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3. Enter the passphrase: roosevelt2016
4. You are now connected to the meeting space wireless internet

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Meeting Materials

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## Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Lead</th>
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</thead>
<tbody>
<tr>
<td>8:00 am</td>
<td>Introductory Remarks and Agenda Review</td>
<td>D. Czufin, TVA</td>
</tr>
<tr>
<td>8:15 am</td>
<td>General Topics</td>
<td>R. Dyle, EPRI</td>
</tr>
<tr>
<td>8:30 am</td>
<td>Material Reliability Program (MRP) Business</td>
<td>B. Rudell, Exelon</td>
</tr>
<tr>
<td></td>
<td>▪ 2016 Budget status, including changes</td>
<td>A. Demma, EPRI</td>
</tr>
<tr>
<td></td>
<td>▪ 2017 Budget update</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ 2018 Budget for endorsement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Industry Highlights and Operating Experience</td>
<td></td>
</tr>
<tr>
<td>10:00 am</td>
<td>Morning Break</td>
<td>All</td>
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<tr>
<td>10:20 am</td>
<td>Steam Generator Management Program (SGMP) Business</td>
<td>J. Stevens, Luminant</td>
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<td></td>
<td>▪ 2016 Budget status, including changes</td>
<td>H. Cothron, EPRI</td>
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<td></td>
<td>▪ 2017 Budget update</td>
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<tr>
<td></td>
<td>▪ 2018 Budget for endorsement</td>
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<td></td>
<td>▪ Industry Highlights and Operating Experience</td>
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<tr>
<td>11:50 am</td>
<td>2018 Budget review</td>
<td>D. Czufin, TVA</td>
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<tr>
<td>12:00 pm</td>
<td>Lunch - Crescent City Ballroom (Mezzanine Level)</td>
<td>All</td>
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<tr>
<td>1:00 pm</td>
<td>MRP Technical Topics</td>
<td>B. Rudell, Exelon</td>
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<tr>
<td></td>
<td>▪ Baffle Former Bolts</td>
<td>A. Demma, EPRI</td>
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<tr>
<td></td>
<td>▪ RPV Updates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>▪ Peening</td>
<td></td>
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<tr>
<td>2:00 pm</td>
<td>Member satisfaction survey</td>
<td>S. Chengelis, EPRI</td>
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<tr>
<td>2:15 pm</td>
<td>SGMP Technical Topics</td>
<td>J. Stevens, Luminant</td>
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<tr>
<td></td>
<td>▪ Sherlock, Triton and Fluid Elastic Instability, Foreign Object Wear prediction</td>
<td>H. Cothron, EPRI</td>
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<tr>
<td>3:15 pm</td>
<td>Review of action items</td>
<td>D. Czufin - All</td>
</tr>
<tr>
<td>3:30 pm</td>
<td>Adjourn</td>
<td></td>
</tr>
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</table>
Action Items from January 2016

- General Items
  - Program leads explore options to support DNP

- SGMP
  - Consider decreasing of guideline review frequency to support DNP
  - D. Czufin took to contact the utility that had not provided OE
  - Report on monthly MAPC call when FEI data is available
  - Review the STP root cause and make recommendations to PMMP
  - Develop a checklist to use in dealing with emerging issues

- MRP
  - Provide a description of the long-term impact of xLPR – compare funding versus the value
  - Provide a comparison of the old budgeting process and the RFA approach
  - Quickly determine if MRP-367 should be updated for 80 years
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<th>First Name</th>
<th>Account</th>
<th>Role</th>
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<td>Mark</td>
<td>Ameren Missouri</td>
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<tr>
<td>Lloyd</td>
<td>Mark</td>
<td>American Electric Power, Inc.</td>
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<td>Thiele</td>
<td>Bryan</td>
<td>Arizona Public Service Co.</td>
<td>Alternate</td>
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<td>Cadogan</td>
<td>Jack</td>
<td>Arizona Public Service Co.</td>
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<td>Adams</td>
<td>Matt</td>
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<td>Parker</td>
<td>Duke Energy Corp.</td>
<td>EOC</td>
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<td>Ajaz</td>
<td>EDF Energy Nuclear Generation, Ltd.</td>
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<td>Sims</td>
<td>William</td>
<td>Entergy Operations, Inc.</td>
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<tr>
<td>Basso</td>
<td>Tom</td>
<td>Exelon Corporation</td>
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<tr>
<td>Bologna</td>
<td>Richard</td>
<td>FirstEnergy Nuclear Operating Co.</td>
<td>EOC</td>
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<td>Gil</td>
<td>Rudy</td>
<td>Florida Power &amp; Light Co.</td>
<td>EOC</td>
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<tr>
<td>Lim</td>
<td>Jaesoo</td>
<td>Korea Hydro &amp; Nuclear Power Co., Ltd.</td>
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<tr>
<td>Tran</td>
<td>Chung</td>
<td>Luminant Holding Company LLC</td>
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<td>Nimick</td>
<td>Jan</td>
<td>Pacific Gas &amp; Electric Co.</td>
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<td>Rajkowski</td>
<td>Leonard</td>
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<td>Williams</td>
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<td>Brad</td>
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<tr>
<td>Connolly</td>
<td>James</td>
<td>STP Nuclear Operating Company</td>
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<tr>
<td>Czufin</td>
<td>David</td>
<td>Tennessee Valley Authority (TVA)</td>
<td>Chairman</td>
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<tr>
<td>McCoy</td>
<td>Jaime</td>
<td>Wolf Creek Nuclear Operating Corp.</td>
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<tr>
<td>Khanifar</td>
<td>Aziz</td>
<td>Xcel Energy Services, Inc.</td>
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Materials Program Changes

August 2016
PSCR Organizational Update

- **PSCR Scope**
  - PSCR takes overall responsibility for materials testing, characterization, and modeling
    - Direct support of the needs of issue programs
    - Better alignment in strategic plans and seamless integration in R&D
    - Funded by issue programs and current PSCR (base + TI) funding streams
    - Additional staff to support the restructuring

- **PSCR Leadership**
  - TAC Chair: Jim Cirilli, Exelon
    - Vice Chair: open
  - Technical Chair: Ian Armson, Rolls Royce
    - EPRI Program Manager: Anne Demma
    - TG Lian has been assigned to support EPRI engagement in Europe
Materials Organizational Chart – August 2016

Kurt Edsinger
Materials

Anne Demma
PSCR
Peter Chou
Gabriel Ilevbare
Raj Pathania
Cem Topbasi
Jean Smith
David Steininger

Greg Frederick
WRTC
Dana Couch
Steve McCracken
Nick Mohr
Artie Peterson
Ben Sutton
Jon Tatman
Stacey Wells

Andy McGehee
BWRVIP
Bob Carter
John Hosler
Wayne Lunceford
Amardeep Mehat
Nathan Palm
Chuck Wirtz

Open
MRP
Al Ahluwalia
Kyle Amberg
Brian Burgos
Paul Crooker
Tim Hardin
Craig Harrington
Mike McDevitt

Helen Cothron
SGMP
Jim Benson
Brent Capell
Rich Guill
Sean Kil
Rick Williams
Together…Shaping the Future of Electricity
Materials Reliability Program

Bernie Rudell
MRP Chairman, Exelon

Anne Demma
Program Manager, EPRI

PMMP Executive Committee Meeting
Tuesday, August 30, 2016

Date: August 22, 2016
Presentation Topics

- 2016 Budget Status and Deliverables
- 2017 Budget
- 2018 Preliminary Budget and RFA structure
- Guidelines Status
- Industry and Regulatory Issues and PWR OE
- 2016 Meetings and Workshops
2016 and 2017 Budgets

- 2016 and 2017 budgets were endorsed by the PMMP at the February 2016 meeting
- 2016-17 Greybook was finalized in April 2016 and sent to members
  - Ahead of new prioritization for 2018
- 2018 Strategic Plan developed (retires Greybook)
## 2016 Budget Overview (February 2016)

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<tr>
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# 2016 Budget Overview (April 2016)

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## 2016 MRP Budget Overview (August 2016)

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<td>Estimated Carry Forward</td>
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<td>Sector Emergent Issue Funding</td>
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<td>Contingency</td>
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## Preliminary 2016 Spend Plan on BFB issue

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<td>MRP contingency funding</td>
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<td>BTP 5-3 and Appendix G delays due to FAVOR Delay</td>
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<td>Dynamic strain project delay</td>
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<td>Focus Area #1 - Cause/EOC, IG, Reg. Interface</td>
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<tr>
<td>Focus Area #4 – Inspection/NDE</td>
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<tr>
<td>Focus Area #5 – Irradiated Mtls (BFB) Testing</td>
<td>903</td>
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<tr>
<td>Focus Area #6 – Aging Mngmt Prog Assessment</td>
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<td><strong>Total Spend Plan</strong></td>
<td><strong>1,219</strong></td>
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</table>
2016 Key Planned Deliverables

- Topical Report for PWSCC Mitigation by Surface Stress Improvement (MRP-335 Rev. 3)
- Basis for ASME Section XI Code Case N-838—Flaw Tolerance Evaluation of Cast Austenitic Stainless Steel (CASS) Piping Components (MRP-362 Rev. 1)
- Effect of Lithium Concentration on IASCC Initiation in Irradiated Stainless Steel (MRP-413)
- Management of Thermal Fatigue in Normally Stagnant Non-Isolable RCS Branch Lines (MRP-146, Rev. 2)
- PWR Supplemental Surveillance Program (PSSP) Capsule Fabrication Report (MRP-412)
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<tr>
<th>Product ID</th>
<th>Title</th>
<th>Item Type</th>
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<th>Status</th>
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<tbody>
<tr>
<td>3002007392</td>
<td>MRP: Topical Report for PWSCC Mitigation by Surface Stress Improvement (MRP-335 Rev. 3)</td>
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<td>3002008636</td>
<td>MRP: Development of Probability of Detection Curves for UT of Dissimilar Metal Welds (MRP-262, Rev. 2)</td>
<td>Report</td>
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<td>3002008082</td>
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<td>3002007897</td>
<td>MRP: Revised Technology for Reactor Vessel J-groove Weld Surface Examination (MRP-410)</td>
<td>Report</td>
<td>7/1/2016</td>
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<td>3002007934</td>
<td>MRP: Administrative Procedures (MRP-130, Rev. 4)</td>
<td>Report</td>
<td>7/22/2016</td>
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<td>3002007852</td>
<td>MRP: Benchmark of Thermal Fatigue Management in France (MRP-409)</td>
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## 2016 MRP Planned Deliverables (2 of 2)

