UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
245 PEACHTREE CENTER AVENUE NE, SUITE 1200
ATLANTA, GEORGIA 30303-1257

June 21, 2018

Mr. Joseph W. Shea, Vice President
Nuclear Regulatory Affairs and
Support Services
Tennessee Valley Authority
1101 Market Street, LP 4A
Chattanooga, TN 37402-2801

SUBJECT: WATTS BAR NUCLEAR PLANT – NUCLEAR REGULATORY COMMISSION SPECIAL INSPECTION REPORT 05000390/2018050 AND 05000391/2018050

Dear Mr. Shea:

On May 14, 2018, the U.S. Nuclear Regulatory Commission (NRC) completed a reactive inspection pursuant to Inspection Procedure 93812, "Special Inspection," at your Watts Bar Nuclear Plant, Units 1 and 2. The enclosed inspection report documents the inspection results which were discussed on May 14, 2018, with Mr. P. Simmons, and other members of your staff.

The special inspection began on April 30, 2018, in accordance with NRC Management Directive 8.3, "NRC Incident Investigation Program," and Inspection Manual Chapter 0309, "Reactive Inspection Decisions Basis for Reactors," based on the initial risk and deterministic criteria evaluation performed by the NRC. The special inspection reviewed the circumstances surrounding the emergency core cooling system gas accumulation acceptance criteria being non-conservative. Conservative acceptance criteria were established; however on April 21, 2018, a gas void determination for the Unit 1 residual heat removal (RHR) system exceeded this criteria, resulting in the inoperability of both trains of RHR and required entry into Technical Specification (TS) 3.0.3 until the RHR system was vented. On April 22, 2018, a similar condition was found for the Unit 2 RHR system that resulted in a TS 3.0.3 entry until the Unit 2 RHR system was vented. Based on this initial assessment, the NRC sent an inspection team to your site on April 30, 2018.

The report documents one licensee-identified violation that was determined to be of very low safety significance. The NRC is treating this violation as a non-cited violation (NCV) consistent with Section 2.3.2 of the Enforcement Policy.

If you contest the violation or significance of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001; with copies to the Regional Administrator, Region II; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at Watts Bar Nuclear Plant.

This letter, its enclosure, and your response (if any) will be made available for public inspection and copying at http://www.nrc.gov/reading-rm/adams.html and at the NRC Public Document Room in accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding."

Sincerely,

/RA/

Joel T. Munday, Director
Division of Reactor Projects

Docket Nos.: 05000390, 05000391
License Nos.: NPF-90, NPF-96

Enclosure:
IR 05000390/2018050 and
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U.S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket Numbers:	50-390, 50-391
License Numbers:	NPF-90, NPF-96
Report Numbers:	05000390/2018050, 05000391/2018050
Enterprise Identifier:	I-2018-050-0001
Facility:	Watts Bar Nuclear Plant, Units 1 and 2
Location:	Spring City, TN 37381
Dates:	April 30, 2018 – May 14, 2018
Team Leader:	T. Morrissey, Senior Resident Inspector
Inspectors:	J. Jandovitz, Resident Inspector J. Eargle, Senior Project Manager
Approved By:	Anthony D. Masters, Chief Reactor Projects Branch 5 Division of Reactor Projects

Enclosure

SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) monitored the licensee's performance by conducting a special inspection at Watts Bar Nuclear Plant, Units 1 and 2, in accordance with the Reactor Oversight Process. The Reactor Oversight Process is the NRC's program for overseeing the safe operation of commercial nuclear power reactors. Refer to https://www.nrc.gov/reactors/operating/oversight.html for more information. A licensee-identified non-cited violation is documented in the inspection results section of the report.

List of Findings and Violations

No NRC findings were identified

REPORT DETAILS

Event Description

Since initial operation of Unit 1 in 1996 and Unit 2 in 2016, Tennessee Valley Authority has not had a complete and adequate design basis that considered the total effects of gas intrusion for the SI and RHR systems. The water hammer effects in the original basis were not accurate, resulting in non-conservative voiding design acceptance criteria for the RHR and SI systems of both units.

