Degradation Specific Flaw Handbook	1	1019037	Dec 2009	n/a	none	n/a	Rev 2 in progress

Major Ongoing SGMP Research Activities

- Dispersant Application for Fouling Mitigation
- Aging Management of Alloy 600 and Alloy 82/182 in the Steam Generator Channel Head Assembly
- Triton: Steam Generator Thermal-Hydraulics Code Development
- Steam Generator Degradation Predictions

Dispersant Application for Fouling Mitigation

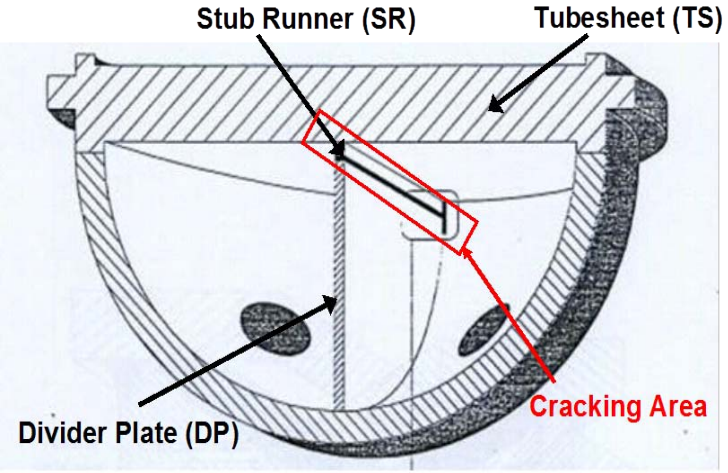
- A significant body of work to qualify, field test and implement dispersant application for the PWR secondary system has been generated
  - Reduction in fouling of 5-10X
  - Improved thermal performance
  - Reduced deposit accumulation
  - Sludge lancing benefits
- Work is ongoing to monitor and evaluate field experience



Example
No Dispersant
Top-of-tubesheet tube collars
Hot Leg Post sludge lancing

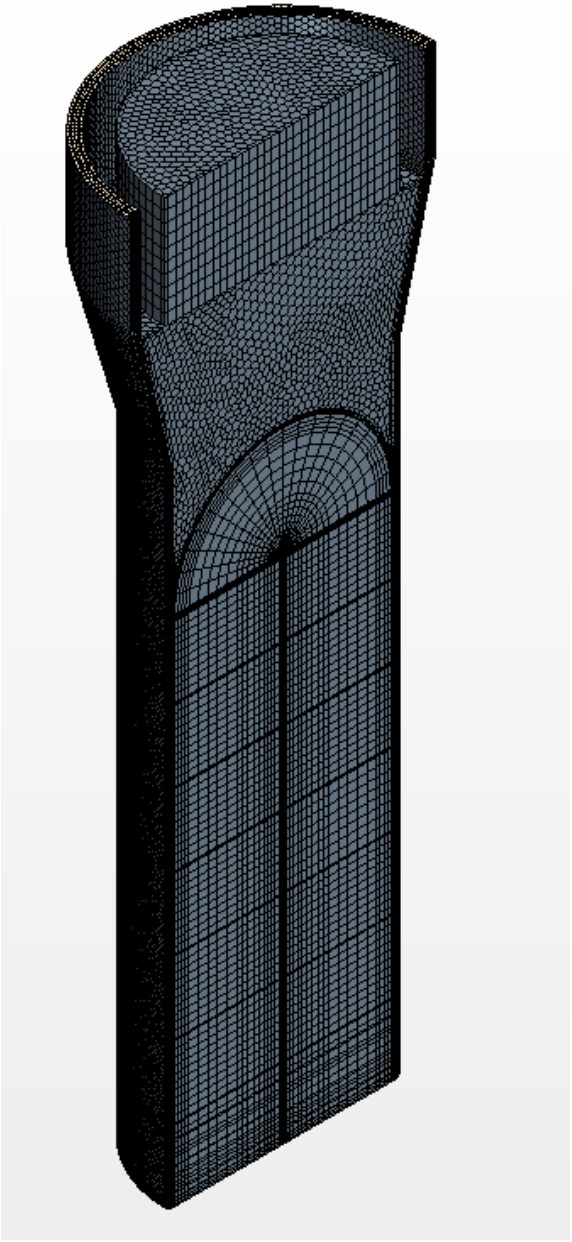
Aging Management of Channel Head

- PWSCC in alloy 600 and associated weld materials in the SG channel head have the potential to propagate over time to pressure boundaries
  - Work to evaluate propagation of divider plate cracks through the low alloy channel head material is complete
    - Analyses shows that postulated flaws will grow to a maximum depth well below allowable flaw depth
  - Work on the propagation to or initiation of PWSCC in the tube-to-tubesheet weld is ongoing – To be completed in 2013
  - Work is ongoing to build a SG channel head mockup to demonstrate an inspection technique if needed