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<td>3002007953</td>
<td>MRP: Management of Thermal Fatigue in Normally Stagnant Non-Isolable RCS Branch Lines (MRP-146, Rev. 2)</td>
<td>Report</td>
<td>10/30/2016</td>
<td>On Schedule</td>
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<td>3002007960</td>
<td>MRP: Screening, Categorization, and Ranking of Reactor Internals Components for Westinghouse and Combustion (MRP-191, Rev. 1)</td>
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<td>3002007849</td>
<td>MRP: PWSCC in Alloys 600 and 690: Quantitative Assessment of Crack Initiation Time (MRP-406)</td>
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<td>3002007948</td>
<td>MRP: PWR Bottom Mounted Nozzle Exam Zone Definition &amp; Basis Development (MRP-411)</td>
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<td>MRP: Aging Management Strategies for Westinghouse and Combustion Engineering PWR Internal Components (MRP-232, Rev. 2)</td>
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<td>MRP: RPV Integrity Primer (MRP-278, Rev.1), A Primer on Theory and Applications</td>
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## MRP 2017 Budget Overview

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### MRP 2018 Budget Overview

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# MRP Reorganized Projects into 10 Research Focus Areas

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<th>RFA</th>
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<tr>
<td>1</td>
<td>Reactor Vessel Internals Assessment, Modeling and Inspection</td>
</tr>
<tr>
<td>2</td>
<td>Reactor Vessel Internals Irradiated Materials Testing</td>
</tr>
<tr>
<td>3</td>
<td>Alloy 600/690 Management, Mitigation, and Inspection</td>
</tr>
<tr>
<td>4</td>
<td>Reliability of CASS Pressure Boundary Components</td>
</tr>
<tr>
<td>5</td>
<td>Pipe Rupture Probability Assessment</td>
</tr>
<tr>
<td>6</td>
<td>Stainless Steel Degradation Mechanism Studies</td>
</tr>
<tr>
<td>7</td>
<td>Fatigue Management (Thermal and Vibration Fatigue)</td>
</tr>
<tr>
<td>8</td>
<td>Replacement Materials Testing (Alloy 690/52/152)</td>
</tr>
<tr>
<td>9</td>
<td>Reactor Pressure Vessel Integrity</td>
</tr>
<tr>
<td>10</td>
<td>Environmentally Assisted Fatigue</td>
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</tbody>
</table>
MRP IC members RFA Prioritization Results

- **Higher priority RFAs**
  - #1 Reactor Vessel Internals Assessment, Modeling and Inspection
  - #9 Reactor Pressure Vessel Integrity
  - #7 Fatigue Management (Thermal and Vibration Fatigue)

- **Middle priority RFAs**
  - #2 Reactor Vessel Internals Irradiated Materials Testing
  - #3 Alloy 600/690 Management, Mitigation, and Inspection
  - #10 Environmentally Assisted Fatigue

- **Lower priority RFAs**
  - #8 Replacement Materials Testing (Alloy 690/52/152)
  - #4 Reliability of CASS Pressure Boundary
  - #5 Pipe Rupture Probability Assessment
  - #6 Stainless Steel Degradation Mechanism Studies
## MRP 2018 Budget by RFA

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<th>RFA</th>
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<th>% OF MRP BUDGET</th>
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<td>2</td>
<td>INTERNALS IRRADIATED MATERIALS TESTING</td>
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<td>3</td>
<td>ALLOY 600/690 MANAGEMENT, MITIGATION, AND INSPECTION</td>
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<td>4</td>
<td>RELIABILITY OF CASS PRESSURE BOUNDARY</td>
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<td>5</td>
<td>PIPE RUPTURE PROBABILITY ASSESSMENT</td>
<td>875</td>
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<td>6</td>
<td>STAINLESS STEEL DEGRAD MECH STUDIES</td>
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<td>7</td>
<td>THERMAL AND VIBRATION FATIGUE</td>
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<td>REPLACEMENT MATERIALS TESTING (ALLOY 690/52/152)</td>
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<td>9</td>
<td>REACTOR PRESSURE VESSEL INTEGRITY</td>
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<td>10</td>
<td>ENVIRONMENTALLY ASSISTED FATIGUE</td>
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MRP 2018 Budget by RFA and Project

H – indicates 3 highest RFAs
M – indicates 3 middle RFAs
L – indicates 4 lowest RFAs
EPRI MRP NEI 03-08 Guidelines
## MRP NEI 03-08 Active Guidelines

<table>
<thead>
<tr>
<th>Doc Number</th>
<th>Product ID</th>
<th>Document Title</th>
<th>Date</th>
<th>Level</th>
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<tbody>
<tr>
<td>MRP-126 Rev 0</td>
<td>1009561</td>
<td>Generic Guidance for an Alloy 600 Management Plan</td>
<td>Nov 2004</td>
<td>Mandatory</td>
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<tr>
<td>MRP-146 Rev 1</td>
<td>1022564</td>
<td>Management of Thermal Fatigue in Normally Stagnant Non-Isolable RCS Branch Lines</td>
<td>Jun 2011</td>
<td>Needed</td>
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<td>MRP-146S Rev 0</td>
<td>1018330</td>
<td>Management of Thermal Fatigue in Normally Stagnant Non-Isolable RCS Branch Lines – Supplemental Guidance</td>
<td>Jan 2009</td>
<td>Needed</td>
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<td>MRP 2015-019</td>
<td>N/A</td>
<td>MRP-146 and MRP-192 Interim Guidance NEI 03-08 Needed &amp; Good Practice Interim Requirements for Management of Thermal Fatigue</td>
<td>May 2015</td>
<td>Needed</td>
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<tr>
<td>MRP-192 Rev 2</td>
<td>1024994</td>
<td>Assessment of RHR Mixing Tee Thermal Fatigue in PWR Plants</td>
<td>Aug 2012</td>
<td>Good Practice</td>
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<td>MRP 2014-006</td>
<td>N/A</td>
<td>MRP-227-A Interim Guidance to inspection requirements of Westinghouse Control Rod Guide Tubes</td>
<td>Feb 2014</td>
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<tr>
<td>MRP-228 Rev 1</td>
<td>1025147</td>
<td>MRP-228 Inspection Standard for PWR Internals</td>
<td>Dec 2015</td>
<td>Needed</td>
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<tr>
<td>MRP 2013-023</td>
<td>N/A</td>
<td>MRP-228 Interim Guidance for Ultrasonic Examinations of Reactor Internal Baffle-Former Bolting</td>
<td>Oct 2013</td>
<td>Needed</td>
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<tr>
<td>MRP-384 Rev 0</td>
<td>3002002963</td>
<td>Guideline for Nondestructive Examination of Reactor Vessel Upper Head Penetrations</td>
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<td>Good Practice</td>
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<td>MRP 2016-021</td>
<td>N/A</td>
<td>BFB Interim Guidance for Tier 1 Plants (4-loop downflow)</td>
<td>Jul 2016</td>
<td>Needed</td>
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</table>
MRP Guideline Deviations
1 MRP Guideline Deviation as August 22, 2016

- Associated with a component replacement
- Once MRP-146, Revision 2 is approved, this will not be a deviation anymore
Industry & Regulatory Issues and recent PWR Materials OE
Industry Challenges

- **Quasi-Laminar Flaws / Hydrogen Flaking Issue (Doel 3 RPV issue)** - Will be discussed in Technical Topics Presentation
  - MRP participated in the meeting organized by the Belgium regulator on this subject in January 2016
  - MRP is assessing the impact of the new information on the previous probabilistic analysis (MRP-367) and will update report as needed

- **Potential Non-conservatism of Branch Technical Position 5-3 Methods to Estimate Initial Toughness of RPV Steels** - Will be discussed in Technical Topics Presentation
  - NRC agrees with MRP-401/ BWRVIP-287 that issue is not immediate safety concern but is performing analyses to determine if BTP must be revised

- **BMN Volumetric Examination**
  - Agreement reached with NRC in 2013 to pursue Code Case to incentivize but not require volumetric exams, however eventually tabled

- **Reactor Vessel Internals: Baffle-Former-Bolt Cracking** - Will be discussed in Technical Topics Presentation
  - During spring 2016 outages, Indian Point 2 and Salem 1 found large quantities of degraded baffle-former-bolts that required replacement, resulting in extended outages
  - The findings raised concern regarding industry preparedness to respond when such degradation is discovered and the impact on the rest of the fleet
Regulatory Issues

- Received a fee waiver for NRC’s review of MRP-227-Rev.1, PWR Internals Inspection and Evaluation Guidelines
- Development work for MRP-227 Rev 2 to address GALL SLR has established an acceptable timeline with NRC to maintain generic reference of MRP-227-A in GALL SLR
- MRP-335, R3, the technical basis for optimized inspection intervals for Alloy 600 locations based on PWSCC mitigation by peening was submitted to the NRC for a safety evaluation (SE)
PWR Materials OE since January 2016 NPC Meeting

2016

- Axial flaw in DM weld at 4” Pressurizer Safety Nozzle, MSIP mitigated in 2006, was determined to be deeper. Root cause concluded flaw depth was miss sized in prior exams. Repaired by Full Structural Weld Overlay
  > NDE Alert letter issued
- BFB Inspection results in high % failed in two Westinghouse 4-Loop down flow units
  > An Industry BFB FG has been established with MRP and PWROG participation
- Thermal Fatigue Exams reveal flaws in two units
  > Not an “emergent issue” as this was addressed in recent interim guidance - Thermal Fatigue FG has the lead on following assessment of these issues
- Evidence of leakage at a Cold Leg RTD Instrument Nozzle
  > ET revealed an axial PWSCC flaw in nozzle, opposite j-groove weld. Repaired RTD nozzle with a Mechanical Nozzle Clamp per Code Case.
- RV Head CRDM/Nozzle Exams identified two shallow off axis indications just below the toe of the J-groove on one nozzle – repaired by grinding to PT white results
  > Not an “emergent issue” – another Cold Head experience.
- ISI identified an acceptable by evaluation flaw in a 14” RHR return line off the hot leg
  > Final Owner causal determination to be reviewed for disposition
2016 MRP Meetings & Workshops
## 2016 Meetings