On April 19, 2018, the Watts Bar Nuclear Plant (WBN) Operations Superintendent called the WBN NRC resident to report that WBN was notified by their contractor of errors in calculations relating to the emergency core cooling system (ECCS) void size. The calculations were being reviewed as part of an extent of condition for an auxiliary feedwater system (AFW) piping stress analysis. The initial acceptance criteria was based on an acceptable delay in injecting water into the reactor coolant system (RCS). On April 19, 2018, interim void volume acceptance criteria were established that were based on stresses from a water hammer event when ECCS is initiated. These reduced values were provided to WBN by Westinghouse and were based on Westinghouse's experience with similar plants, and were not specific to either unit at WBN. This new interim criteria was significantly lower than the previous acceptance criteria. Specifically, the residual heat removal (RHR), or low head injection system, void limit was reduced from 40 cubic feet (ft^3) to 1.3 ft^3, and the safety injection (SI), or high head injection system, void limit was reduced from 27.6 ft^3 to 5 ft^3.

An immediate determination of operability was completed on April 20, 2018, and it was determined that the affected ECCS on Units 1 and 2 were operable but degraded with interim compensatory measures established. The interim compensatory measures were increased frequency of void measurement and venting of ECCS. The frequency was increased from monthly to daily.

On April 21, 2018, WBN notified the NRC that the accumulated gas in the Unit 1 RHR system was found to be greater than the 1.3 ft^3 limit (approximately 5 ft^3). Unit 1 then entered Technical Specification (TS) 3.0.3 and exited the TS once the RHR system was vented. Entry into TS 3.0.3 requires a unit shutdown in six hours unless the condition for the entry is corrected and the TS is exited.

On April 22, 2018, WBN notified the NRC that the accumulated gas in the Unit 2 RHR system was found to be greater than the 1.3 ft^3 limit (approximately 1.367 ft^3). Unit 2 then entered TS 3.0.3 and exited the TS once the RHR system was vented.

Special Inspection Team Charter

A Special Inspection Charter was established on April 26, 2018, containing the scope of the special inspection. The Charter is found in Attachment 2.

INSPECTION SCOPE

Inspections were conducted using the appropriate portions of inspection procedure (IP) 93812, "Special Inspection," in effect at the beginning of the inspection. Currently approved IPs with their attached revision histories are located on the public website at http://www.nrc.gov/reading-rm/doc-collections/insp-manual/inspection-procedure/index.html. The inspectors reviewed selected procedures and records, observed activities, and interviewed personnel to assess licensee performance and compliance with Commission rules and regulations, license conditions, site procedures, and standards.

OTHER ACTIVITIES – TEMPORARY INSTRUCTIONS, INFREQUENT AND ABNORMAL

IP 93812 - Special Inspection (1 Sample)

.1 **Charter Item 1:** Develop a complete sequence of events related to the discovery that the acceptance criteria for gas accumulation in the WBN Unit 1 and Unit 2 SI system and RHR system discharge piping may be non-conservative, which resulted in both units' RHR system being inoperable and follow-up actions taken by the licensee.

See Attachment 1

.2 **Charter Item 2:** Determine if the licensee's acceptance criteria for surveillance requirements to keep ECCS full of water are consistent with the plant licensing basis and as-built design.

Since initial operation of Unit 1 in 1996 and Unit 2 in 2016, Tennessee Valley Authority has not had a complete and adequate design basis that considered the total effects of gas intrusion for the SI and RHR systems. The water hammer effects in the original basis were not accurate, resulting in non-conservative voiding design acceptance criteria for the RHR and SI systems of both units.

Upon discovery, the licensee, assisted by Westinghouse, established interim ECCS voiding acceptance criteria for WBN Unit 1 and Unit2 SI and RHR systems. The interim acceptance criteria was conservative and developed only for the purpose ensuring operability while further, more accurate analysis is developed. These criteria established the justification for the Prompt Determination of Operability (PDO, condition report (CR) 1407257) and are as follows:

	Alert Limit ft^3	Upper limit ft^3
Unit 1 RHR	3.5	27.1
Unit 2 RHR	4.0	27.5
Unit 1 SI	2.5	16.6
Unit 2 SI	1.0	27.5

The licensee established an operational decision-making issue (ODMI) evaluation document (CR 1407257) that provided trigger values to adjust venting frequencies based on void trend data. Changes to the venting frequencies required concurrence from Operations and Engineering. The venting frequencies are based on maintaining voids at or below the "Alert" limits established.

The licensee determined that the ECCS were considered operable but non-conforming when operating with ECCS voiding within the above established limits. The systems are considered non-conforming since design margins are conservatively reduced and credit overpressure protection by system relief valves that may transiently lift and reseat. At the conclusion of the inspection, the licensee had plans to determine ECCS design basis voiding limits, utilizing a RELAP5 or similar thermo-hydraulic computer model with plant-specific inputs.