Triton

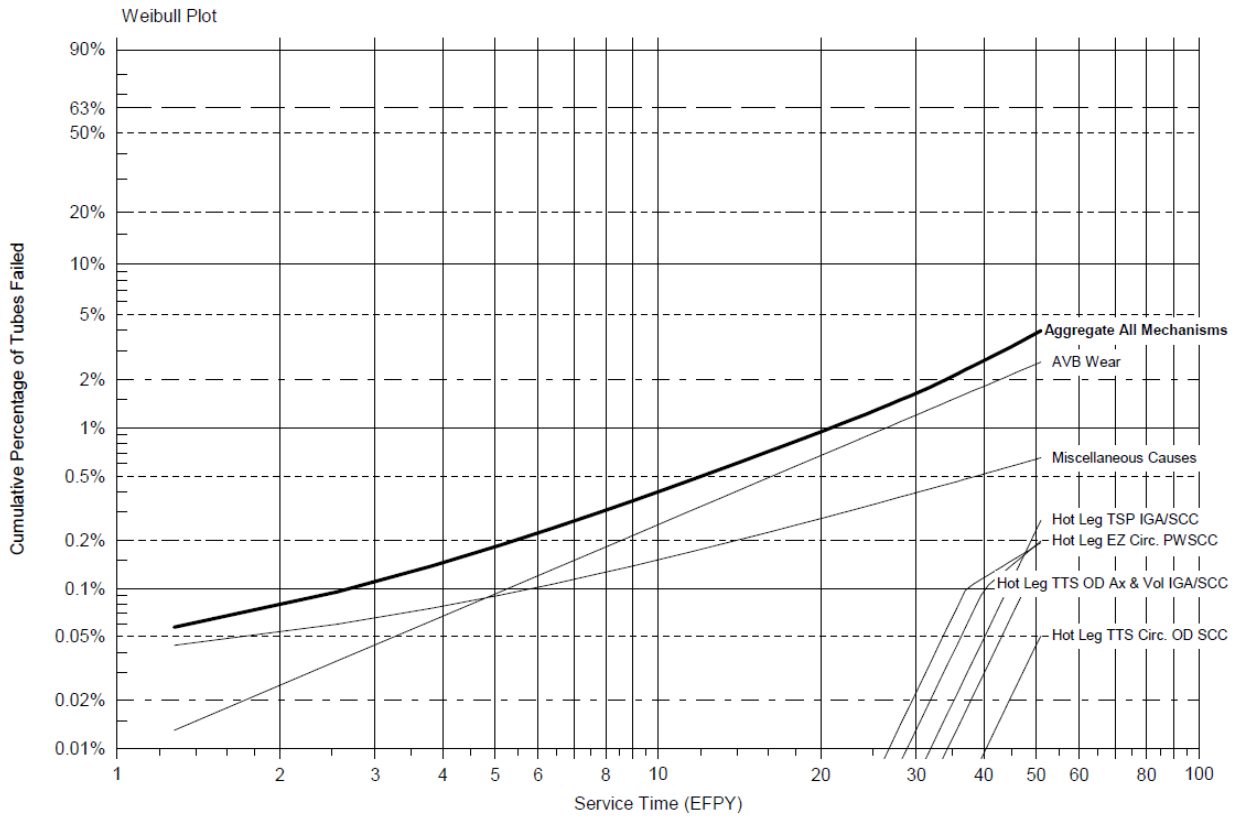
- For more than 25 years, ATHOS has been used to model thermal hydraulics in steam generators
- Limitations of ATHOS include:
  - Modern pre-heater designs and u-bend suppport structures cannot be simulated
  - Results lack details of the flow field on the secondary side
  - Techniques to simulate accumulated deposits lead to unrealistic deposit distributions
- Triton is currently under development to address these limitations
  - Version 1.0 is on plan to be released March 2015



Steam Generator Degradation Predictions

- Objective of work is to provide utilities with tools for estimating the future extent of tube degradation in steam generators with advanced tubing alloys

- Update to include:
  - Alloy 600TT
  - Alloy 690TT
  - Alloy 800NG



Example: Predicted tube plugging due to Alloy 600TT degradation

Open SG Task Force Issues

- Noise Monitoring
  - Recommendations have been provided to the Examination Guidelines Revision 8 Committee
    - New appendix has been drafted for noise monitoring
- AVB Position Verification
  - White paper developed incorporating information from 2012 meeting among SG vendors
  - Recommendations have been provided to the E&R TAC for consideration for inclusion in the next revision of the Integrity Assessment Guidelines
  - SGMP Project began project in 2012 to provide generic input for plant-specific U-bend tube fatigue analysis
  - Follow up survey in 2012 indicates the utilities are familiar with the issue and are taking actions as appropriate
- Performance Standards
  - EPRI Technical Report 1012984, “Technical Basis for SG Tube Integrity Performance Acceptance Standards”, provided to NRC

SGMP Key Contact Information

- PMMP Executive Sponsor

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NDE Program

Industry / NRC Management Meeting on Materials Issues

July 17, 2013

Joe Donahue, Duke Energy

Topics

- NIFG (NDE Implementation Focus Group) status
  Industry response to missed flaws at North Anna

- Recent OE related to NDE Reliability
  Diablo Canyon overlay; Nine Mile RHR weld; Harris CRDM

- Research directions to further address NDE reliability improvement
  Processes, technology, analysis software, modeling & simulation

Focus of NDE Improvements

- Extent of Condition
- Appendix VIII
  - Site Specific Mockup Process
- NDE Implementation
  - UT Examination Technology Selection (encoded or non-encoded)
  - Pre-Job Briefing
  - Team Scanning Guidance
- Oversight
  - DM Weld Oversight Guidance
- Examiner Proficiency
  - Hands-on Practice

NIFG Products

- Improvements issued under NEI 03-08 process:
  - EPRI Report 3002000041, “Nondestructive Evaluation: Improvement Focus Group Extent of Condition Actions in Response to North Anna Dissimilar Metal Weld Operating Experience” Final Report, February 2013
  - EPRI Report 30002000091, “Nondestructive Evaluation: Guideline for Conducting Ultrasonic Examinations of Dissimilar Metal Welds, Revision 1”, Final Report, May 2013
  - EPRI Report 3000200204, “Nondestructive Evaluation: Performance Demonstration Initiative (PDI) Guidance for Improved Reliability in Ultrasonic Examinations”, Final Report, May 2013

NEI 03-08 Guidance

The utility shall perform an evaluation of each DMW scheduled for examination in accordance with Appendix A to determine the examination technology (encoded or non-encoded) to be applied for the DMW examination.	Needed
The utility shall have a process delineating that when team scanning is utilized; the guidance of Appendix B, "Guidance for the Application of Team Scanning for Ultrasonic Examination of DM Welds," shall be followed.	Needed
The utility should develop and implement a DMW examination oversight process.	Good Practice
The utility shall have a process defined to conduct a pre-job brief to ensure that examination personnel understand the importance, technical, and administrative details of the DMW examination activity.	Needed
Utility shall have a process to ensure compliance with PDI site-specific mockup guidance, Revision C	Needed
Utility should have a process to verify hands-on practice in accordance with PDI guideline PDI-GL-001, Revision B	Good Practice