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Location</th>
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<tbody>
<tr>
<td>MRP TACs and IC Meeting</td>
<td>June 6-10</td>
<td>Westin Hotel Westminster, CO</td>
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<tr>
<td><strong>International Light Water Reactors</strong></td>
<td><strong>August 1-4</strong></td>
<td><strong>Hyatt Regency McCormick Place, Chicago, IL</strong></td>
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<tr>
<td>EPRI Nuclear Power Council Meetings</td>
<td>Aug. 29–Sept. 1</td>
<td>New Orleans, LA</td>
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<tr>
<td>– PMMP Meeting (Aug 30)</td>
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<tr>
<td>– MAPC Meeting (Aug 31)</td>
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<tr>
<td>MRP TACs and IC Meeting</td>
<td>November 14-18</td>
<td>Eilan Hotel, San Antonio, TX</td>
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## 2016 MRP International Workshops & Visits

<table>
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<th>Jan</th>
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<th>Mar</th>
<th>Apr</th>
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<tbody>
<tr>
<td></td>
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<td>Visits to Kyushu and Shikoku, IGALL meeting and MRP Japan Workshop: April 4-8, Osaka &amp; Tokyo, Japan</td>
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<tr>
<td>May</td>
<td>Jun</td>
<td>Jul</td>
<td>Aug</td>
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<tr>
<td>MRP Reactor internals workshop: KHNP, May 16-17, Korea</td>
<td>MRP Workshop Focused on LR (LTO in Spain): June 15-17, Spain</td>
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<td></td>
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<tr>
<td>Sept</td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
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<tr>
<td>MRP Workshops: KHNP, Sept. 20-22 with SGMP and NDE in Korea</td>
<td>MRP Workshops and Visits: Ringhals and EDF October 10-14, Sweden</td>
<td>Nuclear Sector Japan Seminars: Oct. 25-26, Tokyo, Japan</td>
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</table>
Committee Membership and Leadership
Program Organization and Leadership

Materials Reliability Program (IC)
Rudell, Exelon
Hoehn, Ameren
Demma, EPRI

Regulatory Interface
Richter, NEI
Dyle, EPRI

Materials Review Visits

Support TAC
Hoehn, Ameren
Childress, Duke Energy
Burgos, since Aug. 1 (replaced McDevitt who retires Sept. 30)

Inspection TAC
Smith, Exelon
Doss, Duke
Spanner, EPRI

Mitigation & Testing TAC
Efsing, Ringhals
Koehler, Xcel Energy
Smith, EPRI

Assessment TAC
Sims, Entergy (Will step down After Peening SER)
Wells, Southern Nuclear
Amberge, EPRI
Together…Shaping the Future of Electricity
Steam Generator Management Program

Jim Stevens  
SGMP Chairman, Luminant

Helen Cothron  
Program Manager, EPRI

PMMP Executive Committee Meeting  
Tuesday, August 30, 2016

Date: August 15, 2016
Presentation Topics

- 2016 Budget Status and Deliverables
- 2017/2018 Budget
- 2016 Events
- Guidelines Status
- Industry Challenges and Regulatory Issues
- Operating Experience
- SGMP Membership Changes
2016 Budget and Deliverables
<table>
<thead>
<tr>
<th></th>
<th>2016 ($K)</th>
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<tbody>
<tr>
<td>Funding (Base + Supplemental)</td>
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<tr>
<td>Carryforward</td>
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<td><strong>Total Available Funding</strong></td>
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<tr>
<td>Total Planned Expense</td>
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<tr>
<td><strong>Total Fund Balance</strong></td>
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Summary of 2016 SGMP Deliverables

- 3 Guideline Documents
  - NEI 03-08 mandatory and needed elements
- 8 Technical Reports
- 1 Software Product
- 1 Technical Transfer
- 1 Database Update
- Triton Version 1
## 2016 SGMP Delivered Products

<table>
<thead>
<tr>
<th>Deliverable Name</th>
<th>PID #</th>
<th>Committed Date</th>
<th>Delivered Date</th>
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<tbody>
<tr>
<td>Generic Elements of U-Bend Tube Vibration Induced Fatigue Analysis for Westinghouse Model 44F Steam Generators</td>
<td>3002007562</td>
<td>June-16</td>
<td>April-16</td>
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<td>Generic Elements of U-Bend Tube Vibration Induced Fatigue Analysis for Westinghouse Model 51F Steam Generators</td>
<td>3002007565</td>
<td>June-16</td>
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<tr>
<td>Model Assisted Probability of Detection Software using R (MAPOD-R) Revision 2</td>
<td>3002007857</td>
<td>Sept-16</td>
<td>May-16</td>
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<tr>
<td>Steam Generator Integrity Assessment Guidelines, Revision 4</td>
<td>3002007571</td>
<td>July-16</td>
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<tr>
<td>Pressurized Water Reactor Steam Generator Examination Guidelines, Revision 8</td>
<td>3002007572</td>
<td>July-16</td>
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<td>Assessment of Lead Induced Stress Corrosion Cracking Inhibitor Effectiveness</td>
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<td>Correlating Primary-to-Secondary Leakage with Probability of Burst</td>
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<td>Alternatives to Hydrazine for PWR Secondary Chemistry Control; Evaluation of Diethylhydroxylamine (DEHA)</td>
<td>3002007608</td>
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<td>Steam Generator Foreign Object Handbook, Revision 2</td>
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<td>Development of Algorithms for Automated Analysis of SG Eddy Current Data</td>
<td>3002007710</td>
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<td>Assessment of Processes for Implementation of Auto Data Analysis Systems</td>
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<td>Steam Generator Degradation Database (SGDD) Version 7.3</td>
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<td>Pressurized Water Reactor Chemistry Knowledge Transfer, Volume 2 - Secondary System Purification</td>
<td>3002007911</td>
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<td>Triton Steam Generator Thermal-Hydraulics Code; Version 1.0</td>
<td>3002005515</td>
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Steam Generator Integrity Assessment Guidelines

- NEI 03-08 Mandatory, Needed and Good Practice Elements
- Updated with latest research results and operating experience
- Major changes
  - Guidance for performing assessments with less than 100% inspection
  - Guidance for inspection scope, expansion scope and integrity assessments when small numbers of indications are identified
  - Recommendation for examination of the channel head
  - Recommendation to perform eddy current noise monitoring

Report 3002007571 published June 2016 – Implementation Date August 2017
PWR Steam Generator Examination Guidelines

- NEI 03-08 Needed and Good Practice Elements
- Updated with latest research results and operating experience
- Major changes
  - Guidance for automated data analysis
    - Single pass system endorsed for Alloy 690TT
  - Guidance for measuring and monitoring eddy current noise

Report 3002007572 published June 2016 – Implementation Date August 2017
### 2017/2018 Budget

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<td>Maintenance of SGMP (Technique and Personnel Qualification, Guidelines, Databases,</td>
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<td>Tech Transfer)</td>
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<tr>
<td>Understanding Wear Mechanisms</td>
<td>1176</td>
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<tr>
<td>Chemistry and Fouling</td>
<td>646</td>
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<td>Managing Corrosion Mechanisms</td>
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<tr>
<td>Development of ECT Improvement</td>
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<td>State of the Art Software for Understanding Flow Conditions</td>
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2016 Events
## 2016 SGMP Events

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<th>Location</th>
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<tbody>
<tr>
<td>EPRI Nuclear Power Council Meetings</td>
<td>Feb 8-11</td>
<td>Austin, TX</td>
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<td>– PMMP &amp; MAPC meetings</td>
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<tr>
<td>Steam Generator Task Force Meeting</td>
<td>Feb 3</td>
<td>Washington DC</td>
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<tr>
<td>SGDD Training: Data Entry</td>
<td>May</td>
<td>Webcast</td>
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<tr>
<td>SGDD Training: Reporting</td>
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<tr>
<td>SGMP TAG Meeting (June 7-9)</td>
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<td>Salt Lake City, UT</td>
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<td>– SGMP IC Meeting (June 8 and 9)</td>
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<tr>
<td>– NDE TAC Meeting (June 7)</td>
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<tr>
<td>– E&amp;R TAC Meeting (June 7)</td>
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<tr>
<td>– TS TAC Meeting (June 7)</td>
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<tr>
<td>35th Steam Generator NDE and Tube Integrity Workshop</td>
<td>July 17–20</td>
<td>Clearwater Beach, FL</td>
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<tr>
<td>Steam Generator Task Force Meeting</td>
<td>Aug 17</td>
<td>Washington, DC</td>
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# 2016 SGMP Events

<table>
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<th>Location</th>
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</table>
| EPRI Nuclear Power Council Meetings  
  – PMMP Meeting  
  – MAPC Meeting | Aug 29 - Sept 1 | New Orleans, LA |
| SGDD Training: Data Entry | Nov | Webcast |
| SGDD Training: Reporting | Dec 6-8 | New Orleans, LA |
| SGMP TAG Meeting (Dec 6-8)  
  – SGMP IC Meeting (Dec 7-8)  
  – NDE TAC Meeting (Dec 6)  
  – E&R TAC Meeting (Dec 6)  
  – TS TAC Meeting (Dec 6) | Dec 6-8 | New Orleans, LA |
SGMP Guidelines
### SGMP Guideline Status and Revision Schedule

<table>
<thead>
<tr>
<th>Guideline Title</th>
<th>Current Rev #</th>
<th>Report #</th>
<th>Last Pub Date</th>
<th>Implementation Date(s)</th>
<th>Interim Guidance</th>
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<th>Comments</th>
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<td>3002007571</td>
<td>June 2016</td>
<td>8/31/2017</td>
<td>None</td>
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<td>EPRI SG In Situ Pressure Test Guidelines</td>
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<td>1025132</td>
<td>Oct 2012</td>
<td>10/10/13</td>
<td>None</td>
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<td>PWR SG Examination Guidelines</td>
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<td>3002007572</td>
<td>June 2016</td>
<td>8/31/2017</td>
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<td>PWR SG Primary-to-Secondary Leakage Guidelines</td>
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<td>1022832</td>
<td>Sept 2011</td>
<td>4/11/2012 7/11/2012</td>
<td>None</td>
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<td>Revision will begin 2016</td>
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## SGMP Guideline Status and Revision Schedule