The inspectors concluded that there was reasonable assurance that the ECCS would perform their safety functions as long as gas voiding was maintained within the operability limits established by the licensee. Additional details associated with the inspectors' review of the calculations associated with the above established limits is documented under Charter Item 7.

.3 **Charter Item 3:** Review drawings, walk down portions of the RHR and SI systems, and determine if the vent locations enable system venting to meet void size acceptance criteria.

The team reviewed applicable ECCS piping and instrumentation diagrams (P&IDs) and isometric drawings and walked down accessible portions of the RHR and SI systems to verify vent locations enabled proper venting of the systems.

The team interviewed licensee personnel involved with ultra sonic testing (UT) of horizontal RHR pipe locations that were not in the vicinity of high point vents. The licensee selected pipe locations to UT that may be at or slightly above the elevation of the vent valves to verify if any voiding was present. These locations were selected based on pipe slope data obtained during the NRC Generic Letter (GL) 2008-01, "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal and Containment Spray Systems," walkdowns. All selected pipe locations were determined to be full of water by UT.

The team determined that the vent valve locations were acceptable. This conclusion was based on inspector review of isometric drawings, review of Unit 1 and Unit 2 GL 2008-01 walkdown reports, limited inspector walkdowns of accessible piping, and reviews of locations selected and UT data obtained as noted above.

.4 **Charter Item 4:** Determine how the licensee is identifying, quantifying, trending, and venting the gas.

The team reviewed the licensee's methodology associated with the UT testing of ECCS piping to determine the amount of pipe voiding. The team observed the performance of procedure 1-SI-63-10.1-A, "ECCS Discharge Pipes Venting – Train A Inside Containment," and found the measurement of voids and the venting methodology to be acceptable. The methodology of determining gas volume by UT is an acceptable method as described in GL 2008-01. The team also reviewed Unit 1 and Unit 2 void trending data obtained since March 2016 for the ECCS. Accurate trending data prior to March 2016 was not available. NRC Integrated Inspection Report 05000390/2016002, 05000391/2016002 (ML16228A005) documents a non-cited violation associated with this issue.

Overall, the team determined that the licensee was appropriately identifying, quantifying, trending and venting gas from the ECCS.

.5 **Charter Item 5:** Evaluate the licensee's venting process activities to ensure that there is no adverse impact the plant operations. Review the configuration control and circumstances regarding the overpressure of the Unit 1 RHR train event that occurred on April 24, 2018.

The team reviewed the licensee's venting process activities and venting procedures. The team determined that the venting process would have no impact on plant operations. On April 24, 2018, Unit 1 Operations allowed ECCS venting to be performed at the same time the cold leg accumulator #3 was being filled. Operations did not recognize the conflict in performing these procedures at the same time as performing other operations of ECCS. The parallel performance resulted in pressurizing the standby RHR train and lifting of its relief valve. The regulatory significance of this event will be documented in the NRC quarterly integrated inspection report.

.6 **Charter Item 6:** Review licensee's compliance with the guidance and commitments in the licensee's responses to GL 2008-01. Compare operating experience involving gas voiding of emergency core cooling system discharge piping to actions implemented at Watts Bar. Determine if there are any generic issues related to the design and operation practices that resulted in the voiding of the ECCS discharge piping beyond those already described in GL 2008-01. Promptly communicate these issues to NRC regional management.

The team reviewed selected licensee commitments to GL 2008-01 to verify compliance with the GL. The team reviewed system isometric drawings as well as the GL 2008-01 walkdown reports for both units to verify vent locations were appropriate. The licensee's GL 2008-01 walkdowns utilized a Ziplevel™ to obtain horizontal ECCS piping slopes. The data recorded was the relative position on a horizontal pipe location referenced to a fixed location. This data was used to determine the high point on horizontal ECCS piping. During the special inspection, the licensee selected several RHR pipe locations for both units based on the walkdown report data to confirm the piping was full of water. The team reviewed the selected locations on the isometric drawings and based on the locations being full of water determined that the vent valves were appropriately positioned.

Although Unit 2 was not subject to GL 2008-01 since it was still in the construction phase, the inspectors verified that Unit 2 did comply with the requested actions in the GL and installed vents similar to Unit 1.

