Jet Pump Optimized Inspection Guidance

Bob Carter, EPRI
BWRVIP Assessment Committee Task Manager
EPRI-NRC Technical Exchange Meetings
June 2-4, 2015
BWR Jet Pump Overview
Jet Pumps as Installed
Jet Pump Assembly Inspection and Flaw Evaluation Guidance History
BWRVIP-06 Revision 1-A
BWR RPV Internals Safety Evaluation

• Developed to proactively address the continuing observations of IGSCC in BWR reactor internals
• Evaluated component function and potential failure modes and locations with the primary safety function for the jet pumps being maintenance of two-thirds core height
• Identified short and long-term actions needed for management of reactor internals
• Jet Pump Assembly evaluation concluded that the occurrence of an instantaneous recirculation line break in conjunction with undetected degradation of a jet pump, such that two-third core coverage could not be maintained, is a low probability event and thus no short-term actions were necessary to assure safety
• A long-term action was identified to evaluate the potential for cracking that might compromise a jet pump’s safety function and develop appropriate generic guidelines for detection, inspection, repair or mitigation to assure the long-term function of jet pumps
BWRVIP-41, Revision 0

• BWRVIP-41, BWR Vessel and Internals Project, Jet Pump Assembly Inspection and Flaw Evaluation Guidelines
  – Published October 1997
  – Included comprehensive Visual and Ultrasonic inspection guidance
  – Final Safety Evaluation Issued by the NRC on February 4, 2001
  – Final SE did not contain any conditions or limitations
BWRVIP-41, Revision 1

• Primary reasons for revision:
  – Change all Modified VT-1 (MVT-1) exams (i.e., 1 mil wire resolution) to Enhanced VT-1 (EVT-1) exams (i.e., ½ mil wire resolution)
  – Incorporate the revised jet pump beam inspection requirements of BWRVIP-138, which were developed in response to 2002 Quad Cities Jet Pump beam failure

• Published September 2005

• BWRVIP-138 and BWRVIP-41, Rev. 1 originally submitted to the NRC in 2005, but subsequently withdrawn in order to further address jet pump beam inspection guidance
BWRVIP-41, Revision 2

• Primary reason for revision:
  – Incorporate the updated jet pump beam inspection requirements of BWRVIP-138, Rev. 1, which was more conservative than the jet pump beam guidance in the BWRVIP-41, Rev. 0

• Published July 2009

• BWRVIP-138, Rev. 1 submitted to the NRC in March 2009 and a final SE, with no conditions or limitations, was received in March 2012

• BWRVIP-41, Rev. 2 was not submitted to the NRC because plans were already in place for another revision to incorporate guidance for hidden welds
BWRVIP-41, Revision 3

• Primary reason for revision:
  – Incorporate guidance to address the inspection and evaluation requirements for hidden welds, which addressed a long standing open item for the jet pump guidelines

• Published September 2010

• BWRVIP-41, Rev. 3 was not submitted to the NRC because work was already underway BWRVIP-41, Rev. 4, the optimized version the jet pump inspection and evaluation guidelines
Optimization of BWRVIP Inspection and Flaw Evaluation Guidelines
Background

- BWRVIP I&E Guidelines were developed from 1994 to 1999 and largely based on safety considerations and potential degradation mechanisms including limited inspection results
  - Program based on normal water chemistry, thus no credit taken for or consideration of SCC mitigation via improved water chemistry (MHWC/NMCA)
- Post-implementation of I&E Guidelines
  - Significant inspection data generated which provides insight regarding component degradation trends and mitigation effectiveness
  - Widespread implementation of MHWC / NMCA and desire to obtain credit for SCC mitigation
  - EPRI/BWRVIP R&D efforts have improved knowledge of degradation mechanisms
  - NDE improvements both in UT and VT
Objective

• Optimize inspection programs based on:
  – Field inspection data and fleet operating experience
  – Evaluation of mitigation credit for benefits of HWC / NMCA
  – Current NDE capabilities
• Primary considerations:
  – Inspection results
  – Crack growth studies
  – Structural evaluations
Approach

• Phase 1: Component Prioritization
  – Prioritize order for optimizing inspection of components addressed by BWRVIP

• Phase 2: Inspection Optimization
  – Develop revised inspection recommendations for each component:
    • Technical basis report
    • Revision to inspection guidelines
    • Submit reports to NRC for approval
  • Approach presented to NRC at 6/11/2011 public meeting
Phase 1 Prioritization Process

- Systematic process established for screening & prioritizing I&E Guidelines
- Prioritization approach
  - Relevant attributes identified
    - Available inspection data
    - Effectiveness of mitigation
    - Applicable NDE techniques
    - Structural margin
    - Other factors (e.g., fluence, fatigue cycling)
    - Utility value
  - Ranking and weighting of attributes
  - Final ranking by consensus
## Phase 1 Results