<table>
<thead>
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<th>Guideline Title</th>
<th>Current Rev #</th>
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<th>Implementation Date(s)</th>
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<tr>
<td>PWR Primary Water Chemistry Guidelines</td>
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<td>3002000505</td>
<td>April 2014</td>
<td>1/28/2015</td>
<td>None</td>
<td>2018</td>
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<tr>
<td>PWR Secondary Water Chemistry Guidelines</td>
<td>7</td>
<td>1016555</td>
<td>Feb 2009</td>
<td>8/20/09 11/20/09</td>
<td>SGMP-IG-13-01 SGMP-IG-14-01</td>
<td>N/A</td>
<td>Rev 8 in progress</td>
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<td>Steam Generator Management Program Administrative Procedures</td>
<td>4</td>
<td>3002005168</td>
<td>Mar 2015</td>
<td>3/9/2016</td>
<td>None</td>
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<tr>
<td>Steam Generator Degradation Specific Flaw Handbook</td>
<td>2</td>
<td>3002005426</td>
<td>Nov 2015</td>
<td>N/A</td>
<td>None</td>
<td>N/A</td>
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</table>
NEI 03-08 Deviations

• Three long-term deviations
  – Two Steam Generator Examination Guidelines, R7
  – Single party auto analysis
  – Steam Generator Integrity Assessment Guidelines, R3
  – Use of site-specific sizing indices

• Two short term deviations
  – Steam Generator Examination Guidelines, R7
  – PSI prior to hydro
  – Secondary Water Chemistry Guidelines, R7
  – Exceeding control parameters during startup
Industry Issues
Industry Issues

- Assuring High Performance of Single Party Auto Analysis Systems
- Foreign Object Wear
  - Detection of FOs
  - Inspection Scope
  - Estimating Wear rates from FOs
- Cracking in Alloy 600TT Steam Generator Tubes
- Wear in Replacement Steam Generators
- Need for a State of the Art Thermal Hydraulic Code
Regulatory Issues

- NRC has accepted SGMP Research Conclusions Regarding Divider Plate Crack Propagation
  - Staff Interim Guidance Letter

- NRC will review published guidelines in 2016 to ensure all their technical issues have been resolved
  - Most of the technical issues have been incorporated into the guidelines; however, not all of them are requirements

- Single pass auto analysis

- Site-specific equivalency of generic eddy current technique qualifications

- In plane fluid elastic instability
Operating Experience
Operating Experience Update

- South Texas identified a 0.09 volt volumetric indication in Alloy 690TT tubing during a steam generator inspection in 2015.
- Utility has completed the apparent cause and determined that if the indication is not a false call, the degradation is most likely pitting corrosion.
- They will be taking action in the future to address pitting corrosion in their hard sludge pile.
- SGMP will be conducting research 2017/2018 investigating pitting corrosion in Alloy 690TT tubing.
Committee Membership Changes
<table>
<thead>
<tr>
<th>Position</th>
<th>Name</th>
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Larry Miller has changed positions and will no longer be in SGMP Vice Chairman is leading while TS TAC identifies a replacement.
Together...Shaping the Future of Electricity
2018 Budget Review

“Presentation Placeholder – No slides”
MRP Technical Topics

Brian Burgos, Technical Leader, Principal, EPRI
Kyle Amberge, Technical Leader, Principal, EPRI
Tim Hardin, Technical Executive, EPRI
Paul Crooker, Technical Leader, Principal, EPRI
Anne Demma, Program Manager, EPRI
Bernie Rudell, MRP Chairman, Exelon

PMMP Meeting, New Orleans, August 30, 2016
Topic 1 - Baffle-Former Bolt Focus Group (BFB FG) Update
Background
Westinghouse NSSS Internals

- Upper Support Plate
- Upper Support Column
- Inlet Nozzle
- Upper Core Plate
- Baffle Plate
- Lower Core Plate
- Lower Support Column Body
- Bottom-Mounted Instrumentation Column Body
- Vessel Head
- Hold Down Spring
- Control Rod Guide Tube
- Outlet Nozzle
- Pressure Vessel
- Core Barrel
- Thermal Shield
- Former Plate
- Lower Core Support Plate
Baffle-Former Assembly

Example Baffle-Former Bolt Locations

Core Barrel

Baffle Plate

Former Plate

Source: ML15331A264
Baffle-Former Assembly Details

Baffle to Former Bolt (Long & Short)

Source: ML15331A179
Coolant Flow Configurations

Downflow Configuration
- Coolant Flow
- Baffle Plate
- Former Plate

Upflow Configuration
- New Flow Hole
- Plug
- Coolant Flow
- Core Barrel
- Coolant Flow
- Thermal Neutron Shield

Source: ML073190376
Timeline

**Operating Experience**

- First UT baffle-former bolts (BFB) inspections in French PWR CP0 units and first cracks found
- DC Cook finds degraded baffle-former bolts by visual inspection
- First degraded baffle-former bolts found in U.S.
- MRP publishes assessment of French BFB OE (MRP-03)
- Ginna performs first MRP-227 inspections
- Indian Point 2, Salem 1 find degraded bolts (visual+UT)
- MRP publishes Reactor Internals Inspection Guidelines (MRP-227)
- NRC reviews & approves MRP-227
- WCAP-13266: BFB Program for the Westinghouse Owners Group - Plant Categorization
- NRC Information Notice 98-11 on BFBs
- Westinghouse Technical Bulletin TB-12-5, related to the DC Cook OE

**Guidance**
Past Operating Plant Experience

EDF 1989-Present
Joint Owners Group Program 1998-2000
Industry MRP-227-A Inspections (through end of 2015)
B&W and International Plants
EDF Experience 1989-Present

Baffle bolt failures reported - Limited to CP0 design
• 3-loop (converted to upflow), with significant plant-to-plant variability (CPY design <5 indications over life of plant)

EDF Periodic bolt replacement of failed original bolts, and periodic replacements included previously replaced bolts
• Maintain sufficient number of “healthy bolts” to push next inspection to 10 years (based on projection model)

Overall BFB Timeline – CP0 Units
- X-axis: number of operating hours
- Y-axis: cumulative number of bolts found ‘failed’/‘unconclusive’
- : evolution trend, assuming 5 failed bolts per year

BUG2-FES2-FES1-BUG3: 4/6 CP0 units are ‘affected’
BUG5-BUG4: 2/6 CP0 units are ‘unaffected’
Joint Owners Baffle Bolt Program (15-22 EFPY)

Sponsored Inspections of four plants (1998-2000)

- Point Beach Unit 2: 2-loop, Upflow (converted), Type 347SS
  - 8% UT Indications
  - Partial replacement program
- Farley Unit 1: 3-loop, Upflow (converted), Type 316SS
  - No UT Indications
  - Proactive replacement of minimum pattern
- Ginna: 2-loop, Downflow, Type 347SS
  - 9% UT Indications (Of these, 14 were sent for metallurgical examination. Results showed no indications of cracking, so this 9% likely contains a number of false calls)
  - Partial replacement program
- Farley Unit 2: 3-loop, Converted Upflow (downflow at time of inspection), Type 316SS
  - No UT Indications
  - Proactive replacement of minimum pattern

NO 4-LOOP PLANTS EXAMINED
Industry MRP-227-A Baffle-Former Bolt Inspections (25-35 EFPY) through end of 2015

- Point Beach Unit 1: 2-Loop, Upflow (converted), Type 347SS
  - 1st Inspection: No UT Indications
- Point Beach Unit 2: 2-Loop, Upflow (converted), Type 347SS
  - 2nd Inspection: 2% Additional UT Indications
- Ginna: 2-Loop, Downflow, Type 347SS
  - 2nd Inspection (partial inspection of 123 original bolts and 56 replacement bolts): 1 Additional UT Indications (Partial Replacement – 25 bolts)
- Prairie Island Unit 1: 2-Loop, Downflow, Type 347SS
  - 1st Inspection: 6% UT Indications
- Prairie Island Unit 2: 2-Loop, Downflow, Type 347SS
  - 1st Inspection: 10% UT Indications
- Surry Unit 1: 3-Loop, Downflow, Type 347SS
  - 1st Inspection: <1% UT Indications
- Surry Unit 2: 3-Loop, Downflow, Type 347SS
  - 1st Inspection: <1% UT Indications
- Robinson: 3-Loop, Downflow, Type 347SS
  - 1st Inspection: <1% UT Indications
- Turkey Point Unit 3: 3-Loop, Downflow, Type 347SS
  - 1st Inspection: No UT Indications in 305 of 1088 bolts inspected

NO 4-LOOP PLANTS EXAMINED
B&W and International Plant Results

- Oconee Unit 1, Type 304SS
  - No relevant UT indications - Four BFBs uninspectable due to large welds on locking bars
- Oconee Unit 2, Type 304SS
  - No relevant UT indications - One BFB uninspectable due to UT probe not seating properly
- Oconee Unit 3, Type 304SS
  - One BFB identified with crack-like indications - One BFB uninspectable due to UT probe not seating properly
- Crystal River Unit 3, Type 304SS
  - No relevant UT indications - UT performed due to visual indication from baffle-to-baffle bolts

- Doel 1: 2-Loop Downflow, Type 316SS
  - 1st Inspection: 2% UT Indications
- Doel 2: 2-Loop Downflow, Type 316SS
  - 1st Inspection: <1% UT Indications
- Krsko: 2-Loop, Downflow (prior to inspection), Type 316SS
  - 1st Inspection: <1% UT Indications
- Tihange 1: 3-Loop, Upflow (converted), Type 316SS
  - 960 of 1088 bolts inspected in each of the following inspections
  - 1st Inspection: 4% UT Indications
  - 2nd Inspection: 3% UT Indications
  - 3rd Inspection: No confirmed UT Indications (5 bolts either not inspectable or not interpretable)
Observations from Broader OE

Prior to the recent OE at Cook Unit 2, Indian Point Unit 2, and Salem Unit 1 (discussed later in the presentation), the following observations can be made:

• Bolts with UT indications tend to be randomly distributed
• Distributions are consistent with expectations of IASCC failures
• Quantity and distribution of bolts with indications bounded by historical generic safety assessment generated in mid-1990s (WCAP-15328)
• Industry response to replacement of bolts with indications has been positive
Recent Operating Plant Experience

DC Cook 2 - 2010
Indian Point 2 - 2016
Salem 1 - 2016
DC Cook Unit 2 (2010 / 22 EFPY) (4-Loop Downflow Configuration)

- Fuel failure in peripheral assembly attributed to wear against broken bolt head
- Bolt heads and lock bars found on lower core plate
- Visual inspections revealed 18 degraded bolts on single plate
  - Additional bolts removed from plate with visual indications to define extent of localized degradation (approx. 40 bolts in single patch)
  - Additional test bolts removed from symmetrical locations to evaluate potential for degradation on other plates (all of these test bolts were found to be intact)
- No UT inspections performed in 2010 (at that time UT was not qualified or optimized for the Cook 2 bolt design)
- Degraded and test bolts replaced
- Westinghouse issued Technical Bulletin TB-12-5
- 100% Visual inspection conducted in 2012 with no additional indications
Indian Point Unit 2 (2016 / 31 EFPY) (4-Loop Downflow Configuration)

