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Leonard D. Wert, Director
Division of Reactor Projects
United States Nuclear Regulatory Commission
Region II
Sam Nunn Atlanta Federal Center
61 Forsyth Street SW, Suite 23T85
Atlanta, GA 30303-8931

Subject: NRC Special Inspection Report for RHRSW Valve Damage at Browns Ferry

Dear Mr. Wert:

The report[*] issued by the Nuclear Regulatory Commission (NRC) on the special inspection conducted at Browns Ferry following discovery of recurring vibration-induced damage to flow control valves on the residual heat removal service water (RHRSW) outlet of the residual heat removal (RHR) heat exchangers answered many questions, but raised many others. In the attachment to this letter, I have attempted to provide context for the unanswered questions. I would appreciate the NRC's written answers to these questions, or the identification of publicly available documents containing the answers, or a telephone conference call with the NRC to discuss the answers, or the issuance of a revised special inspection report remedying its many, many shortfalls, omissions, and inconsistencies.

I pay particular attention to NRC's special inspection reports and generally find them very good. In fact, by letter dated December 10, 2007, to Acting Regional Administrator Victor McCree, I complimented the NRC for a stellar special inspection team report[†] regarding cooling water flow rates through the RHR room coolers at Brunswick. This Browns Ferry special team inspection report was at the other end of the spectrum. I would strongly recommend that the NRC examine

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[*] Letter dated May 30, 2008, from Leonard D. Wert, Director – Division of Reactor Projects, Nuclear Regulatory Commission, to William R. Campbell Jr., Chief Nuclear Officer and Execituve Vice President, Tennessee Valley Authority, "Browns Ferry Nuclear Plant – NRC Special Inspection Report 05000259/2008009, 050000260/2008009 and 050000296/2008009." Available in ADAMS under ML081510829.

[†] Letter dated November 16, 2007, from Charles A. Castro, Director – Division of Reactor Projects, Nuclear Regulatory Commission, to J. Scarola, Vice President, Carolina Power and Light Company, "Brunswick Steam Electric Plant – NRC Special Inspection Report No. 05000325/2007011 and 050000324/2007011." Available in ADAMS under ML073200779.

why the Brunswick special inspection report turned out so well and this one turned out so differently so future reports more closely resemble that one than this one.

Sincerely,

David Lochbaum
Director, Nuclear Safety Project

Attachment: as stated

Credit for Doing Less Now Than Was Unacceptable Before

The NRC issued a green non-cited violation for a performance deficiency that resulted in repetitive stem-to-disc separation of residual heat removal service water heat exchanger outlet valves:

> "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." Page 11
>
> "…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 … 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." Page 8
>
> "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"." Page 12

Thus, the violation was a failure by TVA in PER 35419 to "fully identify the root cause of the damage" to valve 3-FCV-023-46 in 2000 with resulting failure to implement corrective actions "to prevent recurrence of stem-to-disc separation."

Per attachment 3, TVA classified PER 35419 as having B priority which required a root cause evaluation. The recurring events associated with this non-cited violation were identified in March 2008:

> "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." Page 3

Per attachment 1, TVA initiated PER 140768 for the stem-to-disc separation of valve 3-FCV-23-34, PER 140824 for the stem-to-disc separation of valve 3-FCV-23-40, and PER 141137 for the stem-to-disc separation of valve 3-FCV-23-46. Stem-to-disc separation of valve 3-FCV-23-46 in 2000 caused TVA to initiate PER 35419:

> "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**" Page 11 (emphasis added)

Per attachment 3, TVA classified PERs 140768, 140824, and 141137 as having C priority which required neither a root cause nor apparent cause evaluation.

Questions:

Q1. Stem-to-disc separation of valve 3-FCV-23-46 in 2000 resulted in B priority PER 35419 with a root cause evaluation. The exact same degradation of this same valve from the exact same cause in 2008 resulted in C priorty PER 141137 with neither an apparent cause or root cause evaluation.

a) Was TVA right in 2000 by requiring a root cause evaluation or right in 2008 by not requiring one?
b) Was TVA right in 2000 by assigning Priority B or right in 2008 by assigning Priority C?

Q2. Why did the NRC reduce the severity of its enforcement action for this violation based in part on TVA having entered the finding into the corrective action program, which was documented by the NRC's special inspection as doing significantly less in response to the same problem than TVA did in its original deficient response?

Credit for Non-Reviewed Design and Licensing Bases Documents - 1

The NRC issued a green non-cited violation for this violation:

> "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." Page 11

> "The other damage states would degrade the valves, but would not render the valve 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." Page 7

Attachment 1 listed the documents reviewed by the NRC during its special inspection. The Updated Final Safety Analysis Report (UFSAR) is <u>not</u> listed. The technical specifications are <u>not</u> listed. The individual plant examination is <u>not</u> listed. The plant safety assessment is <u>not</u> listed. The residual heat removal design basis document is <u>not</u> listed. As point of fact, there is <u>not</u> a single document listed on attachment 1 that could provide the NRC's inspectors with information on the safety functions of the valves or the consequences of their impaired operation.