Team Scanning Effectiveness Assessment

- Being performed July 8 - 21, 2013
- Will evaluate the effectiveness of the examination team to detect and record flaw indications in accordance with the qualified procedure requirements
- The results of each of the examination teams will be evaluated to the applicable Appendix VIII Supplement acceptance criteria for minimum flaw detection and false calls
- Considered effective if the examination results meet the applicable Appendix VIII Supplement acceptance criteria
- Lessons learned will be factored into the NIFG team scanning guidance

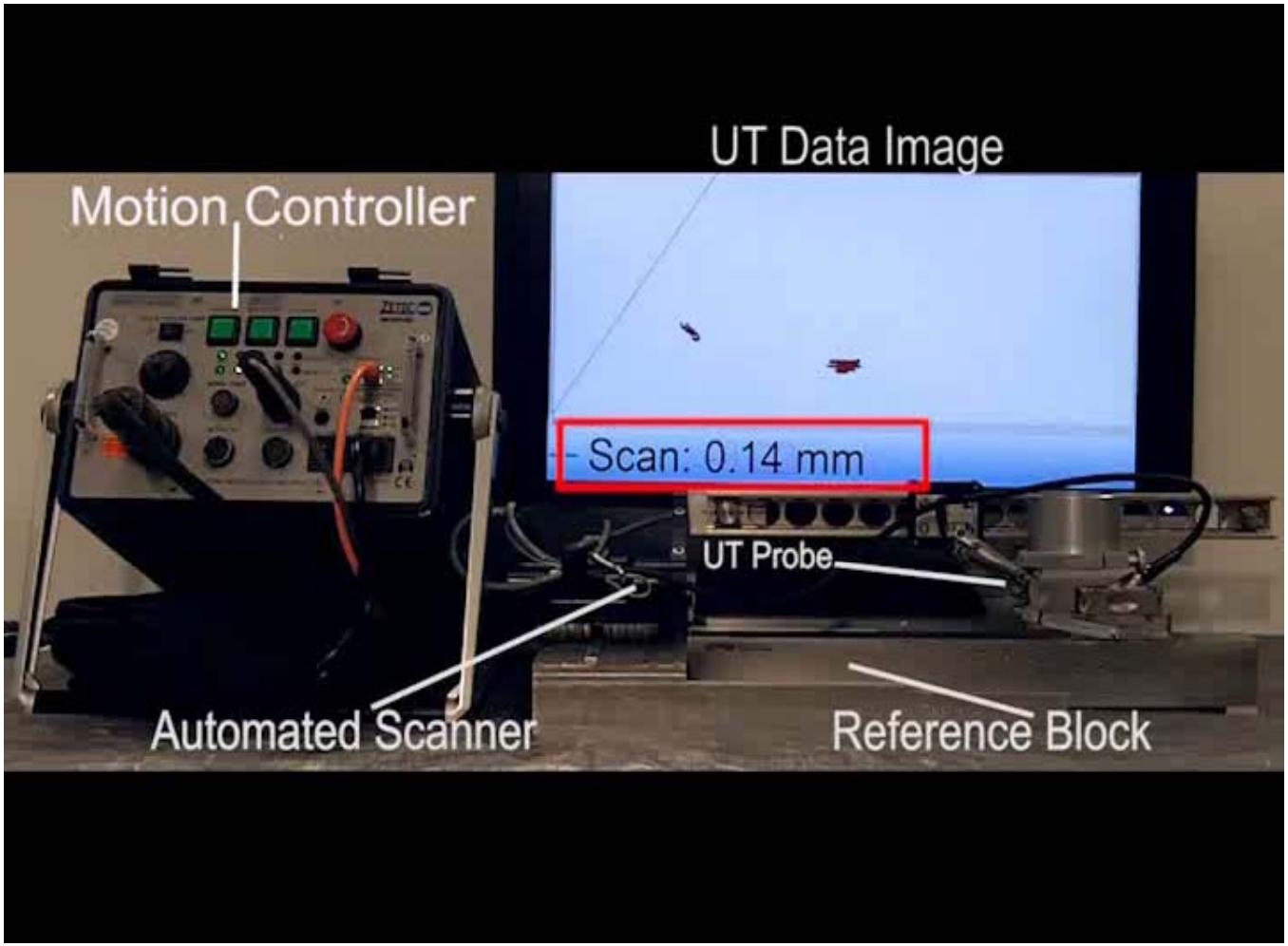
Recent OE related to NDE reliability

- Diablo Canyon, Nine Mile Point
  - 2013 examinations using phased array technology reported flaws that were not reported in prior examinations using conventional technology
- Shearon Harris
  - Independent analysis of recorded UT data discovered a crack indication that had not been reported in the original analysis
- In all three cases, industry is awaiting root cause evaluations and other data before formulating a response