- Degraded bolts/lock bars noted in visual exams performed prior to MRP-227 100% UT exams that were planned to occur during this outage
- Markings on periphery of neighboring fuel assembly identified (no fuel failure).
- Inspections identified 227 with visual degradation or UT indications
  - Includes 14 that were not inspectable
- UT indications were clustered
  - Spanned various quadrants
  - Multiple groups of 10+ adjacent failures / At least one cluster of 50+ adjacent failures
- Observed failure pattern likely exceeds MRP-227 expansion criteria and exceeds WCAP-17096 engineering acceptance criteria
- Site-specific response
  - Performed Acceptable Bolting Pattern Analysis (ABPA)
  - Performed Replacement Bolting Pattern Analysis
  - Performed engineering evaluations supporting Unit 3 Extent of Condition Evaluation
  - Performed engineering evaluations supporting Unit 2 Assessment of Potential Safety Impacts
  - Performed baffle-former bolt removal and replacement
  - Quarantined select bolts for potential future testing
Salem Unit 1 (2016 / 28 EFPY) (4-Loop Downflow Configuration)

- Conducted visual exams every other refueling outage in response to DC Cook Unit 2 OE and TB-12-5; MRP-227 exams were not planned until 2017
- Degraded bolts/lock bars noted in visual exams followed by doing UT exams
- Loose/protruding bolt heads resulted in fuel fretting and one fuel assembly leaker
- Inspections identified 182 with visual degradation or UT indications
  - Includes 18 that were not inspectable
- UT indications were clustered
  - Concentrated to a few adjacent octants
  - Multiple groups of 10+ adjacent failures / At least one cluster of 50+ adjacent failures
- Observed failure pattern likely exceeds MRP-227 expansion criteria and exceeds WCAP-17096 engineering acceptance criteria
- Site-specific response
  - Performed Acceptable Bolting Pattern Analysis (ABPA)
  - Performed Replacement Bolting Pattern Analysis
  - Performed engineering evaluations supporting Unit 1 Justification for Past Operation
  - Performed engineering evaluations supporting Unit 2 Extent of Condition Evaluation
  - Performed baffle-former bolt removal and replacement
  - Quarantined select bolts for potential future testing
Conclusions from Recent OE

- These three plants share a common plant design configuration (4-loop downflow), bolt design, and bolt material
- Bolts with visual or UT indications tend to be clustered
- Distributions seem to indicate the presence of a mechanism causing adjacent bolts to become more susceptible to failure
US Trends – BFB FG Industry OE Database

Exam Req’d by MRP-227A

Current EFPY Range

Number of Assumed Degraded Bolts

- No of Assumed Degraded Bolts-Tier 1
- No of Assumed Degraded Bolts-Tier 2
- No of Assumed Degraded Bolts-Tier 3

EFPY at Inspection

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BFB FG Activities
Industry Response

- The Industry Baffle-Former Bolt Focus Group (BFB FG) was formed in May 2016 to support an integrated approach among industry organizations to address recent operating experience
  - AREVA
  - EPRI
  - PWROG
  - Utility Staff
  - Westinghouse
  - Others

- Six focus areas with key actions defined

<table>
<thead>
<tr>
<th>Focus Area</th>
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<tr>
<td>#1 – Extent of Condition, Interim Guidance, Technical Interfacing with the NRC</td>
<td>MRP</td>
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<td>#2 – Plant/Fleet Operating Experience Assessment</td>
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<td>#5 – Irradiated Testing Support</td>
<td>MRP</td>
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<tr>
<td>#6 – Aging Management Assessment</td>
<td>MRP</td>
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Near Term Industry BFB FG Actions Completed

- Supported presentation to NSIAC on 5/23/2016
  - Westinghouse Technical Bulletin TB-12-5 remains valid
- Provided Industry Alert Letter from the PMMP Chairman to PWR site VPs on 6/1/2016
  - Expect that NEI 03-08 Interim Guidance will require the 4-loop plants identified in the Westinghouse TB-12-5 bulletin to perform UT inspections of all the BFBs or replace an acceptable pattern of bolts at their next outage.
  - Consideration should also be given to proceeding with procurement of replacement bolts prior to issuance of interim guidance due to potentially long manufacturing lead times.
- Westinghouse NSAL 16-01 issued 07/05/16 and revised 08/01/16
- AREVA CSB issued 07/14/16
Near Term Industry BFB FG Actions Completed

- Issued NEI 03-08 “Needed” Interim Guidance on 7/25/2016 regarding BFB inspections for Tier 1 plants as identified in Westinghouse NSAL 16-01

- Assessed Fall 2016 and Spring 2017 outage seasons for developing a contingency plan for tooling and BFB material needs
  - Fall 2016: 3 planned MRP-227 UT inspections (1 of 3 is a Tier 1a plant) and 1 VT-3 inspection (Tier 1b plant)
  - Spring 2017: 2 planned MRP-227 UT inspections (both Tier 1a plants), 1 planned UT inspection (non MRP-227 but a Tier 1a plant), and 1 VT-3 inspection (Tier 1b plant)

- Initiated Hot Cell Post Irradiation Examinations of Indian Point 2 BFBs
  - Microscopic examinations have begun and are currently underway
Planned BFB FG Activities through Mid-2017

- Finalize BFB OE database by adding international data and UT inspection results from 2016-2017 exams in the US
- Continue with Hot Cell PIE work for IP2 and SAL1
- Provide additional NEI 03-08 Interim Guidance for the remainder of U.S. PWR fleet (2-loop and 3-loop plants) later in Fall 2016 or early 2017
- Establish fundamental understanding of BFB failure mechanism(s) and develop potential changes to MRP-227 inspection guidance as needed
  - Re-inspection frequency for UT exams
  - Allowance for proactive BFB replacement to manage aging
Topic 2 - RPV Integrity Updates

Brian Burgos, Technical Leader, Principal, EPRI
Tim Hardin, Technical Executive, EPRI

PMMP Meeting, New Orleans, August 30, 2016
Appendix G P-T Curve
Small Surface Flaw Issue

Brian Burgos, Technical Leader, Principal, EPRI
Tim Hardin, Technical Executive, EPRI

PMMP Meeting, New Orleans, August 30, 2016
Background

- In August 2012, NRC informed industry of a concern regarding potentially high Conditional Probability of Failure (CPF) for RPV when a small inside-surface circumferentially-oriented flaw is postulated during cooldown.
- 2012-2013 MRP performed independent FAVOR analyses (MRP-368).
- 2014: MRP work continued, seeking to define a potential solution to ensure safety goals (CPF < 1E-6) are met under all conditions.
- 2014: BWRVIP began investigation of impact of shallow surface flaws on BWR leak test conditions.
- Before work could be completed, computational anomalies in the FAVOR software were identified.
  - MRP informed NRC in August 2014.
- NRC plans to issue revised FAVOR by end of September 2016.
Future Work on Small Surface Flaw Issue

- Cladding residual stresses “drive” this issue and FAVOR handles cladding stresses using a Stress Free Temperature (SFT) approach
  - Stresses are zero at the SFT and increase as vessel temperature decreases
- To date, both the NRC and industry analyses have used SFT = 488°F — a conservative value
  - Derived from measured of the circumferential stress component, which acts on an axial flaw
- However, the small surface flaw is a circumferential flaw
  - In the basis work for the Alternate PTS Rule, NRC determined that the only feasible through-clad flaw in an RPV is a circumferential flaw
- After revised FAVOR code is released, MRP & BWRVIP will resume work to resolve the small flaw issues using a lower SFT appropriate for the circumferentially-oriented small surface flaw
  - A significant reduction in CPF is possible, mitigating issue
Branch Technical Position 5-3 Issue
Background

- NUREG 0800 Branch Technical Position 5-3 provides to estimate RT\textsubscript{NDT} and Upper Shelf Energy (USE) when drop weight (T\textsubscript{NDT}) and/or weak-direction Charpy V-notch (CVN) test data are not available
- In 2014 potentially non-conservatisms in BTP 5-3 were identified
- MRP/BWRVIP and PWROG conducted projects to address potential non-conservatisms in BTP
  - MRP/BWRVIP evaluated conservatism of the BTP methods and assessed safety significance of nonconservatisms (MRP-401/BWRVIP-287)
  - Probabilistic fracture mechanics (PFM) analyses showed there is negligible risk to PWRs from use of existing BTP through 60 years of operation
  - PWROG’s “Material-Orientation Toughness Assessment” (MOTA) showed existing P-T curve methods for PWRs have available conservative margin to offset BTP in most cases
Present NRC Position & Activity on BTP 5-3 Issue

- There has been ongoing engagement with NRC on this issue
- NRC agrees that “no PWRs need to update their P-T limits and PTS evaluations for 60 years of operation” (NRC Report at ASME XI WGOPC, May 2016)
- NRC has tasked ORNL to perform analyses similar to those in MRP-401/BWRVIP-287 to address operation through 80 years of operation
  - To be completed by end of 2016
- No decision has been made regarding whether or not BTP 5-3 will be revised
  - Likely depends on results of ORNL 80-year analyses
Future MRP Work on BTP 5-3 Issue

- When the new version of FAVOR becomes available, MRP plans to update MRP-401/BWRVIP-287
  - Sensitivity studies performed with the beta version (Fall 2015) of FAVOR indicate that certain changes made in the code will increase CPF and negatively impact the conclusions of MRP-401/BWRVIP-287
  - Updating the analysis using the lower SFT previously discussed may yield more favorable results for 80 year analyses
GE developed an alternate methodology for determination of Initial RT_{NDT} for materials in BWR vessels, similar to BTP 5-3

Technical basis was documented in 1994 BWR Owner’s Group report (NEDC-32399P), which was reviewed & approved by NRC

When BTP 5-3 issue was raised in 2014, NRC said its review would also include the adequacy of the GE procedure

EPRI review of NEDC-32399P identified a concern that the technical basis did not include any data for forgings

Because 9+ PWRs have used GE procedure to estimate Initial RT_{NDT} of nozzle forgings, MRP co-funded BWRVIP project to evaluate GE procedure for forgings

– GE Hitachi generated a draft report offering qualitative arguments for the conservatism of the procedure for forgings because test data necessary for qualitative analysis were not available
Update on GE Procedure for Estimating Initial $RT_{NDT}$ (2/2)

