UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
SAM NUNN ATLANTA FEDERAL CENTER
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ATLANTA, GEORGIA 30303-8931

May 30, 2008

Mr. William R. Campbell, Jr.
Chief Nuclear Officer and Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT - NRC SPECIAL INSPECTION REPORT 05000259/2008009, 05000260/2008009 AND 05000296/2008009

Dear Mr. Campbell:

On May 2, 2008, the Nuclear Regulatory Commission (NRC) completed a special inspection at your Browns Ferry facility. The enclosed report documents the inspection findings which were discussed on May 2 with Mr. R. West and other members of his staff.

Between March 24 and March 30, 2008, your staff disassembled both Division I 3A and 3C, and Division II, 3B and 3D, residual heat removal heat exchanger service water (RHR HX SW) outlet flow control valves (FCVs) and found significant degradation in each valve including stem-to-disc separation in several. During the last Unit 2 refueling outage, your staff had identified similar degradation in two of the Unit 2 RHR HX SW outlet FCVs.

On April 18, 2008, NRC Region II management established a Special Inspection Team using the guidance contained in Management Directive 8.3, NRC Incident Investigation Program. The Special Inspection Team was chartered to identify the degradation mechanisms that had affected these valves, review the past and current root-cause evaluations, review the interim and long-term corrective actions, and verify that the interim corrective actions are adequate to ensure the operability of the Units 2 and 3 RHR HX SW outlet FCVs, until a long-term resolution is implemented. The inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations and with the conditions of your license. The inspectors reviewed selected procedures and records, conducted field walkdowns, observed activities, and interviewed personnel.

Based on the results of this inspection, the inspectors identified one issue of very low safety significance (Green) that was determined to involve a violation of NRC requirements. However, because of its very low safety significance and because it has been entered into your Corrective Action Program, the NRC is treating this issue as a non-cited violation, in accordance with Section VI.A.1 of the NRC's Enforcement Policy. If you deny the non-cited violation, you should provide a response with the basis for your denial, within 30 days of the date of this inspection report to the Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington DC 20555-0001, with copies to the Regional Administrator, Region II; the Director, Office of

Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at the Browns Ferry facility.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (The Public Electronic Reading Room).

Sincerely,

/JHM RA for/

Leonard D. Wert, Director
Division of Reactor Projects

Docket Nos.: 50-259, 50-260, 50-296
License Nos.: DPR-33, DPR-52, DPR-68

Enclosure: Inspection Report 05000259/2008009, 05000260/2008009 and 05000296/2008009
w/Attachment: Supplemental Information

cc w/encl.: (See page 3)

Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at the Browns Ferry facility.

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Letter to William R. Campbell, Jr. from Leonard D. Wert dated May 30, 2008

SUBJECT: BROWNS FERRY NUCLEAR PLANT - NRC SPECIAL INSPECTION REPORT 05000259/2008009, 05000260/2008009 AND 05000296/2008009

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U. S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket Nos:	50-259, 50-260, 50-296
License Nos:	DPR-33, DPR-52, DPR-68
Report No:	05000259/2008009, 05000260/2008009 and 05000296/2008009
Licensee:	Tennessee Valley Authority (TVA)
Facility:	Browns Ferry Nuclear Plant, Units 1, 2 & 3
Location:	Corner of Shaw and Nuclear Plant Roads Athens, AL 35611
Dates:	April 27 – May 2, 2008
Inspectors:	R. Hagar, Senior Resident Inspector - Robinson C. Stancil, Resident Inspector - Browns Ferry
Approved by:	Rebecca L. Nease, Chief Reactor Project Branch 6 Division of Reactor Projects

Enclosure

SUMMARY OF FINDINGS

IR 05000259/2008009, 05000260/2008009 and 05000296/2008009; 04/27/08 – 05/02/08; Browns Ferry Nuclear Plant, Units 1, 2 and 3; Event Followup.

The special inspection team (SIT) inspection was conducted by a senior resident inspector and a resident inspector. One finding of very low safety significance (Green) was identified. The significance of most findings is indicated by their color (Green, White, Yellow, Red) using Inspection Manual Chapter (IMC) 0609, "Significance Determination Process" (SDP). The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

A. NRC-Identified and Self-Revealing Findings

- Green. The inspectors identified a Green non-cited violation of 10 CFR 50, Appendix B, Criterion XVI, for the licensee's failure in March, 2000, to take action to preclude repetition of stem-to-disc separation events in residual heat removal heat exchanger service water outlet valves. The finding is more-than-minor, because if left uncorrected the condition would become a more significant safety and regulatory concern. In Phase 1 of the SDP, described in IMC 0609, Attachment 4, this finding screened as Green because it affected the Mitigating Systems cornerstone and was a design deficiency confirmed not to result in loss of operability or functionality. The finding has a cross-cutting aspect in the area of problem identification and resolution (P.1(c)) because the licensee did not thoroughly evaluate a problem such that the resolutions addressed causes and extents of condition. (Section 4OA3.3)

B. Inspection Results

- Degradation that occurred in the residual heat removal heat exchanger service water outlet flow control valves included broken motor lugs, broken motor leads, separations of valve discs from their stems, broken stem-to-disc tack welds, stem shear, slipped anti-rotation collars, separations of valve handwheels from their shafts, a gasket leak, a broken disc flute, and dislodging of a stem cap.