Research directions to improve reliability

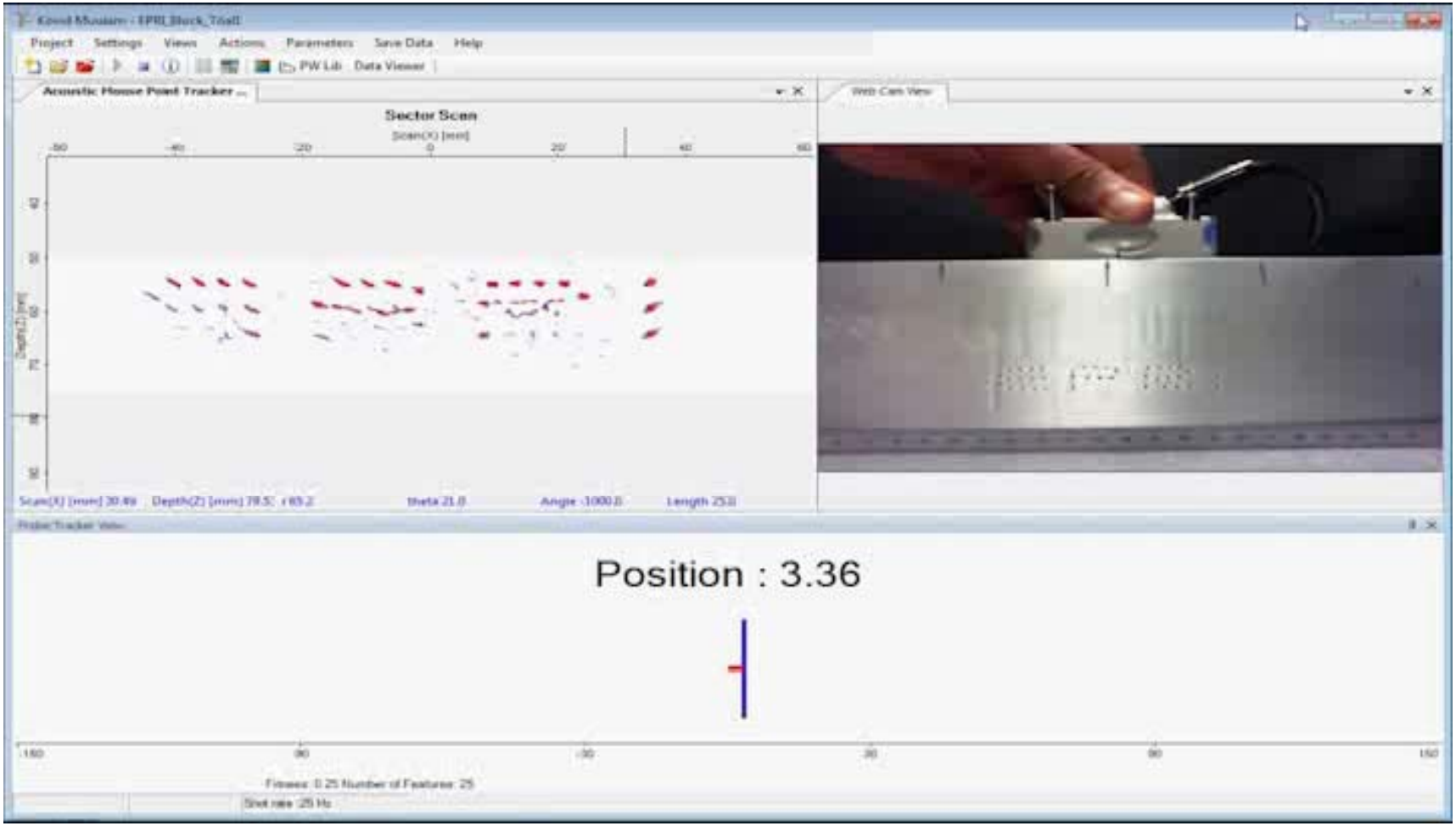
- Potential process improvements
  - Multi reviews
  - Independence
- Technology development
  - Easier encoding
- Longer horizon
  - Software to analyze the data independently
  - Modeling and simulation
  - Acoustic mouse
- Discuss risks in speaker notes
  - Technological success
  - Workforce