- In January 2016 public meeting, NRC expressed its position that GE procedure is potentially nonconservative for base metal (both plates and forgings)

- Because NRC position broadens the issue, BWRVIP then initiated project to more broadly evaluate the conservatism of the GE procedure
  - Project is in progress
  - Similar to approach in MRP-401/BWRVIP-287, project will determine the uncertainty associated with use of the GE procedure and then assess impact on vessel shell failure risk
  - Report will combine work from GE Hitachi with this effort

- PWRs are not relying on this effort to address potential concern for PWR nozzles; PWROG PA-MSC-1091R3 (Demonstrate Appendix G Margins for PWR RPV Nozzles and Beltline) will be used to address nozzle issue by using a generic SA-508 fracture toughness
Doel 3 Quasi-laminar Flaw Issue
Status of Issue and Plans

- In 2013 MRP-367 assessed the relevance of the ~8,000 quasi-laminar flaws (hydrogen flaking) reported at Doel 3 in 2012
  - For the limiting U.S. forged-ring PWR, safety goals are met when similar flaking is assumed for operation through 60 years

- In 2014 Electrabel conducted another, more sensitive UT to ensure all flaws were detected
  - Result: More reported flaws (~13,000)

- MRP plans to update MRP-367 for (1) new flaw cartography and (2) address 80 years of operation

- In late 2015, NRC tasked ORNL to review MRP-367
  - ORNL provided draft report to NRC in late 2015 which NRC is still reviewing
  - NRC will provide feedback to MRP by mid-September 2016 regarding whether or not any ORNL comments are consequential for planned MRP-367 update
  - Update of MRP-367 will proceed after feedback from NRC is received
Topic 3 - Status on PWSCC Mitigation by Peening
PWSCC Mitigation by Peening
- Complete MRP Program in 2016

Technical Readiness & MRP R&D

- Peening LWRs in Japan
  - Both PWRs and BWRs
  - PWRs mitigated during RFOs
  - Laser and Water Jet Technologies
  - Nozzles, J-Groove Welds and DMWs

MRP R&D Program Complete
- PWSCC Initiation Testing
- Residual Stress Relaxation
- Vendor Technical Basis Information

Documentation and Guidance
- Technical Basis
  - MRP-267, Rev 2 – published 2016
- Topical Report (MRP-335, Rev 3)
  - Incorporate SE into -A revision within 3 months of SE issue date
- Utility Implementation Guidance
  - MRP-336, Rev 1 – published 2016

ASME Code

- Dissimilar Metal Butt- Welds (DMWs)
  - Code Case N-770-5
- Reactor Pressure Vessel Head Penetration Nozzles (RPVHPNs)
  - Code Case N-729-5

NRC Safety Evaluation

- MRP-335 Rev 3 Safety Evaluation (SE) for Optimizing Inspections after Mitigation
  - Technical Documents submitted to NRC
  - Fee Exemption and Acceptance Reviews
  - Requests for Additional Information
  - SE
    - NRC anticipates issuing by 9/30
    - OMB Assessment - in-progress

Implementation

- In-service peening of:
  - RV outlet and inlet nozzles
  - Bottom-mounted nozzles
  - Reactor vessel top head penetration nozzles

  - RPVHPN mockups for post-peening UT inspectability demonstrations
    - 1 complete for laser process
    - 2 in-progress for spares

Plant Applications

- 8 PWRs planning to mitigate Alloy 600/182 components by peening:
  - 2016 - Byron-2 (completed spring 2016), Braidwood-1, Wolf Creek, ANO-1
  - 2017 - Callaway, Byron-1, Braidwood-2, ANO-2
- 3 additional PWRs in planning, but funding not approved
  - Palisades, Indian Point-3, Indian Point-2
Together…Shaping the Future of Electricity
BACKUP SLIDES on BAFFLE FORMER BOLTS ISSUE
Primary objectives in the short term:
- Developed an OE database and analyze for trends to identify potential relationships between known failures and plant design/operating conditions
  - This will be a significant input in developing additional Interim Guidance
- Issue initial NEI 03-08 Interim Guidance to MRP-227/228 in the Fall 2016 timeframe
  - Potential update to Interim Guidance in 2017 based on OE from Fall 2016 and Spring 2017 refueling outages and other focus group activities
- Confirm refueling outage schedules for the next 2 years to feed into Focus Area #3 (Repair / Replacement needs)
  - This is needed to develop planning for both UT and replacement tooling and inventory assessment of typical BFB designs
- Support interfacing between regulatory authorities and industry groups
Plant/Fleet Operating Experience Assessment
(Focus Area #2)

- Primary focus is on the development of the Westinghouse NSAL and the AREVA Customer Service Bulletin
  - NSAL issued 7/5/16 and revised 8/1/16
  - AREVA CSB issued 7/14/16
- Assisted in the development of an operating experience assessment
- Will continue to review OE
Repair / Replacement *(Focus Area #3)*

- Recent OE at IP2 and Salem 1 identified issues related to replacement tooling availability
  - Delays in BFB replacement tooling were experienced due to limited availability of equipment
- Ongoing evaluations are underway for vendor capital and/or PWROG tooling investment
  - What is the appropriate amount of tooling needed
  - How do the outages overlap in Fall 2016/Spring 2017
  - Are modifications or changes needed to the existing equipment for production or reliability
- Material availability assessment completed
  - Both vendors have bolting material to fabricate roughly 1,500 BFBs
  - Items under consideration
    - Are increased machining rates required to potential provide sufficient bolts in a timely manner if required
    - Is a common bolt design possible to allow for faster machining rates
Inspection / NDE (Focus Area #4)

- Current NDE UT methods are identifying defects
- Review bolting UT results for lessons learned relevant to the protocol
- Provide input to Focus Area #5 on recommended NDE examinations of bolts received from IP2 and Salem 1
  - Recommended PT prior to Destructive Examination
- Evaluate the ability to correlate UT signals with measured crack size from destructive examination
  - May be impractical with multiple bolt designs and varying vendor UT techniques
  - Internal hex head bolts and locking devices are particularly difficult to UT
Irradiated Testing Support (Focus Area #5)

Short-Term Testing (2016)
- Work to support Indian Point and Salem root cause and operability analyses

Intermediate-Term Testing (2016)
- Testing with fleet-wide applicability resulting from the OE

Long-Term Testing (2017+)
- Evaluation of IASCC susceptibility of BFB materials with respect to dose and time
  - IP2 has shipped 32 bolts to the Westinghouse Hot Cell Facility (received 6/29/16)
  - Shipment of Salem bolts (6+) to follow
  - Ginna bolts (6) to be shipped in August 2016
Aging Management Assessment (*Focus Area #6*)

- Focus Area #6 is taking a long term approach toward understanding the mechanisms and adjusting the guidance of MRP-227 as required; for example:
  - Review previous aging management assessments and compare to recent OE
  - What materials/structural models best replicate observed OE and what do they predict for the future
- Evaluation of repair/replacement modifications
  - Account for these within MRP-227 (re-inspection criteria)
  - Relative effectiveness of options over the long term
- Recommend adjustments to WCAP-17096 methodology as appropriate
Together…Shaping the Future of Electricity
2016 Nuclear Sector Member Satisfaction
Member Satisfaction - Background

- EPRI has captured member satisfaction feedback in various forms for many years
- Current member satisfaction survey adopted by Board in 2006
- Results reviewed regularly with Board
  - one of Corporate Performance Indices (CPIs)
- Member feedback used to drive continuous improvement across EPRI
  - focus on areas with greatest impact on satisfaction
Nuclear Member Satisfaction Survey Results

**2015 Results**

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<td>Ease of Doing Business</td>
<td>86.1%</td>
</tr>
<tr>
<td>Technical Program Value</td>
<td>93.2%</td>
</tr>
<tr>
<td>Overall Satisfaction</td>
<td>92.4%</td>
</tr>
</tbody>
</table>

**2010-2015 Trend**

- Impact of research on improving my business
- The program's strategic priorities and directions
- Quality of research results
- Relevance of research carried out by the program
- Technical staff expertise

**Who completed the Survey**
# Improvement Initiatives

<table>
<thead>
<tr>
<th>Category</th>
<th>Initiative</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research and</td>
<td>• Research Focus Areas</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td>Development</td>
<td>• Project Overview Forms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Quality Management Program</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech Transfer</td>
<td>• Executive Summary</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td></td>
<td>• Onsite EPRI updates/regional meetings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• International workshops</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• International NPC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Digital Strategy (ongoing)</td>
<td></td>
</tr>
<tr>
<td>Simplification</td>
<td>• On-line Pricing</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td></td>
<td>• Invoice Review</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• New Pricing Model</td>
<td></td>
</tr>
<tr>
<td>Website</td>
<td>• New Search Engine</td>
<td>Implemented 2016</td>
</tr>
<tr>
<td></td>
<td>• Member Center Improvements</td>
<td></td>
</tr>
</tbody>
</table>

Listening and Responding to the Feedback of our Members
Digital Delivery Enhancements

1st Stage Bowl/Case

Becomes
Digital Delivery Enhancements

Becomes
New Search Engine

The search engine gets smarter over time based on use.

It tracks what people search and where they go with the results.

The more the search engine is used, the faster it learns.

As it learns, features such as relevance and search term recognition will dramatically improve, and as a result improve your search experience.

You make the search engine better by using it!
Survey instrument

Key components …

1. Who you are
   without a name and organization, we can’t count your input!

2. Number of years you have been an Advisor

3. How we’re doing

4. How you assess EPRI value

5. Key improvement in ease of doing business

6. Value you have received from this Program
Survey instrument

Key components

7. Rate each statement based on how satisfied you are

8. Rank the top 5 statements as indicated in the instructions

9. Would you recommend EPRI

10. If you are not satisfied with us in any area, please tell us why

<table>
<thead>
<tr>
<th>Understanding EPRI</th>
<th>Research &amp; Development</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Information provided by EPRI about resources available to members</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>2. Ability to actively participate through membership in the program</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>3. Understanding your role as an advisor</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>4. Understanding of EPRI’s collaborative business model</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>5. Leverage received from the collaborative model</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>6. Ease of contracting with EPRI</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>7. Reliability of research carried out by the program</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>8. Quality of research results</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>9. Impact of research on improving my business</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>10. Completeness of communications with EPRI</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>11. Technical staff expertise</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>12. Technical staff accessibility</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>13. Technical staff availability</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>14. Compliance with schedules</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>15. Effectiveness of program management</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>16. Communication of R&amp;D project status</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>17. Thought leadership</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>18. Ease of understanding context of research results</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>19. Timeliness in which research results are delivered</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>20. Quality of advisory meeting content</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>21. Quality of webcast presentations (i.e., materials presented)</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>22. Frequency of communications from EPRI to members (e.g., news and updates)</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>23. Relevance of e-mail/news to your specific needs</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>24. Responsiveness to member feedback</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>25. Ease of finding information on EPRI website</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
<tr>
<td>26. Reliability of information on EPRI website</td>
<td>S 4 3 2 1 DK</td>
<td>S 4 3 2 1 DK</td>
</tr>
</tbody>
</table>

Would you recommend EPRI to a colleague or peer? 