- In all cases, the degradation mechanism was a combination of operating the valves under conditions that induced high levels of vibration in the valves and the vulnerability of the valves to vibration-induced damage.

- Repairs have been sufficient to support continued operation and the current operability determination in the near term, because the repairs have reduced the vulnerability of the valves to vibration-induced damage. However, no evidence suggests that those repairs have eliminated that vulnerability.

- Planned long-term corrective actions include replacing the currently-installed Walworth and Anchor-Darling valves in Units 2 and 3 with Copes-Vulcan valves identical to those in Unit 1, to further reduce the valves' vulnerability to vibration induced damage.

- The implemented corrective actions only partially address the root cause, in that those actions have reduced the vulnerability of the valves to vibration-induced damage, but have not yet effectively changed the conditions under which the valves are operated. The planned corrective actions are expected to further reduce the vulnerability of the valves to vibration-induced damage, but no changes are planned to change the conditions under which the valves are operated.

- The only generic safety issue associated with this inspection (vibration-induced damage to safety-related components) has been adequately addressed in generic communications.

REPORT DETAILS

Initial Conditions

During the period of March 24 to March 30, 2008, Unit 3 was shutdown in Operating Mode 5 for a planned refueling outage which had begun on March 18, 2008, and Units 1 and 2 were operating at 100% reactor power.

Event Description

On March 24, 2008, the licensee disassembled and inspected the 3A residual heat removal heat exchanger service water (RHR HX SW) outlet valve and found that it had experienced stem-to-disc separation with severe erosion of the valve body and internal rib guides. On March 25 and March 28, respectively, the licensee disassembled and inspected the 3C and 3B RHR HX SW outlet valves and found that they had also experienced significant internal damage, as well as, stem-to-disc separation. On March 30, the licensee determined that the 3D RHR HX SW outlet valve had not experienced stem-to-disc separation but had experienced tack weld breakage and minor valve body erosion.

Special Inspection Team (SIT) Charter

Based on the criteria specified in Management Directive 8.3, NRC Incident Investigation Program, and Inspection Procedure 71153, "Event Follow-up," a special inspection was initiated in accordance with Inspection Procedure 93812, Special Inspection. The objectives of the inspection, described in the charter, are listed below and are addressed in the identified sections:

1. Develop a complete description of the degradation found in the Units 2 and 3 RHR HX SW outlet flow control valves (FCVs), and the various degradation mechanism(s) observed over multiple operating cycles. (Section 4OA3.1)

2. Review the licensee's repair efforts of all units RHR HX SW outlet FCVs to determine if repairs are sufficient to support operation and the current operability determination. (Section 4OA3.2)

3. Review the licensee's root cause analysis and extent of condition. Assess the adequacy of the licensee's implemented and/or planned corrective actions to address the root cause. (Section 4OA3.3)

4. Review industry operating experience and the licensee's actions in response to any related operating experience items including Information Notice 2006-015, "Vibration-Induced Degradation and Failure of Safety Related Valves." (Section 4OA3.4)

5. Identify any potential generic safety issues and make recommendations for appropriate follow-up actions (e.g., Information Notices, Generic Letters, Bulletins). (Section 4OA3.5)

OTHER ACTIVITIES

4OA3 Event Followup

.1 Degradation Found in the RHR HX SW Outlet FCVs

a. Inspection Scope

The inspectors walked down the RHR HX SW outlet FCVs in Units 1, 2, and 3, interviewed selected plant personnel, and reviewed problem evaluation reports (PERs) and work orders (WOs) associated with the degradation that occurred in these valves to develop a complete description of the degradation that had been found in these valves and to identify the degradation mechanisms.

b. Observations and Findings

The inspectors noted that valves from different manufacturers were installed in the different units: Copes-Vulcan valves were installed in Unit 1, Walworth valves with fluted discs were installed in unit 2, and Anchor-Darling valves are installed in unit 3. Licensee records show that these valves have all been installed in their respective units since each unit's restart date, except for the 2C and 2D HX valves in Unit 2. With respect to those valves:

- The 2C RHR HX SW outlet valve (2-FCV-23-0040) operated for a short period with a non-fluted disc. That period began in March, 2003, after the valve experienced a broken disc flute and the licensee installed a non-fluted disc to replace the broken disc. That period ended in October, 2003, when the licensee re-installed a fluted disc after the valve experienced seat leakage and a stem-to-disc failure.

- During the 2007 Unit 2 refueling outage, the licensee identified a stem shear with severe valve body and rib guide erosion on the 2D RHR HX SW outlet valve (2-FCV-23-52). The licensee subsequently replaced this valve with a 12-inch Anchor Darling model like those in Unit 3.

Licensee records also show that the subject valves had experienced the following damage since each unit's restart:

	Number of damage occurrences since unit restart	
Type of Damage	in Unit 2 valves	in Unit 3 valves
broken motor lugs	2	2
broken motor leads	0	5
stem-to-disc separation	1	4
broken stem-to-disc tack welds	0	1
stem shear	1	0
slipped anti-rotation collar	0	5
handwheel separation	4	1

broken disc flute	1	0
stem cap separation	1	1
gasket leakage	1	0

Records reviewed by the inspectors showed no damage to the RHR HX SW outlet FCVs in Unit 1.