Research directions to improve reliability
Longer horizon – Acoustic Mouse



Today – a lot of equipment is required to achieve encoded data

Research directions to improve reliability
Longer horizon – Acoustic Mouse



Builds a map: can lift and reposition the probe, and the system isn't lost

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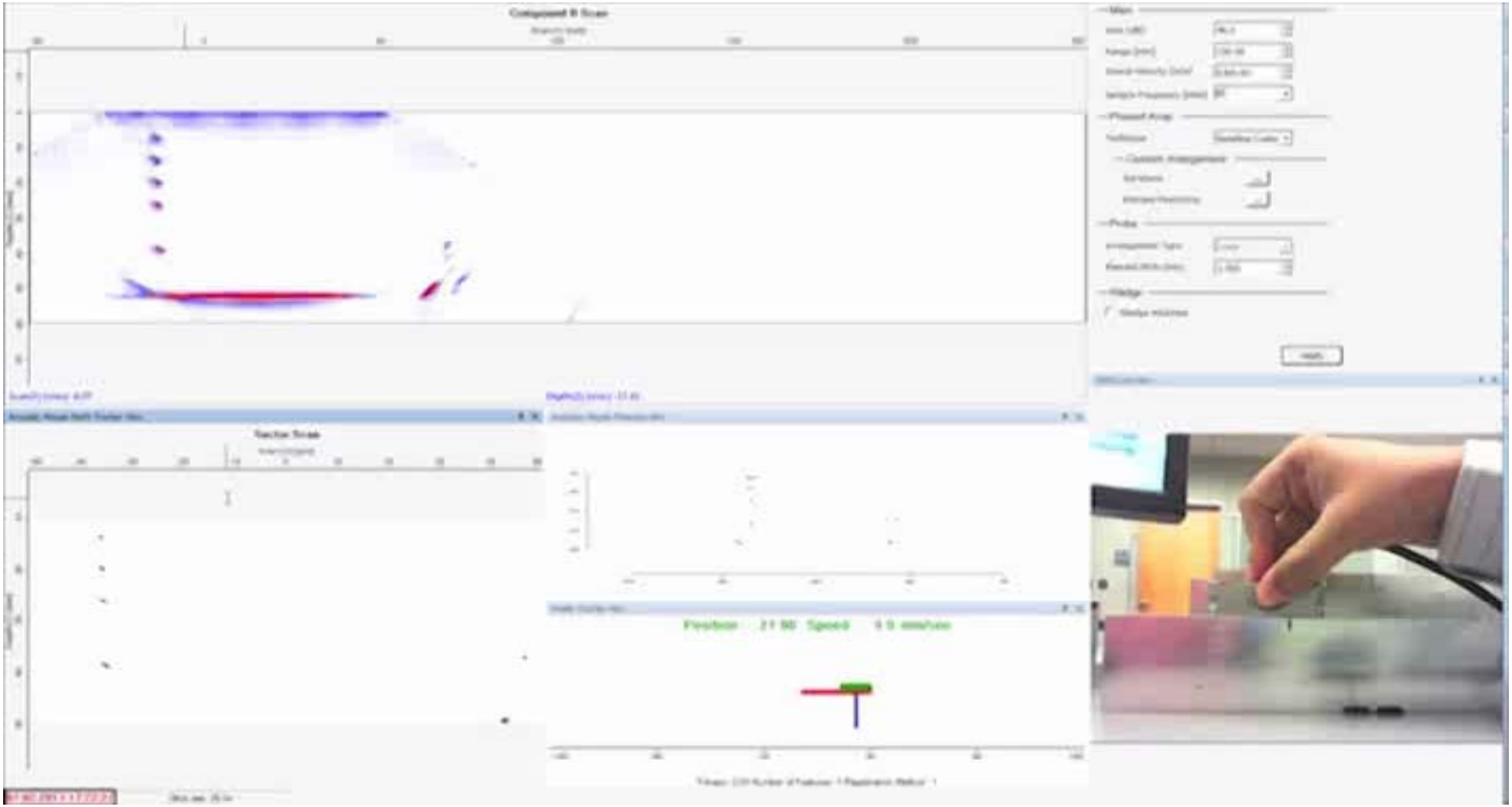
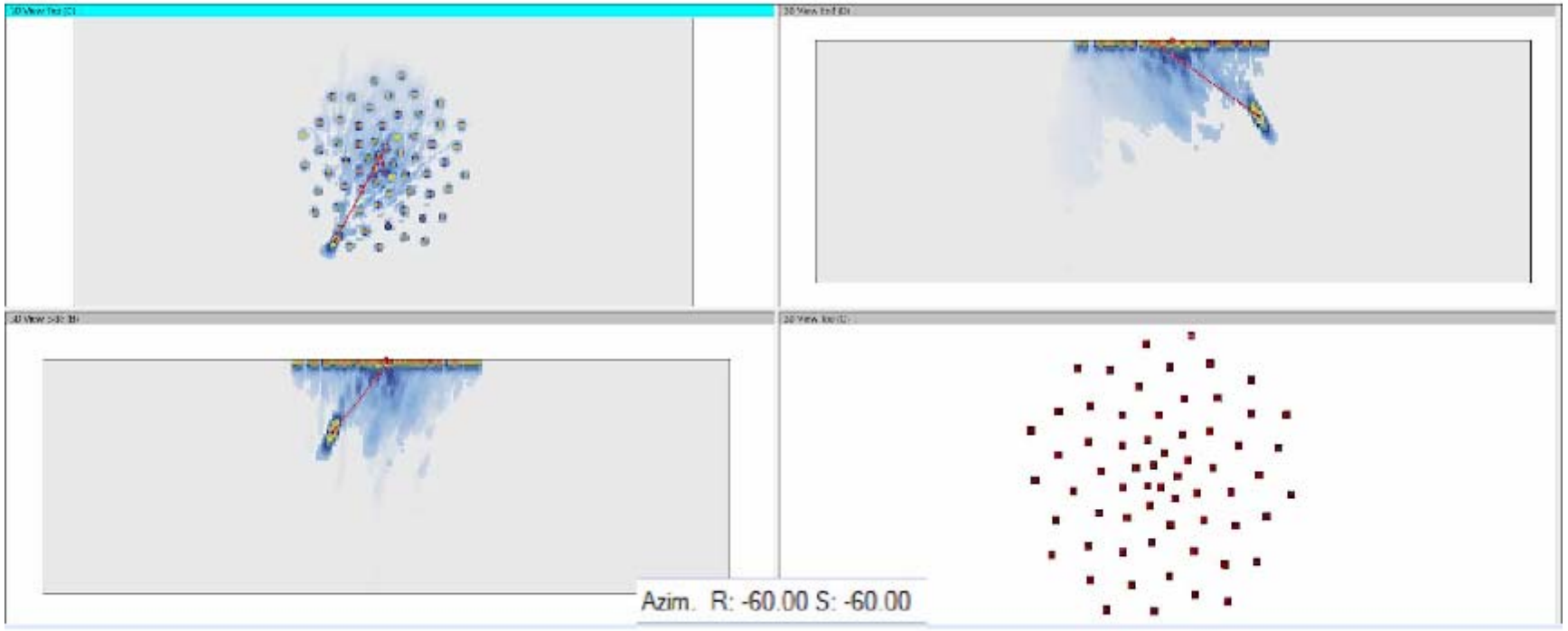
Key Results to Date
B-Scan Data Collection



Research directions to improve reliability
Longer horizon – Acoustic Mouse



For 3D imaging, will need a special 'sparse array' probe that can look in all directions

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EPRI | ELECTRIC POWER RESEARCH INSTITUTE