Definitely Would ☐  Probably Would ☐  Maybe or Maybe Not ☐  Definitively Would Not ☐

To help us better understand your concerns, for any statement with a rating of 3 or lower, please provide an explanation or example which led you to that rating.
Together…Shaping the Future of Electricity
# 2015 Nuclear Member Satisfaction Scores, By Area

<table>
<thead>
<tr>
<th>Program Area</th>
<th>Surveyed Co’s</th>
<th>% Response</th>
<th>Overall Performance</th>
<th>Technical Program Value</th>
<th>Ease of Doing Business</th>
<th>Overall Satisfaction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Sector Council</td>
<td>19/39</td>
<td>48.7%</td>
<td>94.4%</td>
<td>96.6%</td>
<td>81.1%</td>
<td>93.3%</td>
<td>91.3%</td>
</tr>
<tr>
<td>Materials Degradation / Aging</td>
<td>18/40</td>
<td>45.0%</td>
<td>91.5%</td>
<td>92.1%</td>
<td>84.2%</td>
<td>92.1%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Fuel Reliability</td>
<td>15/40</td>
<td>37.5%</td>
<td>89.5%</td>
<td>91.4%</td>
<td>89.5%</td>
<td>89.5%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Used Fuel and High-Level Waste Management</td>
<td>16/40</td>
<td>40.0%</td>
<td>96.8%</td>
<td>96.0%</td>
<td>90.5%</td>
<td>97.8%</td>
<td>95.3%</td>
</tr>
<tr>
<td>Nondestructive Evaluation</td>
<td>13/40</td>
<td>32.5%</td>
<td>90.0%</td>
<td>92.7%</td>
<td>81.8%</td>
<td>90.0%</td>
<td>88.6%</td>
</tr>
<tr>
<td>Equipment Reliability</td>
<td>30/40</td>
<td>75.0%</td>
<td>91.0%</td>
<td>91.2%</td>
<td>83.8%</td>
<td>90.7%</td>
<td>89.2%</td>
</tr>
<tr>
<td>Risk and Safety Management</td>
<td>16/40</td>
<td>40.0%</td>
<td>92.2%</td>
<td>94.4%</td>
<td>91.1%</td>
<td>91.1%</td>
<td>92.2%</td>
</tr>
<tr>
<td>Strategic Initiatives (ANT and LTO)</td>
<td>20/40</td>
<td>50.0%</td>
<td>95.0%</td>
<td>95.7%</td>
<td>90.7%</td>
<td>95.7%</td>
<td>94.2%</td>
</tr>
<tr>
<td>Chemistry, Low-Level Waste and Radiation Management</td>
<td>15/40</td>
<td>37.5%</td>
<td>94.4%</td>
<td>94.4%</td>
<td>88.8%</td>
<td>95.8%</td>
<td>93.3%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>92.3%</strong></td>
<td><strong>93.2%</strong></td>
<td><strong>86.1%</strong></td>
<td><strong>88.8%</strong></td>
<td><strong>95.8%</strong></td>
<td><strong>92.4%</strong></td>
<td><strong>91.0%</strong></td>
</tr>
</tbody>
</table>
SGMP Technical Topic
Status of High Impact Activities

Helen Cothron
SGMP Program Manager

PMMP Executive Committee Meeting
Tuesday, August 30, 2016

Date: August 15, 2016
Presentation Content

- Sherlock Project
- Triton
- In-Plane Fluid-Elastic Instability Testing
## Sherlock – Test Program Using Two Retired Steam Generators

<table>
<thead>
<tr>
<th></th>
<th>Cruas 4</th>
<th>Paluel 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Areva (Recirculating)</td>
<td></td>
</tr>
<tr>
<td><strong>Tube bundle</strong></td>
<td>U-tubes – Alloy 600TT (Vallourec)</td>
<td></td>
</tr>
<tr>
<td><strong>TTS</strong></td>
<td>Mechanical rolling + kiss rolling</td>
<td></td>
</tr>
<tr>
<td><strong>Operating time</strong></td>
<td>~30 years (more than 200.000 h)</td>
<td></td>
</tr>
<tr>
<td><strong>NPP</strong></td>
<td>900 MWe</td>
<td>1300 MWe</td>
</tr>
<tr>
<td><strong>φ tubes</strong></td>
<td>7/8&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td><strong>Chemical Cleaning</strong></td>
<td>2007 (HTCC)</td>
<td>None</td>
</tr>
<tr>
<td><strong>Water Coolant</strong></td>
<td>River</td>
<td>Sea</td>
</tr>
<tr>
<td><strong>Secondary chemistry</strong></td>
<td>Morpholine low pH</td>
<td>Ammonia high pH</td>
</tr>
<tr>
<td><strong>SG Replacement</strong></td>
<td>2014 (done)</td>
<td>In progress</td>
</tr>
</tbody>
</table>

2 SGs with complementary degradations of interest and design
Status of Sherlock Project

2010-2013
• Setting up
• Choice of SGS, Choice of topics, Partnership

2014
• NDT during SG replacement (Cruas)
• Primary side & Secondary side

2015
• NDT during SG replacement (Paluel)
• Primary side & Secondary side

2016-2018
• Preparing works in Storage Building + Lab/ prototype works
• Finalize examination programs, Find sub-contractors, etc

2018-2019
• Works in storage building
• Decontamination, Sampling, NDT

2019-2023
• Laboratory Examinations
• Visual, Mechanical, Metallurgical, Chemical exams

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EdF Changes to the Project

• Recent changes in French regulations resulted in:
  • Increased work necessary to adapt the SG storage building to comply with the regulation for the decontamination and sampling steps
  • Large increase in the total project budget

• EDF financial difficulties have lead to a reduction in the Sherlock project budget (as well as the budget for many other EDF projects)
  • To comply with budget constraints, the project scope will be modified to include the examination of only the Cruas SG

→ The expectation is that most of the initial project objectives can be met

- EdF, AREVA, and EPRI are renegotiating the agreement
  - Expect project to be extended to 2023
Triton – State of the Art Steam Generator Thermal-Hydraulics Code

- Simulates velocities, void fractions, temperatures, secondary side pressure
- Thermal hydraulic conditions affect:
  - Flow induced vibration, wear, and fatigue
  - Deposit formation
  - Foreign object assessments
  - Thermal performance
- Results of thermal hydraulic code output can be used to inform:
  - Uprates
  - Fouling assessments
  - Tube plugging
Status

- **Alpha-1 version released November 2014**
  - Recirculating SG’s with and without preheaters
- **Alpha-2 version released February 2016**
  - Once-Through Steam Generators (OTSG’s)
  - Preheater and support plate customization
  - Options for heat transfer and momentum correlations
  - Post-processing capabilities
- **Beta version planned for June 2016**
  - Did not pass software testing
  - New beta version released August 2016
- **Version 1.0 planned for December 2016**
In-Plane Fluid-Elastic Instability Tests Status

- Air Flow tests complete
  - Objective was to develop a basic understanding of in-plane vibration to prepare for two-phase Freon tests
  - Able to demonstrate in-plane fluid elastic instability
- What we learned
  - Applying a small preload suppresses in-plane vibration - Need to validate with two-phase conditions
  - Still unsure how significant out of plane vibration affects in plane vibration initiation – Need to validate with two-phase conditions
  - Number of supports (one vs two) more important than gap size
  - Coupling is important to initiate in-plane FEI – all tubes should be flexible
In-Plane Fluid-Elastic Instability Tests

- Planning stages for two-phase Freon tests underway
  - Use two support configurations and the most relevant two-phase flow conditions, demonstrate in-plane fluid elastic instability
  - Meeting with expert panel August 10-11, 2016
    - Test configuration is still under discussion
    - One test with a hold point
  - Tests will cost more than expected
    - Negotiating the cost
    - CNL may share the cost
Tube Bundle Layout

Row no. & bend radius
- R1 = 1384.3 mm (54.5")
- R2 = 1374.8 mm (54.125")
- R3 = 1365.3 mm (53.75")
- R4 = 1355.7 mm (53.375")
- R5 = 1346.2 mm (53.0")
- R6 = 1336.7 mm (52.625")
- R7 = 1327.2 mm (52.25")
- R8 = 1317.6 mm (51.875")
- R9 = 1308.1 mm (51.5")

Inboard Strongback wall

Flow direction

Tube 1B
1. Displacement
2. Impact force

Tube 1D
1. Displacement
2. Impact force
3. Acceleration

Tube 2C Acceleration
Tube 3D Acceleration
Tube 4C Acceleration
Tube 5D Acceleration
Tube 6C Acceleration

Outboard Strong back wall

Column A B C D E

= Fixed tube
= Flexible tube
I = Instrumented tube
# Air Flow Tests Completed Prior to Hold Point