The team did not identify any operating experience involving ECCS voiding issues that was not already addressed by WBN's response to the GL. The operating experience associated with the calculation errors that resulted in non-conservative void acceptance criteria at WBN has been placed in the corrective action program for TVA's Sequoyah (CR 1392429) and Browns Ferry (CR 1392435) nuclear plants.

The team did not identify any generic issues related to design or operational practices that resulted in ECCS pipe voiding that was beyond what was covered in the GL. No generic issues were communicated to regional management.

.7 **Charter Item 7:** Review the licensee's calculations relating to ECCS void size. Review key assumptions and facts. Determine if the licensee's root cause analysis and corrective actions have addressed the extent of condition for gas accumulation of ECCS.

The licensee's root cause analysis was not completed in time for this inspection. At the close of the inspection, the licensee approved a root cause evaluation charter. The team reviewed the root cause charter and determined that it appropriately included items that needed to be addressed. The charter included: review of ECCS vent acceptance criteria shortfalls including the non-conservative calculation error, review of NRC GL 2008-01 implementation at WBN, review of ECCS venting methodology, and a review of the licensee's thoroughness in addressing plant issues. The charter also included reviewing the extent of condition to those systems addressed by GL 2008-01.

The inspectors reviewed the licensee's methodology in determining the system operability and operability limits for gas voids in ECCS piping to ensure there was reasonable assurance that the ECCS could perform their safety function if required. The calculations reviewed were associated with Unit 1 and Unit 2 RHR and SI systems.

The inspectors reviewed:

- System drawings and flow diagrams to ensure that the licensee properly established the boundary for the water hammer evaluation;
- Licensee calculations to ensure that the licensee's methodology for determining potential water hammer pressures/forces for various gas void sizes was sound and that inputs and assumptions were reasonable and reliable;
- Licensee calculations to ensure that pipe stresses were analyzed using the peak loads to evaluate the bounding void sizes on the piping system; and
- Design criteria documents to ensure that the calculated pipe and pipe support forces were within the licensee's operability limits.

In addition, the inspectors:

- Conducted interviews with licensee personnel and reviewed supporting documents to ensure that the licensee's engineering judgment used to screen out pipe supports with load increases of 10 percent or less from further evaluation based on operability allowable limits established in design criteria documents was reasonable;
- Conducted interviews with licensee personnel and reviewed the licensee's evaluation of valves that are required to operate (active) to ensure that they would remain functional after a system transient due to gas voiding; and
- Reviewed a valve vendor manual to ensure that the vendor recommendations and/or operational limits were not exceeded by the calculated pressure transients.

The inspectors concluded that there was reasonable assurance that the ECCS would have performed their design basis functions as long as any gas voiding was maintained within the operability limits established by the licensee.

.8 **Charter Item 8:** Assess licensee's actions to capture and evaluate the differences between Unit 1 and Unit 2 as they related to conclusions of the root cause evaluation.

The root cause evaluation was not completed in time for this inspection. At the close of the inspection, the licensee approved a root cause evaluation charter.

The team noted that the licensee was aware and had taken into account unit differences in their ECCS venting methodology that has been incorporated in unit-specific venting procedures. The team also verified that unit differences were addressed in the calculations associated with the interim acceptance criteria established.

.9 **Charter Item 9:** Assess the licensee's operability evaluation, including compensatory measures. Review actions against applicable procedures and 10 CFR 50.59 if applicable.

The team reviewed the licensee's prompt operability determination (CR 1407257) that provided interim limits for voiding of both units' ECCS. The limits established are listed under Charter Item 2. The team reviewed the calculations associated with these limits and determined that there was reasonable assurance for operability. Additional details associated with the inspectors' review of these calculations is documented under Charter Item 7. The team reviewed trend data and determined that the frequency for UT and venting of the ECCS systems was conservative. Initially, UT and venting was completed each shift. The licensee appropriately changed the frequency based on trend data.

.10 **Charter Item 10:** Collect data necessary to support a risk analysis. Specifically, obtain information associated with the degree to which the SI and RHR systems were affected, extent of damage from water hammer, and the ability to recover from damage.

The team determined, based on review of the operability acceptance criteria calculations for RHR and SI voiding, that the NRC had reasonable assurance that the systems remained operable but non-conforming, and that no damage would be expected. The team reviewed historical voiding data documented since March 2016 for both units' ECCS systems to verify the voiding measured was bounded by the interim acceptance criteria.