EPRI Long Term Operations Program

Mike Gallagher

Exelon, VP License Renewal

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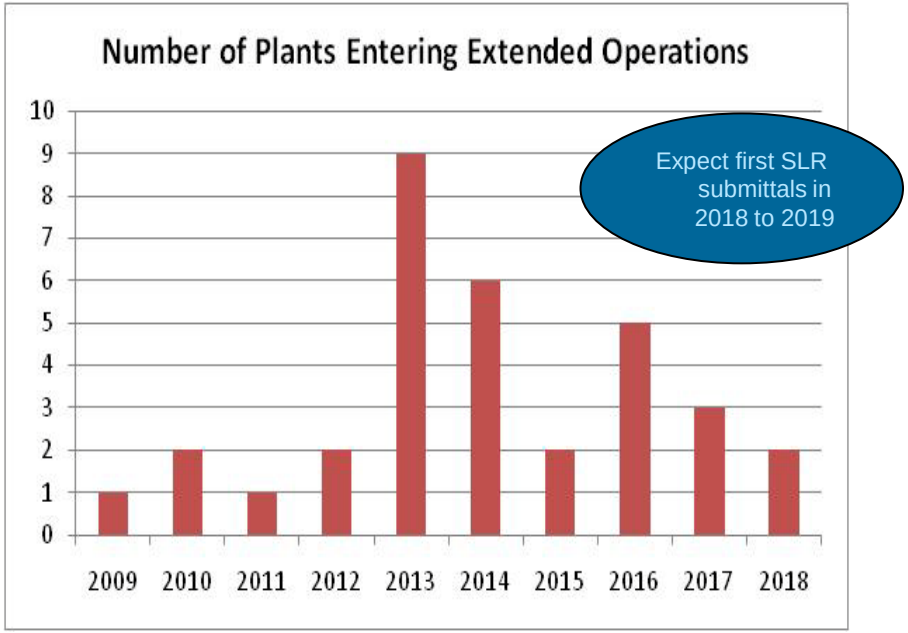
EPRI, Program Manager

NRC/Industry Executive Materials Meeting

July 17, 2013

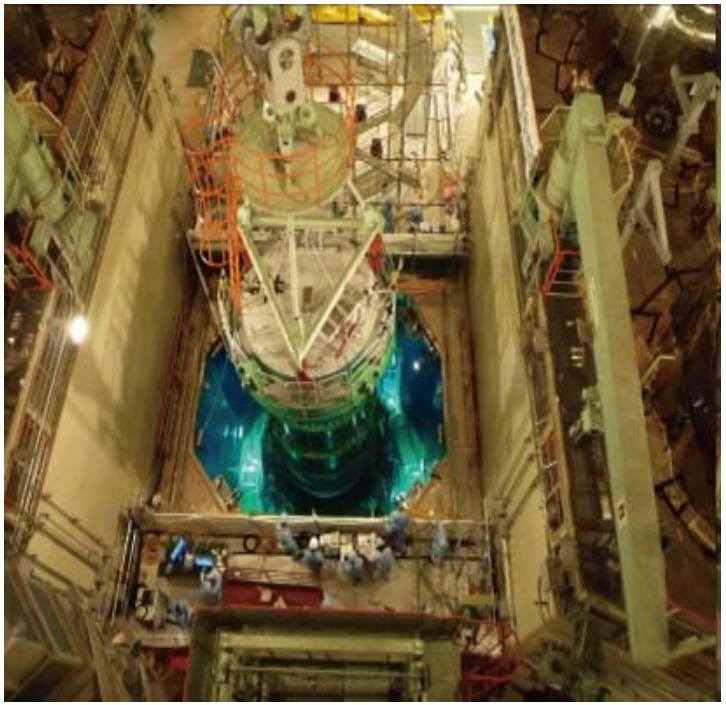
LTO Goals and Objectives

- Technical basis for safe, reliable plant operation through extended lifetime
- Useful results in 2014 to 2019 timeframe
- Demonstrated technologies to support long-term plant management
- Research projects built on and integrated with other EPRI programs
- External collaboration with DOE LWRS, EDF, MAI



LTO Program R&D Focus Areas

- Identification of Potentially Life Limiting SCCs
- Technical Basis for Aging Management Programs
- Enabling Technologies
  - Pilot plant projects and demonstrations
  - Integrated Life Cycle Management
- Opportunities for Modernization
  - Advanced I&C
  - On-line monitoring
  - Advanced risks and PRA



AMPs for LTO – Is the Right R&D Occurring?

- LTO Issue Tracking Table
- EPRI SME contribution to the EMDAs (NRC and DOE funded project)
- On-going EPRI R&D projects identified incremental needs for long-term operations
  - MDM LTO flag added
  - Irradiated concrete R&D
  - Synergic effects on electrical cables
- Mapped R&D to AMPs using GALL Rev 2

PWR Materials LTO Summary

- Neutron Fluence Effects
  - RPV embrittlement
  - SS materials data for >60 years
    - Threshold stress
    - Reduction in toughness
    - Void swelling
  - Impact on core periphery materials
- Fatigue Usage
- Steam Generator Corrosion Limits
  - FAC impact
  - Number of cleaning cycles

BWR Materials LTO Summary

- Neutron Fluence Effects
  - RPV embrittlement
  - Irradiation effects on LAS resistance to environmentally assisted cracking
  - SS materials data for >60 years
  - Impact on CASS reactor internals
  - Impact on nickel alloys
  - Irradiated material welding
- Fatigue Usage
- Late-life SCC Initiation
  - Impact of oxide formation/environment exposure

EPRI R&D Projects to Support the AMPS

- June 20, 2013 meeting with NEI License Renewal Tasks Force, EPRI, NRC LR and NRC Research

- GALL, rev 2 AMPs were binned into 3 categories:

  1) R&D to address knowledge gaps for 60 to 80 years to better understand and manage materials performance