Comprehensive timelines of the damage that occurred to the RHR HX SW outlet FCVs in Units 2 and 3 are provided in Attachments 1 and 2 to this report. Those timelines show, in part, that:

- In Unit 2, the earliest occurrence of damage to these valves was in December, 1994, when a handwheel separated from Valve 2-023-040. That date was approximately 42 months after the July, 1991, restart of the unit.

- In Unit 3, the earliest damage occurrence was a broken motor lug in March, 1997, approximately 17 months after the October, 1995, restart of that unit.

- Damage events generally occurred earlier in plant life in Unit 3 than they did in Unit 2.

- More damage events affected Unit 3 valves than Unit 2 valves.

- The licensee's responses to these events included 2 B-priority root-cause analyses, 11 C-priority apparent-cause evaluations, 7 C-priority no-cause evaluations, and 2 D-priority apparent-cause evaluations.

Licensee evaluations of these damage states consistently indicated that all of the damage identified above was caused by vibration; several evaluations referred to that vibration as "normal". The inspectors determined that the damage had actually been caused by a combination of two factors:

- During shutdown cooling, the licensee operated these valves in a way that allowed relatively-severe cavitation to occur immediately downstream of the valve discs. That cavitation induced vibration that affected both the valve body and the valve stem-disc assembly.

- The valves were vulnerable to vibration-induced damage.

.2 Efforts to Repair the Subject Valves

a. Inspection Scope

The inspectors reviewed licensee records to determine whether repairs are sufficient to support operation and the operability determinations documented in Functional Evaluations 42538 (Unit 2) and 42520 (Unit 3) .

b. Observations and Findings

The inspectors determined that the licensee had repaired the damage the valves had experienced, and that the licensee had also made several changes to the valves to reduce the valves' vulnerability to vibration-induced damage. The damage states and the corresponding changes made by the licensee are summarized in the table below.

Damage state	Change(s) made to address
Broken motor lugs & leads	Removed all motor terminal blocks (no longer requiring lugs) and replaced with Raychem splices
Stem-to-disc separation	Replaced threaded and tack-welded connections between the valve stems and the discs with full-welded connections
Slipped anti-rotation collar	Slightly drilled the valve stems at the set-screw locations and replaced the standard set screw with a "dog-point"-style set screw
Handwheel separation	Removed set screws, spot-drilled the handwheel shafts, and then on each shaft installed two set screws back-to-back

The inspectors considered that the damage states that had the greatest safety significance were broken motor leads and lugs, because those can disable the valve actuators, and slippage of the anti-rotation collar, because that event can prevent the valve from responding to actuator operation. The other damage states would degrade the valves, but would not render the valves incapable of performing their safety functions, which are to open to remove reactor decay heat and to close to isolate flow from a heat exchanger tube rupture.

Using engineering judgment, the inspectors determined that the changes made by the licensee had reduced the vulnerability of the valves to vibration-induced damage. In particular, as shown in the table above, the licensee has made changes to address the damage states that had the greatest significance (broken motor leads and lugs and slippage of the anti-rotation collar). However, the inspectors noted that the licensee had no evidence to indicate that these changes had eliminated that vulnerability. Furthermore, the inspectors noted that the licensee's long-term plan to address this issue included replacing the Walworth and Anchor-Darling valves currently installed in Units 2 and 3 with Copes-Vulcan valves identical to those currently installed in Unit 1. Because the Copes-Vulcan valves contain approximately 50% more mass than do the Walworth and Anchor-Darling valves, the inspectors considered that completing that replacement should further reduce the vulnerability of the valves to vibration-induced damage. However, the inspectors also noted that the licensee had no evidence to indicate that Copes-Vulcan valves are immune to vibration-induced damage.

For this charter item, because the licensee has taken action to reduce the vulnerability of these valves to vibration-induced damage, the inspectors concluded that repairs are sufficient to support operation and the operability determination. However, continued monitoring of these valves during shutdown-cooling operation will be required to determine whether additional actions are necessary.

.3 Root-Cause Analyses and Extent of Condition

a. Inspection Scope

The inspectors reviewed the licensee's root-cause analyses and extent-of-condition determinations to determine whether the licensee's implemented and/or planned corrective actions address the root cause.

b. Observations and Findings

As mentioned above, the inspectors determined and the licensee staff agreed that the damage the RHR HX SW outlet FCVs had experienced had been caused by the combination of operating those valves in a way that induced vibration and the vulnerability of those valves to vibration-induced damage. The "root cause" was therefore that combination.

As the timelines in attachments 2 and 3 show, the licensee completed two root-cause analyses that address the damage these valves have experienced: (1) PER 35419, which the licensee initiated in April of 2000 after the first stem-to-disc separation event; and (2) PER 104621, which the licensee initiated in June of 2006, after the RHR SW system had exceeded the performance criteria established in accordance with 10 CFR 50.65 (Maintenance Rule) and had, therefore, been classified under paragraph (a)(1) of that rule.