Questions:

Q1. How could the NRC inspectors evaluate whether TVA was maintaining and operating the subject valves within applicable design and licensing basis requirements without looking at any of the documents containing said design and licensing basis requirements?

Q2. How could the NRC inspectors determine the required functions of the valves without examining any of the documents that specify those functions?

Q3. How could the NRC inspectors or their colleagues determine the safety implications of impaired valve operation without reviewing any of the documents that contain the safety analyses, and associated assumptions and margins, for the valves?

Q4. The valves have safety functions to close under certain conditions and open under other conditions. How did the NRC establish that valves with stem-to-disc separation can open and close when and as needed?

Credit for Non-Reviewed Design and Licensing Bases Documents - 2

The NRC issued a green non-cited violation for this violation of federal safety requirements because TVA entered the finding into its corrective action program:

> "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"." Page 12

Attachment 1 listed the documents reviewed by the NRC's inspectors, including 27 Problem Evaluation Reports (PERs) in the corrective action program at Browns Ferry. PER 143502 was <u>not</u> included on this list.

Questions:

Q1. Did the NRC inspectors, either individually or collectively, review PER 143502?
Q2. If PER 143502 was reviewed by the NRC, why was it omitted from the list of documents reviewed by the NRC?
Q3. If PER 143502 was not reviewed by the NRC, did the NRC rely on rumor and supposition from TVA as the basis for its belief that PER 143502 existed and to what it allegedly contained?

Credit for Non-Implemented Corrective Actions

The NRC's special inspection team reported a single finding:

> "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." Page 11

"…if left corrected…"? It was and it remains uncorrected. There's no "if" involved at all.

All that TVA did following the stem-to-disc separations in 2008 was the same, ineffective band-aid fixes they applied to the stem-to-disc separation in 2000. TVA has plans to do more:

> "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." Page 2

> "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." Page 7

> "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." Page 7

Thus, the finding that was more-than-minor if left uncorrected was documented by the NRC special inspection team to have been left uncorrected.

Questions:

> Q1. Does the NRC have any expectation that TVA might just actually correct the known-to-be-deficient valves before they break again?

> Q2. Why did the NRC credit unimplemented corrective actions?

> Q3. If TVA once again fails to implement corrective actions for this recurring problem (i.e., if the valves suffer vibration-induced damage again), will the NRC once again issue a non-cited violation?

Credit for Unsupported Root Cause Evaluation

The NRC inspectors determined that vibrations during shutdown cooling mode operation of the residual heat removal system caused the damage to the residual heat removal service water flow control valves:

> "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." Page 6

The NRC special inspection report is littered with not-so-relevant factoids such as:

> "Records reviewed by the inspectors showed no damage to the RHR HX SW outlet FCVs in Unit 1." Page 6

> "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." Page 6

> "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." Page 6

> "Damage events generally occurred earlier in plant life in Unit 3 than they did in Unit 2." Page 6

> "More damage events affected Unit 3 valves than Unit 2 valves." Page 6

Attachments 2 and 3 provide timelines for valve damage events on Units 2 and 3 respectively. Column 3 lists the time in months between the damage events and the applicable unit's restart (July 1991 for Unit 2 and October 1995 for Unit 3).

Except for the following instance, the NRC's special inspection team report fails to quantify how much time the three units at Browns Ferry spent in RHR shutdown cooling mode since their restarts:

> "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." Page 9

Even if true, this data point is from 2000 and it may still not be true that Units 2 and 3 have operated in RHR shutdown cooling mode for comparable time periods.

The NRC contends that vibrations occurring during RHR shutdown cooling are causing the valve damage and believes that replacing the vulnerable valves on Units 2 and 3 with the heavier valves installed on Unit 1 will fix the problem. Perhaps, but it might be that Unit 1 has considerably less time spent in RHR shutdown cooling mode (recall that Unit 1 restarted more than a decade more recently than Units 2 and 3).

Attachment 1 listed documents reviewed by the NRC's special inspection team. Based on their titles and types, none of these documents would seem to contain information on the cumulative time spent in RHR shutdown cooling mode for the three units at Browns Ferry.

Without objective evidence suggesting a causal link between RHR shutdown cooling operation and valve damage, the NRC's "root cause" determination is merely a guess. Perhaps a good guess, but a guess nonetheless.

Questions:

> Q1. Without information on RHR shutdown cooling operating times for the three units, how did the NRC forge a connection between vibration-induced damage to the valves from RHR shutdown cooling operation?
>
> Q2. How is NRC's unsupported guess in 2008 substantially different from TVA's equally unsupported guess in 2000 via PER 35419?

Inconsistent Conclusions Regarding Operating Experience

The NRC's special inspection team explicitly examined whether TVA had properly responded to operating experience it received and whether this event warranted issuance of new operating experience report(s) by NRC.