<table>
<thead>
<tr>
<th>Test Series No.</th>
<th>Diametral Clearance (in)</th>
<th>Tube to Support Setup</th>
<th>Dry or Wetted</th>
<th>Number of Flexible Tubes</th>
<th>Tube Support Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>All</td>
<td>n.a.</td>
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<tr>
<td>2</td>
<td>0.040&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1</td>
</tr>
<tr>
<td>3</td>
<td>0.040&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>One (C4)</td>
<td>#1</td>
</tr>
<tr>
<td>4</td>
<td>0.040&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1, #2</td>
</tr>
<tr>
<td>5</td>
<td>0.020&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1</td>
</tr>
<tr>
<td>6</td>
<td>0.020&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1, #2</td>
</tr>
<tr>
<td>7</td>
<td>0.005&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1</td>
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<tr>
<td>8</td>
<td>0.005&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1, #2</td>
</tr>
<tr>
<td>9</td>
<td>0.005&quot;</td>
<td>Centered</td>
<td>Dry</td>
<td>One (C4)</td>
<td>#1</td>
</tr>
<tr>
<td>Test Series No.</td>
<td>Diametral Clearance (in)</td>
<td>Tube to Support Setup</td>
<td>Dry or Wetted</td>
<td>Number of Flexible Tubes</td>
<td>Tube Support Location</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>--------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>10</td>
<td>0.010”</td>
<td>Centered</td>
<td>Dry</td>
<td>One (C4)</td>
<td>#1</td>
</tr>
<tr>
<td>11</td>
<td>0.010”</td>
<td>Centered</td>
<td>Dry</td>
<td>All</td>
<td>#1</td>
</tr>
<tr>
<td>12</td>
<td>0.010”</td>
<td>Light Preload</td>
<td>Dry</td>
<td>One (C4)</td>
<td>#1</td>
</tr>
<tr>
<td>13</td>
<td>0.010”</td>
<td>Light Preload</td>
<td>Dry</td>
<td>All</td>
<td>#1</td>
</tr>
<tr>
<td>14</td>
<td>0.010”</td>
<td>Centered</td>
<td>Dry</td>
<td>Three (2C, 3D, 4C)</td>
<td>#1</td>
</tr>
<tr>
<td>15</td>
<td>0.010”</td>
<td>Centered</td>
<td>Dry</td>
<td>Seven (2C, 3B, 3D, 4C, 5B, 5D, 6C)</td>
<td>#1</td>
</tr>
</tbody>
</table>
Tubes Exhibiting Out-of-Plane FEI in the Lowest Mode at Approximately 2.9 Hz
Tubes Exhibiting Out-of-Plane FEI in Both the 1\textsuperscript{st} and 2\textsuperscript{nd} Modes at Approximately 2.9 Hz and 8.1 Hz

Watch this tube
Tubes Exhibiting Out-of-Plane FEI in Both 1\textsuperscript{st} and 2\textsuperscript{nd} Modes Then Tripped to In-Plane FEI

Initiation of IP-FEI was unpredictable
Typical Vibration Results

- In-Plane Fluid Elastic Instability was observed in the air flow tests - typical results for vibration vs. flow velocity

1. Stepwise increasing flow
2. Sudden onset of IP FEI
3. Stepwise decreasing flow
4. Cessation of IP FEI
5. Threshold Velocity
Schedule

- **Air-Tests Completed**
  - Expert panel will finalize the two-phase Freon test configuration after reviewing final air test report

- **Meeting was held at CNL in August**
  - Discussed air test results and made preliminary recommendations for Freon test matrix
    - 0.020” gap, one AVB support, all flexible tubes
    - Options to be discussed include using a smaller AVB gap and one additional AVB support

- **Prepare for Freon Tests**
  - Some design is complete
  - 2016 funding is depleted
  - Further design, fabrication, setup, and testing will be completed 2017
  - Tests conducted early 2018
Together…Shaping the Future of Electricity
Steam Generator Foreign Object Wear Estimation Model Development

James Benson
Technical Executive

PMMP Meeting
Tuesday, August 30, 2016

Date: August 10, 2016
SG Foreign Object Experience
SG Tube Leak Events Due to Foreign Objects (US)

Source: EPRI SG Degradation Database (2016 is partial data)
SG Tubes Repaired Due to Foreign Objects (US)

Source: EPRI SG Degradation Database (2016 data represents a partial year)
Examples of Foreign Objects Removed From SGs

- Wire at ANO 2 in 2005
- Spiral Wound Cable Sheath at Byron 2 in 2002
- Large Nut in an Unknown SG
- Objects Retrieved at South Texas Project 1 in 2005

## Foreign Object Tube Wear Summary

<table>
<thead>
<tr>
<th>TYPE OF FOREIGN OBJECT EVENT</th>
<th>NUMBER OF EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL I EVENTS (&lt;40%TW)</td>
<td>205</td>
</tr>
<tr>
<td>LEVEL II EVENTS (40-99%TW)</td>
<td>50</td>
</tr>
<tr>
<td>LEVEL III EVENTS (P-S LEAKAGE)</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL NUMBER OF FO EVENTS</strong></td>
<td><strong>275</strong></td>
</tr>
<tr>
<td><strong>NUMBER OF FORCED OUTAGES</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

Summary of Un-Retrieved Secondary Side FOs

Background

- Foreign objects (FO) continue to enter into steam generator (SG) tube bundles
- Some FOs can cause tube wear, which may lead to P/S leakage
- Once FOs are identified by FO Search and Retrieval (FOSAR) equipment or by Eddy Current Testing (ECT), utilities evaluate the need for removal
- Removal of all identified FOs from the SG is not always warranted or possible
  - FO will not cause tube wear (e.g., soft material)
  - FOSAR vendor may be unable to retrieve (e.g., equip not capable or available)
  - Worker radiation dose vs. risk to SG
- In 2009 and 2010, EPRI developed FO Prioritization Strategies which utilities and SG vendors have applied in making decisions on FO retrieval efforts
  - Qualitative estimate of potential that a FO will cause tube wear
  - To date, the strategies being used by the industry appear to be effective (i.e., No SG tube integrity issues from FOs left in the SG)
Current FO Ranking Criteria Based on Operational Risk

- **Category 1 - High Priority**: The object may cause wear greater than the maximum acceptable wear depth before the next tube inspection. The most effort should be put to removing objects that fall into this category.

- **Category 2 - Medium Priority**: The object is not expected to cause wear greater than the maximum acceptable wear depth before the next tube inspection. However, objects that fall into this category may lead to long-term performance issues if not removed.

- **Category 3 - Low Priority**: The object is not expected to cause significant tube wear. Less effort may be made in removing objects that fall in this category.

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**Zone Map—Bounding Triangular Pitch SG Model**

**Zone Map—Representative Square Pitch SG Model**
“The process described … provides a basis for defining retrieval efforts and should not be used to determine final acceptability of any objects remaining inside the steam generator.”

“Final acceptability is a function of many parameters, including actual object size, minimum wall thickness requirements, duration between inspections, and the actual object location, along with specific details regarding the steam generator in question.”

“All of those plant-specific features must be addressed in order to demonstrate final acceptability of any objects found in the secondary side of the steam generator.”
Steam Generator Foreign Object Wear Estimation Model Development

Project Objective

- To develop a practical and simple model for calculating FO-induced tube wear vs. time

Project Tasks

- Perform detailed measurements of fluid forces acting on FOs in SG tube arrays
- Develop a model for estimating SG tube FO wear
- Perform model testing and validation based on field data
- Develop a hybrid model that incorporates current FO Prioritization Strategy
- Develop a functional specification to incorporate the model into a SG FO wear estimation software tool
Expected Benefits of a Model to Predict SG Tube Wear Rates Caused By Foreign Objects

- To provide input to an evaluation to determine acceptability if, for any reason, a particular FO were to remain in the SG.
- To assist in the evaluation of potential tube wear and to determine the length of time that specific FOs can remain in the SG before removal may be required.
- To produce results to confirm if the current industry methodology is conservative and, if so, utilities could use it, as written, without performing an additional assessment (i.e., validates the current approach)
SG Foreign Object Wear Model Development Work Flow

1. FO Force Experiments
2. CFD analysis
3. Development of FO Drag and Lift Force Coefficients
4. Model development

FO Database
Water Flow Test Loops

New Test Loop
Max Flow: 1.5 m/s

Force measurement system in test section

Initial Test Loop
Max Flow: 1.0 m/s
Force Data: Mean Drag Coefficient Correlations

\[ C_d = \frac{F_{\text{drag}}}{\frac{1}{2} \rho U_p^2 A_p} \]

Re = \frac{\rho U_p d}{\mu} \quad \text{Reynolds number}

\[ \Sigma = \frac{S_c}{S_p} \quad \text{Equivalent cylinder to object surface area ratio (} S_c = \pi d (l + \frac{4}{3}) \text{)} \]

\[ d = \frac{A_p}{l} \quad \text{object projected area / object length} \]
PLANT EXAMPLE: Robinson SG - Machining Remnant
(Plate-like FO)

Mode 1: 126 Hz (approx.)

Because this surface is exposed in the base, I think the part is angled from 31/45 to

Model (Simple 1D ‘torsional’)
Robinson FO Case

Define FO Geometry and Analysis Parameters

3D animation

Monte-Carlo simulation

Results output

- Arm of friction force (R)
- Arm of drag force D1
- Friction coefficient (u)
- Torsional stiffness (K)

Support & Tube Material

CS/Alloy 600

Monte-Carlo simulation

Enter parameter range

RUN

Results list

- Wear through Time

Choose parameter to plot

Theta

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Program: 3D Animation (Robinson FO)

3D Animation

animation speed = $\frac{1}{10} \times \text{real speed}$

animation amplitude = $4 \times \text{real amplitude}$
FO Wear Estimation: Monte Carlo Simulation Results (Robinson FO)

Highest probability 40%TW: 20 to 40 days

Highest probability 100%TW: 70 to 150 days

• Actual time to 100%TW: 115 days (approx)
FO Location and Flow Direction Effects Based on CFD

SQUARE ARRAY

ROTATED SQUARE ARRAY
Project Review Meeting with SG Vendors

- Meeting Date: Feb 2, 2016
- Participants: Areva, Westinghouse, B&W
- Purpose of Meeting: To obtain vendor feedback on the value of a tool that can provide an estimate of FO tube wear
- Vendor Feedback:
  - All 3 vendors indicated that they expect that the project could provide benefit to the industry
  - The experimental FO force information would be beneficial for performing FO assessments
  - A wear assessment tool would provide additional information/confirmation for making FO removal decisions
Planned Deliverables

- Technical Report
  - Hybrid FO Wear Model development
  - Underlying theory & experimental data
  - Model validation

- FO tube wear software specification
  - Software would be intended to incorporate the Hybrid FO Wear Model into a software product
Conclusions

- FO wear has been the leading cause of SG tube leaks in recent years
- FOs in steam generators should be retrieved to satisfy structural integrity performance criteria, unless it can be supported by engineering analyses that tube wear from FOs would not challenge SG tube structural integrity
- Prior EPRI reports, containing FO Prioritization Strategies, provide a basis for defining retrieval efforts, but state that they should not be used to determine final acceptability of any objects remaining inside the steam generator
- This project is intended to provide a tool that will determine FO-induced tube wear rates based on specific FO dimensions and SG flow conditions
- The wear rate calculations are expected to provide the SG engineer with additional information to make FO removal decisions
Together…Shaping the Future of Electricity