With respect to the combination of causes described above, the inspectors noted the following in PER 35419:

- This PER had been initiated to address a stem-to-disc separation event that occurred in Valve 3-FCV-023-0046 in Unit 3.

- The licensee determined that the root cause of the subject event had been *"fatigue placed on the valve disc when the flow rate was low causing a high differential pressure across the valve"*.

  With respect to the actual root cause described above, this statement mentions low-flow conditions but does not mention cavitation, vibration resulting from cavitation, or the valves' vulnerability to vibration-induced damage. This PER, therefore, did not fully identify the root cause of the damage.

- The corrective action to address the identified root cause was to change the operation instruction for the RHR SW system so that when one RHR SW heat exchanger (and its associated outlet FCV) is operated at low flow rates, operators

would establish flow through another RHR HX so that the combined flow through both HXs would be approximately 4000 gallons/minute. The licensee expected this change to *"… lower the pressure the valve has to work against thereby lessening the probability of damage to the valve*." The corresponding procedure change was implemented in Revision 45 of Procedure 0-OI-23, "Residual Heat Removal Service Water System," which was issued on May 30, 2000.

Subsequent experience demonstrated that this procedure change was not effective at preventing stem-to-disc separation events. Implementation of corrective actions for this PER, therefore, constituted the performance deficiency documented below (following the observations regarding PER 104621).

- The record for this PER did not include a review of the effectiveness of this corrective action. This record, therefore, did not indicate that the licensee had attempted to verify that the procedure change had the intended effect.

- The record for this PER indicated that the valve vendor (Anchor Darling) had specified the maximum differential pressure that the RHR HX SW outlet FCVs should experience, and had recommended that the valves, which had been subjected to a differential pressure outside the recommended maximum, should be disassembled and inspected. In this PER, the licensee asserted without support that the valve that experienced the failure (3-FCV-023-0046) was the only valve that had been subjected to the conditions that caused the failure, and therefore determined that disassembly and inspection of the other valves was not necessary. However, that assertion was not consistent with operating records, which indicated that the four RHR HX SW outlet FCVs in Unit 3 and the four RHR HX SW outlet FCVs in Unit 2 had all been operated for approximately the same amount of time during shutdown cooling.

The inspectors noted the following in PER 104621:

- This PER had been initiated after valve 3-FCV-23-34 had failed to stroke electrically due to two broken motor leads, and thereby caused the 3A RHR heat exchanger train to exceed its Maintenance Rule performance criteria.

- The identified cause of the damage was *"hard strain and excessive vibration"*, and the identified "cause of the cause" was *"excessive vibration at lower flow conditions. The valves are not big enough physically to minimize this vibration*."

  With respect to the actual "root cause" described above, this statement mentions low-flow conditions and vibration, but does not mention the valves' vulnerability to vibration-induced damage. However, the corrective actions taken (described below) indicate that the licensee recognized that vulnerability. The inspectors, therefore, considered that in this PER, the licensee identified the actual "root cause" of the damage.

- Corrective actions taken to prevent recurrence (of broken motor leads) were to initially replace hard-strained lugs and insulated lugs with uninsulated lugs; retrain the motor-lead wiring; and shrink Raychem on the barrel of the lugs, the insulation on the motor leads, and the control wiring for additional support. In this PER, the description of these corrective actions includes the statement, "*These WO's are for the interim fix, long term fix will be the replacement of the valves with valves similar to those used on U1.*"

- Final valve motor actuator corrective actions, as developed in this PER, resulted in removal of all terminal blocks and installation of Raychem splices. By February, 2008, these corrective actions were completed on all of the RHR HX SW outlet FCVs in Units 2 and 3.

- Since implementing these corrective actions, no broken motor leads have occurred on the affected FCVs.

With respect to this charter item, these observations indicate that the corrective actions implemented by the licensee as a result of their root-cause analyses do not fully address the root causes, in that:

- The only root-cause analyses initiated to address damage to these valves were PERs 35419 and 104621;

- The corrective action described in PER 35419 to change how the valves are operated during shutdown cooling was not effective at preventing stem-to-disc separation events; and

- The corrective actions described in PER 104621 had addressed only the broken-motor-lead damage state.

However, as noted above in section 4OA3.2.b, the licensee had taken corrective action through other PERs and/or work orders to address the other failure states as well. Considering the corrective actions described in PER 104621 along with the other corrective actions discussed above, the inspectors consider that the corrective actions implemented by the licensee has addressed part of the root cause, in that those corrective actions have reduced the vulnerability of the valves to vibration-induced damage. However, the licensee has not yet planned or implemented corrective actions to reduce the vibration that these valves experience by changing how they operate these valves during shutdown cooling.

Development and implementation of corrective actions for PER 35419 constituted the performance deficiency described below.

Introduction: The inspectors identified a Green non-cited violation of 10 CFR 50, Appendix B, Criterion XVI, for the licensee's failure in March, 2000, to take action to preclude repetition of stem-to-disc separation events in RHR HX SW outlet FCVs.