<table>
<thead>
<tr>
<th>No.</th>
<th>I&amp;E Guideline</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core Spray (BWRVIP-18)</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Jet Pump (BWRVIP-41)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shroud (BWRVIP-76)</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Shroud Support (BWRVIP-38)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CRD Guide Tubes (BWRVIP-47)</td>
<td>Medium</td>
</tr>
<tr>
<td>6</td>
<td>Vessel ID Brackets (BWRVIP-48)</td>
<td>Medium</td>
</tr>
<tr>
<td>7</td>
<td>Top Guide Rims / Pins (BWRVIP-26)</td>
<td>Medium</td>
</tr>
<tr>
<td>8</td>
<td>SLC / Core DP Piping (BWRVIP-27)</td>
<td>Medium</td>
</tr>
<tr>
<td>9</td>
<td>LPCI Coupling (BWRVIP-42)</td>
<td>Medium</td>
</tr>
<tr>
<td>10</td>
<td>Access Hole Cover (BWRVIP-180)</td>
<td>Low</td>
</tr>
<tr>
<td>11</td>
<td>Jet Pump Beam (BWRVIP-138)</td>
<td>Low</td>
</tr>
<tr>
<td>12</td>
<td>Top Guide Grid Beam (BWRVIP-183)</td>
<td>Low</td>
</tr>
<tr>
<td>13</td>
<td>Core Plate Bolts (BWRVIP-25)</td>
<td>Low</td>
</tr>
<tr>
<td>14</td>
<td>Steam Dryer (BWRVIP-139)</td>
<td>Low</td>
</tr>
<tr>
<td>15</td>
<td>Bottom Head Drain Piping (BWRVIP-205)</td>
<td>Low</td>
</tr>
</tbody>
</table>
Resultant Changes to I&E Guidelines

• What is changed
  – Incremental changes to the inspection requirements
  – In general, inspection frequency and/or sample size requirements are relaxed, but some are increased
  – More credit for volumetric exams (incentivize its use)

• What is not changed
  – Safety bases
  – Flaw evaluation methodologies
  – Leakage analysis requirements
  – Hidden weld guidance
Status of I&E Guidelines Optimization

- Results of ranking published in BWRVIP-236: Inspection Optimization Program Roadmap
- Core Spray (BWRVIP-18, Revision 2)
  - Revision 2 submitted to the NRC for review and approval on 05/09/2012 (Basis document BWRVIP-251)
- Jet Pump Assembly (BWRVIP-41, Revision 4)
  - Revision 4 submitted to the NRC for review and approval on 09/24/2014 (Basis document, BWRVIP-266)
  - Acceptance review complete, now in technical review
- Core Shroud (BWRVIP-76, Revision 2)
  - Revision 2 is published, but not yet submitted to the NRC (Basis document, BWRVIP-278)
Optimized Version of Jet Pump Assembly Inspection and Flaw Evaluation Guidelines, BWRVIP-41, Revision 4
BWRVIP-41, Revision 4

• Technical basis report published October 2012 (BWRVIP-266)
• Inspection optimization results:
  – Relaxation of sampling requirements for riser welds and high priority diffuser welds
  – 2x longer inspection intervals for most medium priority welds
  – Elimination of inspections for low priority welds
  – Increased inspection frequency for RS-8 and RS-9 (for “susceptible” units)
  – Greater credit for UT inspections
• Overall reduction in inspections by 20-40% depending on plant vintage
• No changes to flaw evaluation and leakage guidance
BWRVIP-41, Revision 4

• Revision 4 states that optimized guidelines therein have not been approved by the NRC and thus are not to be implemented until notified by the BWRVIP that they are approved for use.

• Revision 4 submitted to the NRC for review and approval on 09/24/2014

• NRC “acceptance review” completed 04/23/2015

• Per the current review schedule, RAI expected to be issued to the BWRVIP by 09/28/2015
BWRVIP-41, Revision 4 Interim Guidance

• Currently there is a proposal to accelerate implementation of the Revision 4 supplemental requirements for inspection of the upper riser brace to riser welds (i.e., RS-9 welds)

• As stated in Revision 4, the supplemental inspection guidance applies to RS-9 welds at susceptible plants (i.e., 251 diameter BWR4/5 units with greater than 4.87M lb/hour flow per jet pump)

• The interim guidance is currently in the BWRVIP’s committee review process

• This is an example of the BWRVIP implementing guidance based on operating experience in an expedited manner when it is warranted
Summary

• The BWRVIP commitment has always been to evaluate operating experience (OE) and make appropriate adjustments to the program.

• As a result, the BWRVIP has made several revisions to the original issuance of jet pump Inspection and Evaluation Guidelines.

• BWRVIP-41, Rev. 4 incorporates the latest understanding of operating experience and degradation mechanisms.