

Review June 2016 – July 2017 Baffle-Former Bolt OE

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2016 to 2017 BFB Inspection Summary

- Westinghouse Tier 1A Plants (4-Loop Downflow w/ 347 Bolts) – UT Exams:
 - Indian Point Unit 2 (Spring 2016)
 - Salem Unit 1 (Spring 2016)
 - D.C. Cook 2 (Fall 2016)
 - Indian Point 3 (Spring 2017)
 - Salem Unit 2 (Spring 2017)
 - Diablo Canyon Unit 1 (Spring 2017)
- Westinghouse Tier 1B Plants (4-Loop Downflow w/ 316 Bolts) – VT Exams:
 - Sequoyah Unit 1 (Fall 2016)
 - Sequoyah Unit 2 (Spring 2017)
- Inspections at Westinghouse Plants in Other Tiers:
 - North Anna Unit 1 (Tier 3 plant, Fall 2016 – UT Examination)
 - Ringhals Unit 3 (Tier 2C plant, Fall 2016 – UT Examination)
- Inspections at B&W Plants:
 - ANO Unit 1 (Fall 2016)

Indian Point Unit 2 (Spring 2016 / 31 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
- Degraded bolts/lock bars noted visually prior to performing as-planned MRP-227 100% UT exams
- Markings on periphery of neighboring fuel assembly identified (fuel clad integrity was maintained)
- Inspections identified 227 BFB with visual or UT indications (includes 14 uninspectable)
- UT indications were clustered
 - Spanned various quadrants, mostly in former Rows D through G
 - Multiple groups of 10+ adjacent failures / At least one cluster of 40+ adjacent failures
- Number and pattern of bolts with indications did not meet the existing WCAP-17096-A acceptance criteria
- Site-specific response was required
 - Performed Acceptable Bolting Pattern Analysis (ABPA)
 - Performed Replacement Bolting Pattern Analysis
 - Performed Extent of Condition Evaluation for Unit 3
 - Performed Assessment of Potential Safety Impacts for Unit 2 (formed basis for NSAL-16-1)
 - Performed removal and replacement of 278 BFBs (including additional margin bolts)
 - Quarantined / Shipped select bolts for hot cell testing

Salem Unit 1 (Spring 2016 / 28 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
- 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 performing 100% UT exams
- Loose/protruding bolt heads resulted in fuel fretting and one fuel clad failure
- Inspections identified 182 BFB with visual degradation or UT indications (includes 18 uninspectable)
- UT indications were clustered
 - More concentrated (than Indian Point 2) to a few adjacent octants
 - One cluster of 70+ adjacent failures and a second cluster of 30+ adjacent failures
- Number and pattern of bolts with indications did not meet the existing WCAP-17096-A acceptance criteria
- Site-specific response was required
 - Performed Acceptable Bolting Pattern Analysis (ABPA)
 - Performed Replacement Bolting Pattern Analysis
 - Performed Justification for Past Operation for Unit 1 (formed basis for NSAL-16-1)
 - Performed Extent of Condition Evaluation for Unit 2
 - Performed removal and replacement of 189 BFBs
 - Quarantined / Shipped select bolts for hot cell testing

DC Cook Unit 2 (Fall 2016 / 28 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
- Two (2) on-line fuel leaks identified during fuel cycle prior to fall 2016 outage
 - Associated with two (2) empty bolt-holes from bolts that were not replaced in 2010 (suspected damaged by jetting through a vacant BFB hole)
- MRP-227 Inspections identified 179 BFB with visual degradation or UT indications (includes 9 that were not inspectable, and three (3) with visibly degraded lock-bar welds)
 - Includes 6 replacement 316CW BFBs from 2010 event that exhibited UT indications
 - Five (5) Baffle-Edge-Bolts on one seam identified as visually failed
 - These unique failures are believed to be induced by the large clusters of failed BFBs in the same region
- UT indications were clustered
 - Spanned various quadrants
 - Multiple groups of 6+ adjacent failures / At least one cluster of 50+ adjacent failures
- Number and pattern of bolts with indications did not meet the existing WCAP-17096-A acceptance criteria
- Site-specific response was required
 - Performed Acceptable Bolting Pattern Analysis (ABPA)
 - Performed Replacement Bolting Pattern Analysis
 - Performed Justification for Past Operation for Unit 2 (formed basis for NSAL-16-1)
 - Performed Extent of Condition Evaluation for Unit 1
 - Performed removal and replacement of 201 BFBs (including additional margin bolts)
 - Quarantined / Shipped select bolts for hot cell testing

Sequoyah Unit 1 (Fall 2016 / 25 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 316SS BFBs (Tier 1B Plant per NSAL-16-1)
 - Visual Examination (VT-3) of 832 BFBs per NEI 03-08 “Needed Guidance” in MRP-2016-021
- Inspections (Visual) identified 4 BFBs with non-relevant indications
 - Not indicative of service-induced flaws; deemed non-recordable indications
- No actions were required by the plant
- 100% UT Examination to be completed at the next refueling outage in Spring 2018 per NEI 03-08 “Needed Guidance” in MRP-2016-021