Description: In March, 2000, after RHR HX SW outlet FCV 3-FCV-023-0046 experienced a stem-to-disc separation event, the licensee initiated PER 35419 to address that event, completed a root-cause analysis of that event, and developed a corrective action that was intended to prevent recurrence of stem-to-disc separation events. That corrective action, implemented in May 2000, was to revise an operating procedure to reduce the differential pressure the valves would experience during shutdown-cooling operations. That corrective action was shown to be not effective when in March, 2008, the licensee discovered that stem-to-disc separation had occurred in Valves 3-FCV-023-0034, 3-FCV-023-0040, and 3-FCV-023-0046.

Analysis: This finding was more-than-minor because if left uncorrected the condition would become a more significant safety and regulatory concern, in that failure to adequately address the conditions that caused a stem-to-disc separation event in one valve could allow those conditions to cause not only stem-to-disc separation events in other valves, but also more-risk-significant damage that could render the valves incapable of accomplishing their safety functions. In Phase 1 of the Significance Determination Process described in MC 0609, Attachment 4, this finding affected the Mitigating Systems cornerstone and was a design deficiency confirmed not to result in loss of operability or functionality. The finding, therefore, screened as Green.

The inspectors determined that the cause of this finding was that while evaluating the event that prompted PER 35419, the licensee did not determine that the cause of the event had been a combination of operating the valves under conditions that induced vibration and the vulnerability of the valves to vibration-induced damage, and consequently did not develop effective corrective actions to address both of those factors. The inspectors also determined that although the performance deficiency associated with this finding occurred in 2000, this finding is representative of current licensee performance, because since 2000, the licensee has not changed their corrective action program root cause determination methodology in a way that clearly addresses the weaknesses the inspectors noted in the PER 35419 evaluation. The finding therefore has a cross-cutting aspect in the area of problem identification and resolution, because the licensee did not thoroughly evaluate a problem such that the resolutions address causes and extent of conditions, in that the licensee did not thoroughly evaluate the April, 2000, stem-to-disc separation of valve 3-FCV-023-0046 such that the resolutions addressed the causes of the vibration. (P.1(c))

Enforcement: 10 CFR 50, Appendix B, Criterion XVI requires, in part, that for significant conditions adverse to quality, licensees assure that corrective action is taken to preclude repetition.

Contrary to the above, the licensee failed to take corrective action to preclude repetition of a significant condition adverse to quality, in that:

- the stem-to-disc separation event described in PER 35419 was a significant condition adverse to quality with respect to Criterion XVI, because for that event, licensee procedures required both determination of the cause and corrective action to preclude repetition; and

- the licensee's actions taken in April, 2000, in response to the stem-to-disc separation event described in PER 35419, failed to preclude repetition of stem-to-disc separation events, in that three such events occurred in 2008.

Because this finding was of very low safety significance and has been entered into the licensee's corrective action program as PER 143502, consistent with Section VI.A of the NRC Enforcement Policy, this violation is being treated as a non-cited violation, and is designated as NCV 05000260/2008009-01, "Failure to prevent recurrence of stem-to-disc separation events in residual heat removal service water heat exchanger outlet valves".

.4 Response to Industry Operating Experience

a. Inspection Scope

The inspectors reviewed industry operating experience and the licensee's actions in response to related operating experience items including:

- NRC Information Notice (IN) 2006-015, "Vibration-Induced Degradation and Failure of Safety Related Valves";
- NRC IN 83-70 and Supplement 1, "Vibration-Induced Valve Failures";
- NRC IN 2005-23, "Vibration-Induced Degradation of Butterfly Valves";
- NRC IN 2002-26, "Failures of Steam Dryer Cover Plate After a Recent Power Uprate at a BWR";
- INPO Significant Event Report (SER) 02-005, "Lessons Learned from Power Uprates"; and
- INPO SER83-20 Supplement 1, "Improper Seating of Velan Swing Check Valves Due to Disc/Hangar Arm Binding".

b. Observations and Findings

The inspectors determined that the licensee had reviewed and appropriately responded to the operating experience items identified above.

.5 Potential Generic Safety Issues

a. Inspection Scope

The inspectors reviewed the circumstances within the scope of this inspection to determine whether those circumstances included any potential generic safety issues.

b. Observations and Findings

The inspectors determined that no new generic safety issues were associated with damage to the subject valves, because the inspectors considered that the only related generic safety issue (vibration-induced damage to safety-related components) had been adequately addressed in generic communications.

4OA6 Meetings, Including Exit

On May 2, 2008, the inspectors presented the inspection results to Mr. R. West and other members of the plant staff. The inspectors confirmed that proprietary information was not provided or examined during the inspection.