  2) R&D role where aging degradation is well-characterized

  3) No EPRI R&D – plant specific commitments

- Basis for future discussions with the NRC LR Branch in support of SLR

Results of June 20 Meeting

- Presented the AMPs binned in the 3 categories

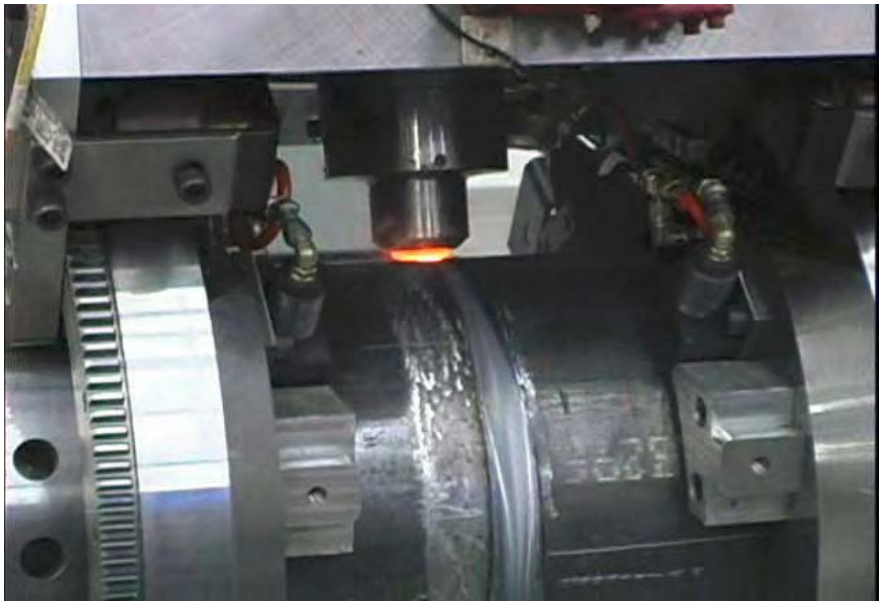
- EPRI Technical Staff presented summary information on the R&D projects to support the category 1 materials AMPs
  - BWRVIP and MRP
  - Irradiated Materials Testing
    - Zorita Internals R&D, Halden Research, IASCC data collection and expert panel, ARRMs project
  - Alloy 690 and weld materials testing
  - Reactor Vessel surveillance capsule programs
  - Environmentally Assisted Fatigue

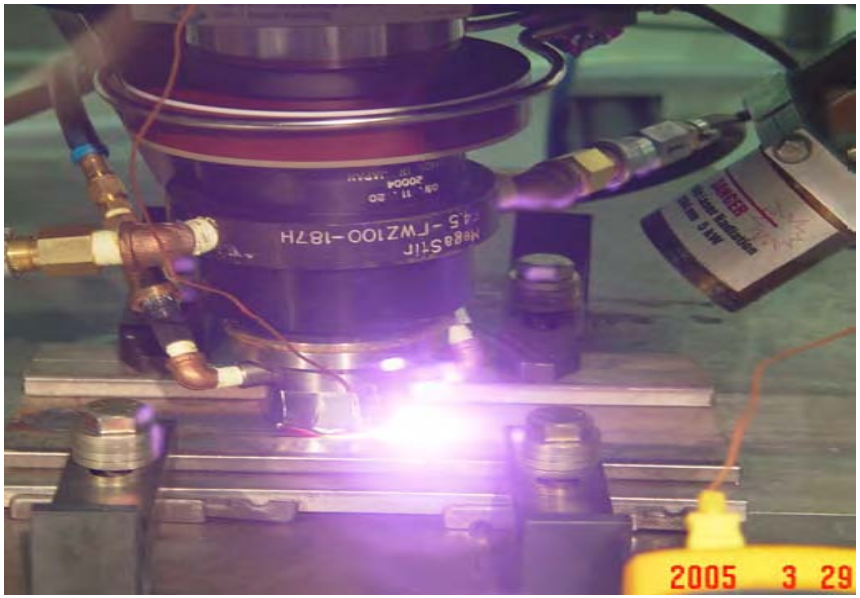
Meeting Conclusions

- EPRI materials R&D projects will continue and results will be published (BWRVIP, MRP)
- EPRI Publication late 2013 on the AMP Gap Review
- Continued meetings with LR and Research staff:
  - Updates on the materials R&D projects
  - Electrical cables R&D projects for LTO
  - Concrete and containment structures R&D for LTO
- Need to support a finding a reasonable assurance based on the progress of the R&D at the time of SLR lead plant review

Summary

- Ongoing R&D needs for SLR have been identified
- Extensive R&D continues to ensure the technical basis for the AMPs are adequate for both LR and SLR
- There maybe some plant specific issues, but no show stoppers identified to-date based on the R&D





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Results of AMP Categorization

Category 1 Background

- AMPs in this category were judged to have technical data needs relative to the projected operating conditions to 80 years
  - Expand current knowledge base to bound conditions
    - Degradation mechanistic understanding for LTO
      - Where to look
    - Degradation rate understanding for LTO
      - When and how often to look

Category 1 Summary

GALL AMP ID	AMP Name	Potential LTO Impact on AMP
XI.M9	BWR Vessel Internals	Irradiation and environmental effects on material performance
XI.M11B	Cracking of Nickel-Alloy Components and Loss of Material Due to Boric Acid-Induced Corrosion in Reactor Coolant Pressure Boundary Components	Environmental effects on material performance
XI.M12	Thermal Aging Embrittlement of Cast Austenitic Stainless Steel (CASS)	Thermal aging and possible irradiation effects on material performance
XI.M16A	PWR Vessel Internals	Irradiation and environmental effects on material performance
X.M31	Reactor Vessel Surveillance	Neutron fluence on reactor pressure vessel materials
XI.S6	Structures Monitoring	ASR susceptibility and irradiation effects on material properties
XI.E1	Insulation Material for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements	Combined effects of thermal and radiation exposure
XI.E2	Insulation Material for Electrical Cables and Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements Used In Instrumentation Circuits	Combined effects of thermal and radiation exposure

Category 2 Background

- R&D projects, on-going programs, and/or relevant operating experience will be used for continuous improvement of the aging management program implementation, but there are no identified knowledge gaps related to application for LTO.
- The on-going research results and relevant OE may prompt changes to the AMPs such as inspection techniques, inspection coverage and frequency.
- Some AMPs in this category are tied to mitigation processes that are monitored and expected to continue, i.e. the EPRI Chemistry Program Guidelines.