North Anna Unit 1 (Fall 2016 / 31 EFPY)

- Westinghouse 3-Loop Converted Upflow Plant w/ 316SS BFBs (Tier 3 Plant per NSAL-16-1)
- MRP-227 BFB UT Examinations identified 3 BFBs with indications
 - Of 1088 Total BFBs, 7 BFBs were non-testable due to lock bar welds on bolt head (original-construction-related condition)
- Number and pattern of bolts with indications well below WCAP-17096-A acceptance criteria
- No plant-specific response required

Ringhals Unit 3 (Fall 2016 / 27.45 EFPY)

- Westinghouse 3-Loop Downflow Plant w/ 316SS BFBs (Tier 2C Plant per NSAL-16-1)
- Planned BFB UT Examinations identified 1 BFB with an indication
 - Of 1088 Total BFBs, 27 BFBs were non-testable
- Number and pattern of bolts with indications well below WCAP-17096-A engineering acceptance criteria
- No plant-specific response required

ANO Unit 1 (Fall 2016 / 32.4 EFPY)

- B&W Plant w/ 316SS BFBs
- As-planned BFB UT Examination per MRP-227-A
 - 100% UT
 - No BFB with indications
 - No uninspectable BFBs
- No plant-specific response required

Indian Point Unit 3 (Spring 2017 / 27.8? EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
- MRP-227 BFB UT Examinations identified 256 BFB with indications
 - Three (3) additional BFBs were non-testable
 - Zero visual indications (no missing or protruding BFBs were observed)
- UT indications were clustered
 - Spanned various quadrants, mostly in former Rows D through G
 - Multiple groups of 10+ adjacent failures / At least one cluster of 40+ adjacent failures
- Number and pattern of bolts with indications did not meet the existing WCAP-17096-A acceptance criteria
- Site-specific response was required
 - Replaced 270 BFBs
 - Including additional BFBs to enhance structural margin for aging effects
 - Consistent with 'Asset Management' approach for utility

Salem Unit 2 (Spring 2017 / 25.4 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
 - Conducted visual exams every other refueling outage in response to 2010 DC Cook Unit 2 OE and TB-12-5
- MRP-227 BFB UT Examinations identified 9 BFB with indications
 - Zero BFBs were non-testable; achieved 100% exam
- Number and pattern of bolts with indications well below existing WCAP-17096-A engineering acceptance criteria
- Proactively replaced 129 BFBs
 - 30 per quadrant + 9 BFBs w/ indications
 - Done to enhance structural margin for aging effects
 - Consistent with 'Asset Management' approach for utility

Diablo Canyon Unit 1 (Spring 2017 / 27.67 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 347SS BFBs (Tier 1A Plant per NSAL-16-1)
- MRP-227 BFB UT Examinations identified 1 BFB with an indication
 - Zero BFBs were non-testable; achieved 100% exam
- Number and pattern of bolts with indications well below existing WCAP-17096-A engineering acceptance criteria
- Proactively replaced 61 BFBs
 - 15 per quadrant + 1 BFB w/ indication
 - Done to enhance structural margin for aging effects
 - Consistent with 'Asset Management' approach for utility

Sequoyah Unit 2 (Spring 2017 / 26.91 EFPY)

- Westinghouse 4-Loop Downflow Plant w/ 316SS BFBs (Tier 1B Plant per NSAL-16-1)
 - Visual Examination (VT-3) of 832 BFBs per NEI 03-08 “Needed Guidance” in MRP-2016-021
- No indications of any kind were identified
- No actions were required by the plant
- 100% UT Examination to be completed at the next refueling outage in Fall 2018 per NEI 03-08 “Needed Guidance” in MRP-2016-021

Conclusions

- One (1) Tier 1A and two (2) Tier 1B plants still left to perform UT examinations
 - VT exams at the two (2) Tier 1B plants revealed no relevant indications
- Safety evaluations summarized in NSAL-16-1 remain bounding for recent OE
 - BFB ‘clustering’ observations do not represent a significant safety hazard
- Inspection results for IP3 are within expected statistical variation based on predictive modeling
- Two Tier 1A plants (Salem 2 and Diablo Canyon Unit 1) exhibited lower than expected BFB degradation which may indicate additional contributing variables are at play beyond bolt stress levels
 - Original 347SS bolt design details and fabrication requirements were changed after first few plants built
 - Limited information is available on the impact of these characteristics on aging degradation
- Multiple variables are involved that could impact susceptibility
 - It is expected that any additional variables would only exacerbate an already susceptible condition and not cause a change in plant susceptibility
- Industry has confidence in NEI 03-08 interim guidance inspection requirements for all Tiers



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