ATTACHMENT: SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

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S. Douglas, General Manager Site Operations
B. Eberly, Corporate Engineering
R. Godwin, Site Support Manager
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K. Harvey, Site Engineering
W. Justice, Engineering Manager
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B. Mitchell, Performance Improvement Manager
B. Trappett, Site Engineering
R. West, Site Vice President
A. Yarbrough, Site Engineering

NRC personnel

T. Ross, Senior Resident Inspector – Browns Ferry

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

None

Closed

None

Opened & Closed

05000260/2008009-01	NCV	"Failure to prevent recurrence of stem-to-disc separation events in residual heat removal service water heat exchanger outlet valves" (4OA3.3)

Closed

None

Previous Items Closed

None

Discussed

None

LIST OF DOCUMENTS REVIEWED

Problem Evaluation Reports

35419, Valve 3-FCV-023-0046 Disk Found Separated from Stem
38168, Anti-Rotation Plate for BFN-3-FCV-023-0046 Found On Top of Packing Gland
38915, 2-FCV-23-52, 2D Outlet Valve Handwheel Fell Off
39727, 2-FCV-23-40 Would Not Electrically Cycle to the Full Closed Position
41912, 3-FCV-23-46 Anti-Rotation Device Out of Position Several Occasions
44050, 2-FCV-023-0040 Valve Seat Requires Machining for Proper Leakage Prevention
44056, 2-FCV-23-46 Failure to Operate
50732, Valve 2-FCV-23-0040 Repeat Maintenance Due to Gasket Leakage
50734, 2-FCV-023-0040 Would Not Completely Close
52672, Valve 2-FCV-023-0046 Three Motor Leads Broken at Terminal Lug Connections
59437, Handwheel for 2-FCV-23-52 Dislocated From Limitorque Stem
69087, Valve 3-FCV-23-34 Indication Remained Double Lit at Full Open
80790, 3-FCV-23-34 Would Not Open from the Control Room
81108, Broken Motor Lead Found on 3-MVOP-23-34
85910, Unplanned Maintenance Rule Unavailability 3A RHR HX
91267, 2-FCV-23-34 Failed to Open On A2 Pump Start
99498, Broken Motor Lead for 3-MVOP-23-34
101897, 2-FCV-23-52 Stem Cover Fell Off
104621, MR PC exceeded on 3A RHR HX
114173, Handwheel for valve 2-FCV-23-52 Found On the Floor
122218, Stem failure of 2-FCV-23-52
127137, 3-FCV-23-34 Failed to Open or Close
136712, RHR SW 3-FCV-23-40 Valve Electrical Failure
140768, 3-FCV-23-34 Stem Separated from Disc
140824, 3-FCV-23-40 Stem Separated from Disc
141137, 3-FCV-23-46 Stem Separated from Disc
141219, 3-FCV-23-52 Broken Tack Welds

Work Orders

94-020161-000, Reinstall 2-MVOP-23-40 Handwheel
96-004063-000, Repair 2-MVOP-23-34 Motor Lugs
97-002514-000, Troubleshoot and Repair 3-MVOP-23-52 Thermalling Out
98-011029-000, Troubleshoot 3-MVOP-23-46 Not Opening
98-011271-001, Reinstall 3-MVOP-23-46 Stem Anti-Rotation Collar
00-003802-000, Disassemble and Refurbish 3-FCV-23-46
00-008114-000, Take Vibration Data On 3-FCV-23-46
02-003214-000, Reinstall 2-MVOP-23-52 Handwheel
02-004605-000, Reinstall Handwheel With Mod On 2-MVOP-23-52
02-004605-001, Install Handwheel Mod On 2-MVOP-23-46
02-004605-002, Install Handwheel Mod On 2-MVOP-23-40
02-004605-003, Install Handwheel Mod On 2-MVOP-23-34
02-004605-004, Install Handwheel Mod On 3-MVOP-23-52
02-004605-005, Install Handwheel Mod On 3-MVOP-23-46
02-004605-006, Install Handwheel Mod On 3-MVOP-23-40

02-004605-007, Install Handwheel Mod On 3-MVOP-23-34
02-006589-001, Repair Operator Shaft and Reinstall Handwheel On 2-MVOP-23-52
03-003010-000, Disassemble, Inspect, and Repair 2-FCV-23-40
03-006967-001, Install New Valve Disc On 2-FCV-23-40
03-007163-000, Realign 3-MVOP-23-46 Anti-Rotation Collar
03-021389-000, Repair 2-MVOP-23-46 Broken Motor Leads
04-714325-000, Realign 3-MVOP-23-46 Anti-Rotation Collar
04-717160-000, Install Anti-Rotation Collar Mod On 3-MVOP-23-46
04-717160-001, Install Anti-Rotation Collar Mod On 3-MVOP-23-52
04-722062-000, Realign 3-MVOP-23-34 Anti-Rotation Collar
04-722067-000, Realign 3-MVOP-23-40 Anti-Rotation Collar
05-714220-001, Troubleshoot and Repair 3-FCV-23-34 Not Opening
05-722104-000, Machine 2-FCV-23-40 Fluted Disc
06-713538-000, Troubleshoot and Repair 3-FCV-23-34 Not Opening
06-716018-000, Reinstall 2-MVOP-23-52 Stem Cap
06-718716-000, Replace 3-MVOP-23-52 Stem Cap
06-725311-000, Disassemble and Inspect 2-FCV-23-52
07-711409-000, Repair 3-MVOP-23-34 Motor Leads
07-720665-000, Replace 3-FCV-23-34 Packing, Handwheel Key, and MOVATS
07-721848-000, Replace 3-MVOP-23-40 Motor Terminations With Raychem Splices
08-710819-000, Inspect and Repair 3-FCV-23-40 Not Moving
08-711543-000, Disassemble, Inspect, and Refurbish 3-FCV-23-34
08-711544-000, Disassemble, Inspect, and Refurbish 3-FCV-23-40
08-711545-000, Disassemble, Inspect, and Refurbish 3-FCV-23-46
08-711546-000, Disassemble, Inspect, and Refurbish 3-FCV-23-52