Category 2 Summary (1 of 3)

GALL AMP ID	AMP Name	Programmatic or Industry Guidance Source
X.M1	Fatigue Monitoring (TLAA)	Plant specific evaluation addressing additional fatigue cycles supported by EPRI Report: Materials Reliability Program: Thermal Fatigue Monitoring Guidelines (MRP-32, Revision 1)
XI.M2	Water Chemistry	EPRI Reports :PWR Primary Water Chemistry Guidelines PWR Secondary Water Chemistry Guidelines; BWRVIP-190: BWR Vessel and Internals Project, BWR Water Chemistry Guidelines - 2008 Revision The Guidelines have an established review and approval cycle and are periodically updated
XI.M3	Reactor Head Closure Stud Bolting	Inspection and assessment guidance in accordance with NRC Regulatory Guide 1.65 supported by on-going EPRI NDE R&D on improved inspection methods
XI.M4	BWR Vessel ID Attachment Welds	Inspection and assessment Guidelines (BWRVIP-48-A: BWR Vessel and Internals Project, Vessel ID Attachment Weld Inspection and Flaw Evaluation Guidelines; ASME Code Section XI
XI.M5	BWR Feedwater Nozzle	Inspection and assessment Guidelines in accordance with NUREG-0619, BWRVIP-74-A: BWR Vessel and Internals Project, BWR Reactor Pressure Vessel Inspection and Flaw Evaluation Guidelines for License Renewal, and ASME Code Section XI
XI.M6	BWR Control Rod Drive Return Line	Inspection and assessment Guidelines in accordance with NUREG-0619, BWRVIP-74-A: BWR Vessel and Internals Project, BWR Reactor Pressure Vessel Inspection and Flaw Evaluation Guidelines for License Renewal, and ASME Code Section XI
XI.M7	BWR Stress Corrosion Cracking	Inspection and guidance in accordance with NRC Generic Letter 88-01 and BWRVIP-75-A: Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedules.

Category 2 Summary (2 of 3)

GALL AMP ID	AMP Name	Programmatic or Industry Guidance Source
XI.M10	Boric Acid Corrosion	Inspection and assessment in accordance with NRC Generic Letter 88-05 and NUREG-1823 supported by MRP-199, Reactor Vessel Head Boric Acid Corrosion Testing, and MRP-268, Reactor Vessel Bottom Mounted Nozzle Boric Acid Corrosion Testing: Design and Analysis of Full-Scale BMN Mockups,
XI.M17	Flow-Accelerated Corrosion	FAC Program Implementation NSAC-202 “Recommendations for Effective Flow-Accelerated Corrosion Program”
XI.M18	Bolting Integrity	Inspection and assessment per EPRI Report: Nuclear Maintenance Applications Center: Bolted Joint Fundamentals. Periodically updated.
XI.M19	Steam Generators	EPRI Steam Generator Management Program Guidelines for inspections, assessments and repairs; periodically updated – see listing in Section 7 under SGMP
XI.M21A	Closed Treated Water Systems	Guidance per EPRI Report: Closed Cooling Water Chemistry Guideline, Revision 1
XI.M25	BWR Reactor Water Cleanup System	BWRVIP-190: BWR Vessel and Internals Project, BWR Water Chemistry Guidelines—2008 Revision
XI.M35	One-Time Inspection of ASME Code Class 1 Small Bore Piping	MRP -146 guidelines for location selection criteria for thermal fatigue in addition to ASME Section XI

Category 2 Summary (3 of 3)

GALL AMP ID	AMP Name	Programmatic or Industry Guidance Source
XI.M37	Flux Thimble Tube Inspection	Inspection and assessment per MRP- 227A: Pressurized Water Reactor Internals Inspection and Evaluation
XI.M38	Inspection of Internal Surfaces in Miscellaneous Piping and Ducting Components	Inspection and repair/replace as needed; Guidance in EPRI Reports, Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools, Revision 4 and "Nuclear Maintenance Applications Center: Passive Component Maintenance Guide for Nuclear Power Plant Personnel"; reports periodically updated
XI.M40	Monitoring of Neutron-Absorbing Materials Other than Boraflex	Monitoring and assessment technology per EPRI Report, Strategy for Managing the Long Term Use of BORAL(R) in Spent Fuel Storage Pools
XI.M41	Buried and Underground Piping and Tanks	NEI Initiative 09-14 "Guideline for the Management of Underground Piping and Tank Integrity"
XI.S8	Protective Coating Monitoring and Maintenance Program	Inspection and assessment in accordance with EPRI Reports, "Plant Support Engineering: Guideline on Nuclear Safety-Related Coatings, Revision 2" and "Field Guide: Coatings Assessment"

Category 3 Background

- These AMPs are typically plant specific and managed with periodic inspections, repairs and replacements.
  - No identified R&D effort for application to LTO period.
- ASME Code compliance efforts are included in this category.

Category 3 Summary (1 of 3)

GALL AMP ID	AMP Name
XI.M1	ASME Section XI In-service Inspection
XI.M20	Open-Cycle Cooling Water System
XI.M22	Boraflex Monitoring
XI.M23	Inspection of Overhead Heavy Load and Light Load (Related to Refueling) Handling Systems (corrosion and loss of preload)
XI.M24	Compressed Air Monitoring
XI.M26	Fire Protection
XI.M27	Fire Water System
XI.M29	Aboveground Metallic Tanks

Category 3 Summary (2 of 3)

GALL AMP ID	AMP Name
XI.M30	Fuel Oil Chemistry
XI.M32	One-Time Inspection
XI.M33	Selective Leaching
XI.M36	External Surfaces Monitoring of Mechanical Components
XI.M39	Lube Oil Analysis
XI.S1	ASME Section XI, Subsection IWE
XI.S2	ASME Section XI, Subsection IWL
XI.S3	ASME Section XI, Subsection IWF

Category 3 Summary (3 of 3)

GALL AMP ID	AMP Name
XI.S4	10 CFR Part 50, Appendix J
XI.S5	Masonry Walls
XI.S7	RG 1.127, Inspection of Water-Control Structures Associated with Nuclear Power Plants
XI.E3	Inaccessible Power Cables Not Subject to 10 CFR 50.49 Environmental Qualification Requirements
XI.E4	Metal Enclosed Bus
XI.E5	Fuse Holders
XI.E6	Electrical Cable Connections Not Subject to 10 CFR 50.49 Environmental Qualification Requirements

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