> "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"
>
> "The inspectors determined that the licensee had reviewed and appropriately responded to the operating experience items identified above." Page 12
>
> and
>
> "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." Page 12

Assuming for the moment that the prime purpose of operating experience is to share information on problems so that others can implement measures to preclude recurrence of the problems, these two NRC conclusions are contradictory.

The first conclusion was that TVA received six prior operating experience reports about vibration-induced damage and had appropriately responded to them. And yet, the vibration-induced damage to the valves happened again in 2008.

The second conclusion was that no new generic communications need to be issued as a result of this Browns Ferry event. This conclusion contains the implicit element that no new vibration-induced failure modes or effects were uncovered by the Browns Ferry event. In other words, the depth and breadth of the operating experience distributed by the cited documents sufficiently described what happened at Browns Ferry.

But if the information in those prior documents was truly sufficient, TVA should have been able to take the steps necessary to preclude the recurrence of vibration-induced damage of the valves.

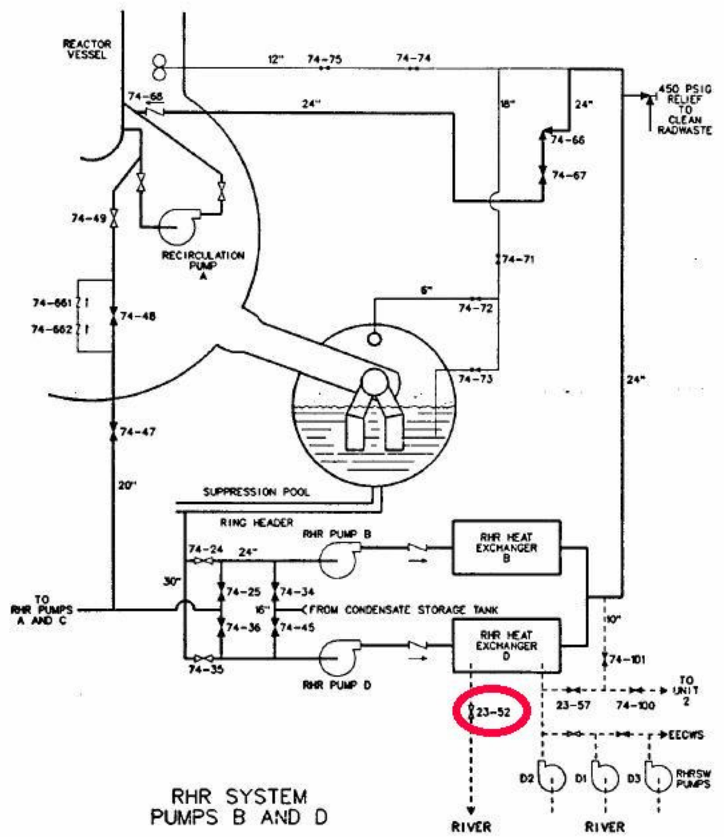
Thus, either TVA responded inadequately to adequately provided operating experience or TVA responded adequately to inadequately provided operating experience. There is no other legitimate outcome.

Question:

Q. Would NRC care to correct its inconsistent assessment of operating experience?

BACKGROUND

The residual heat removal (RHR) system at Browns Ferry consists of two trains. Each train consists of two RHR pumps, two RHR heat exchangers, and associated piping and valves. The diagram shows RHR train B, which has RHR pumps and heat exchangers B and D. RHR train A is virtually identical.



Schematic diagram of one loop of the Residual Heat Removal system

The valves in question are on the residual heat removal service water (RHRSW) outlet from the RHR heat exchangers. One such valve is circled in the graphic. Water from the RHR pumps flows through the RHR heat exchangers inside thousands of metal tubes. River water pumped by the RHRSW pumps enters the shells of the RHR heat exchangers and passes along the outside of the metal tubes. Heat flows through the tube walls to cool the RHR water and warm the RHRSW water. The subject valves open fully or partially to control the river water flow rate through the heat exchangers and close if one or more tubes break to prevent radioactively contaminated RHR water from reaching the river.

The RHR system has many modes of operation, including:

Low Pressure Coolant Injection: In event of an accident, the RHR pumps can take water from the suppression pool and supply it to the recirculation loop piping to keep the reactor core covered with water.

Suppression Pool Cooling: During normal reactor operation and following an accident, the RHR pumps can take water from the suppression pool, route it through the RHR heat exchangers where it is cooled by river water, and return the cooled water to the suppression pool.

Containment Spray: Following an accident, the RHR pumps can take water from the suppression pool, route it through the RHR heat exchangers where it is cooled by river water, and deliver the cooled water to spray nozzles located inside the drywell (the inverted lightbulb shaped structure around the reactor vessel) and/or inside the suppression pool.

Shutdown Cooling: After the reactor has been shut down, the RHR system can take water from the recirculation loop piping, route it through the RHR heat exchangers where it is cooled by river water, and return the cooled water to the recirculation loop piping. This mode removes decay heat still being generated by the reactor core.