Procedures

TVA Corporate Procedure SPP-3.1, Corrective Action Program, Rev. 13
TVA Corporate Procedure SPP-3.1, Corrective Action Program, Rev. 1
TVA Business Procedure BP-250, Corrective Action Handbook, Rev. 12
MCI-0-000-GLV001, Generic Maintenance Instruction For Globe Valves, Rev. 21
Surveillance Instruction 2-SI-3.2.1, First and Augmented In-Service Test Valve Performance, Rev. 23
Surveillance Instruction 3-SI-3.2.1, First and Augmented In-Service Test Valve Performance, Rev. 9
Surveillance Instruction 2-SI-4.5.C.1(3), Residual Heat Removal Service Water Pump and Header Operability and Flow Test, Rev. 98
Surveillance Instruction 3-SI-4.5.C.1(3), Residual Heat Removal Service Water Pump and Header Operability and Flow Test, Rev. 30
Functional Evaluation 42538 (PER 141380) Unit 2 Heat Exchanger Outlet Valves 2-FCV-23-34,-40,-46 & 52
Functional Evaluation 42520 (PER 140768) Unit 3 Heat Exchanger Outlet Valves 3-FCV-23-34,-40,-46 & 52 and 2-FCV-23-52
Operations Instruction 0-OI-23, Residual Heat Removal Service Water System, Rev. 45
Operations Instruction 2-OI-74, Residual Heat Removal System, Rev. 137

Other Documents

Engineering Design Change 69327, Revise design output to allow repair of valves as needed

NRC Information Notice 2006-015, Vibration-Induced Degradation and Failure of Safety Related Valves

NRC IN 83-70 and Supplement 1, Vibration-Induced Valve Failures

NRC IN 2005-23, Vibration-Induced Degradation of Butterfly Valves

NRC IN 2002-26, Failures of Steam Dryer Cover Plate After a Recent Power Uprate at a Boiling-Water Reactor

INPO Significant Event Report 02-005, Lessons Learned from Power Uprates

INPO Significant Event Report 83-20 Supplement 1, Improper Seating of Velan Swing Check Valves Due to Disc/Hangar Arm Binding

Attachment 2: Damage Summary for Unit 2 Valves

The table in this attachment shows the damage experienced by the four RHR HX SW outlet FCVs in unit 2 (valves 2-023-0034, 2-023-0040, 2-023-0046, and 2-023-0052) versus time since the unit was restarted. In this table,

- The first two columns show various times described by year and month.
- The "Δt" column shows the number of months that had elapsed between the unit restart date and the corresponding date.
- The four columns labeled "Damage in valve" and the valve numbers include code letters that indicate the damage experience by each valve during each corresponding month and year. The code letters are decoded below. In these columns, the valves are referred to by only the last two characters of their valve numbers.
- The column labeled "PER/WO/Comment" either identifies the problem evaluation report (PER) initiated to address the issue, the work order (WO) under which repairs were completed, or a related comment.
- The "Priority" Column identifies the relative priority the licensee assigned to the corresponding PER (the priority codes are decoded below).
- The "Corrective Actions" column summarizes the licensee's response as described in the corresponding PER or WO.

			Damage[1] in valve:						
Year	M	Δt	34	40	46	52	PER / WO / Comment	Priority[2]	Corrective Actions
1991	7		n				Unit 2 restart		
1994	12	42		f			WO 94-020161-000		reinstalled handwheel
1996	3	57	a				WO 96-004063		repaired motor lugs
2001	11	126				f	PER 59437	CA	initiated PER to initiate handwheel mod
							WO 02-004605-000		repaired handwheel
2002	3	130				f	PER 38915		initiated WO 02-004605-xxx for handwheel modification development and implementation
							WO 02-003214-000		reinstalled handwheel
	8	135	n				WO 02-004605-003		installed handwheel mod
				n			WO 02-004605-002		installed handwheel mod
						n	WO 02-004605-000		installed handwheel mod
					n		WO 02-004605-001		installed handwheel mod
2003	2	141		g			PER 39727	CA	initiated EDC 51557 to allow fluted or non-fluted disc
							PER 50734	D	cause not determined

							WO 03-003010-000		replaced fluted with non-fluted disc
	3	142		h			PER 50732	CA	revised gasket-torquing procedures
	10	149		c			WO 03-006967-001		replaced with fluted disc
	11	150			a		PER 52672	CA	
							WO 03-021389-000		repaired broken motor leads
2004	3	154			j		PER 41912	CA	revised setscrew design & installation
2006	4	180				i	PER 101897	D	closed to WO
							WO 06-716018-000		re-installed stem cap
	11	187				f	PER 114173	D	closed to WO
							WO 02-006589-001		re-installed handwheel & repaired operator
2007	3	191		n			WO 05-722104-000		machined fluted disc for better flow
						d	PER 122218	CN	initiated DCN 68948
							WO 06-725311-000		replaced Walworth valve with Anchor-Darling 12” valve via DCN 68948

[1] Damage states:
- a. broken motor lugs
- b. broken motor leads
- c. stem-disc separation
- d. stem shear
- e. slipped anti-rotation collar
- f. separated handwheel
- g. broken disc flute
- h. gasket leakage
- i. stem cap separation
- j. trend
- n. non-damage comment

[2] Classification of the PER:
- A: A priority
- BA: B priority, apparent cause
- BR: B priority, root cause
- CA: C priority, apparent cause
- CN: C priority, no cause evaluation
- CR: C priority, root cause
- D: track and trend

Attachment 3: Damage Summary for Unit 3 Valves

The table in this attachment shows the damage experienced by the four RHR HX SW outlet FCVs in unit 3 (valves 3-023-0034, 3-023-0040, 3-023-0046, and 3-023-0052) versus time since the unit was restarted. In this table,

- The first two columns show various times described by year and month.
- The "Δt" column shows the number of months that had elapsed between the unit restart date and the corresponding date.
- The four columns labeled "Damage in valve" and the valve numbers include code letters that indicate the damage experience by each valve during each corresponding month and year. The code letters are decoded below. In these columns, the valves are referred to by only the last two characters of their valve numbers.
- The column labeled "PER/WO/Comment" either identifies the problem evaluation report (PER) initiated to address the issue, the work order (WO) under which repairs were completed, or a related comment.
- The "Priority" Column identifies the relative priority the licensee assigned to the corresponding PER (the priority codes are decoded below).
- The "Corrective Actions" column summarizes the licensee's response as described in the corresponding PER or WO.

			Damage[1] in valve:						
Year	M	Δt	34	40	46	52	PER / WO / Comment	Priority[2]	Corrective Actions
1995	10		n				Unit 3 restart		
1997	3	17				a	PER 97-0541-000		
							WO 97-002514-000		re-lugged the leads
1998	10	35			a		PER 38168	CA	changed procedure to prevent set screw from backing out
							WO 98-011029-000		re-lugged the leads
					e		PER 38168		revised a maintenance procedure to require that measures be taken to prevent the set screw from `backing off`
							WO 98-011271-001		realigned & lock-tightened collar
2000	4	53			c		PER 35419	BR	refurbished the valve
							WO 00-003802-000		chased threads and re-tack welded disc assembly
	10	59			n		WO 00-008114-000		took vibration data at 600 GPM
2001	8	69			n		WO 02-004605-005		installed handwheel mod

2002	8	81	f				WO 02-004605-007		installed handwheel mod
				n			WO 02-004605-006		installed handwheel mod
						n	WO 02-004605-004		installed handwheel mod
2003	4	88			e		WO 03-007163-000		re-aligned collar
2004	4	100			e		WO 04-714325-000		re-aligned collar
					h		PER 41912 for adverse trend on anti-rotation collar failures	CA	revised vendor drawing for alternate style setscrew, initiated WO 04-717160-000
	9	105	e				PER 69087	CA	initiated ECD for anti-rotation collar mod
							WO 04-722062-000		re-aligned collar
				e			WO 04-722067-000		re-aligned collar
2005	4	112	b				PER 81108	CN	initiated WO to install new terminal lead
							WO 05-714220-001		installed new terminal lead
2006	3	123	b,b				PER 99498	CA	closed action to WO
							WO 06-713538-000		replaced & installed Raychem splice
					n		WO 04-717160-000		installed anti-rotation collar mod
						n	WO 04-717160-001		installed anti-rotation collar mod
	6	126	n				PER 104621 for MR PC exceeded; valves in (a)(1)	BR	initiated 10-point plan for improvement
2007	7	138	b				PER 127137	CN	initiated WOs to remove terminal blocks and install Raychem splices
							WO 07-711409-000		removed terminal blocks & installed Raychem splices
			n				WO 07-720665-000		repaired cocked gland follower & reinstalled handwheel key
2008	1	144		b			PER 136712	CA	referred to PER 127137 actions
							WO 07-721848-000		removed terminal blocks & installed Raychem splices
							WO 08-710819-000		investigated valve not moving
	3	146	c				PER 140768	CN	initiate WO to refurbish the valve
							WO 08-711543-000		installed full weld per EDC 69327
				c			PER 140824	CN	initiated EDC 69327 to install full weld

									instead of tack welds
							WO 08-711544-000		installed full weld per EDC 69327
					c		PER 141137	CN	referred to EDC 69327 to install full weld instead of tack welds
							WO 08-711545-000		installed full weld per EDC 69327
						k	PER 141219	CN	referred to EDC 69327 to install full weld instead of tack welds
							WO 08-711546-000		installed full weld per EDC 69327
						i	WO 06-718716-000		re-installed stem cap

[1] Damage states:
- a. broken motor lugs
- b. broken motor leads
- c. stem-to-disc separation
- d. stem shear
- e. slipped anti-rotation collar
- f. separated handwheel
- g. broken disc flute
- h. gasket leakage
- i. stem cap separation
- j. trend
- k. stem-to-disc tack welds broken
- n. non-damage comment

[2] Classification of the PER:
- A: A priority
- BA: B priority, apparent cause
- BR: B priority, root cause
- CA: C priority, apparent cause
- CN: C priority, no cause evaluation
- CR: C priority, root cause
- D: track and trend