INSPECTION RESULTS

Licensee-Identified Non-Cited Violation	IP 93812 Special Inspection
This violation of very low safety significance (Green) was identified by the licensee and has been entered into the licensee's corrective action program and is being treated as a Non-Cited Violation, consistent with Section 2.3.2 of the Enforcement Policy.	

Violation: Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 (10 CFR 50), Appendix B, Criterion III, "Design Control," requires the licensee to effectively implement design control measures for piping analysis calculations* associated with the Unit 1 and Unit 2 emergency core cooling systems (ECCS).

Contrary to the above, since initial operation of Unit 1 in 1996 and Unit 2 in 2016, Tennessee Valley Authority failed to ensure the proper hydraulic time history was utilized in TVA's "TPIPE" special purpose computer program used to determine static and dynamic linear elastic analyses for the ECCS including the effects of pipe voiding. This resulted in non-conservative voiding design acceptance criteria for the RHR and SI systems of both units. This performance deficiency was more than minor because it was associated with the Design Control attribute of the Mitigating Systems Cornerstone and affected the cornerstone objective of ensuring the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the failure to utilize proper hydraulic time history in the licensee's "TPIPE" computer model resulted in developing non-conservative voiding acceptance criteria that was used during operation that could challenge ECCS functionality. The finding was determined to be of very low safety significance since additional analysis determined with reasonable assurance that the systems remained operable but non-conforming and would have performed their safety function.

Significance/Severity Level: Green. Using Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power," dated June 19, 2012, the inspectors determined that this finding was of very low safety significance (Green) because the finding affected the design or qualification of mitigating systems; however, the mitigating systems maintained their operability.

Corrective Action Reference: CR 1407257

* "TPIPE" Piping analysis calculations impacted

Unit 1		
Analysis Number	Description	Current Revision
N36303A	SI pumps to shield building penetrations	19
N37401A	RHR pumps to shield building penetrations	35
060002000901	SI/RHR piping accumulators 1 and 4 to cold legs	31
060002000902	SI/RHR piping accumulators 2 and 3 to RCS cold legs	29
060002000903	SI piping cold leg injection piping	17

060002000904	SI piping SI pumps to RCS loop	16
Unit 2		
N36304A	SI pumps to penetrations	14
N37404A	RHR pumps to penetrations	7
060002500901	SI/RHR piping accumulators to cold legs	9
060002500902	SI/RHR piping penetration to loop 2 and 3 cold legs and accumulators	14
060002500903	RHR piping penetration to inline anchors	1
N36301R	SI piping between two in line anchors	0

EXIT MEETINGS AND DEBRIEFS

The inspectors confirmed that proprietary information was controlled to protect from public disclosure.

On May 14, 2018, the team presented the special inspection results to Mr. P. Simmons, Site Vice President, and other members of the licensee's staff.

DOCUMENTS REVIEWED

Corrective Action Documents Written as a Result of the Inspection
CR 02192942, Pre-Fire Plan Enhancements
CR 1411405; Evaluate Westinghouse Recommendation of ECCS Venting
CR 1411408; Door/Hatch Configuration Control During Containment Entry

Procedures
NPG Standard Department Procedure NEDP-28 Emergency Core Cooling System Gas Management Guidance. Revision 0
N-UT-11, Ultrasonic Examination for Detecting and Measuring Fluid Levels in Austenitic and Ferritic Systems, Revision 7

Drawings
Unit 1, 1-47W810-1, Flow Diagram Residual Heat Removal System, Revision 20
Unit 2, 2-47W810-1, Flow Diagram Residual Heat Removal System, Revision 26
Unit 1, 1-47W811-1, Flow Diagram Safety Injection System, Revision 64
Unit 2, 2-47W811-1, Flow Diagram Safety Injection System, Revision 54
Unit 1, H-435-007-026, Design Change Authorization (DCA) 39382-12, Prob. N3-63-R45R, Anal. Isometric for SIS Vent (1-VTV-63-654) Revision 1
Unit 1, 47W435-219, Problem 0600200-09-03 PENET X-33, Isometric-Static, Thermal & Dynamic Analysis of SIS System, 4" & 2" Cold Leg Injection from PEN X-33 to Break PTANC on 09-01 & 09-04, Revision 4
Unit 1, 1-47W435-260B, Problem 0600200-09-01, Analysis Isometric of SIS Piping, Revision 2
Unit 1, 1-47W435-280, Problem 0600200-09-04, Analysis Isometric of SIS Piping, Revision 2
Unit 1, 1-47W435-283, Problem 0600200-09-07, Analysis Isometric of SIS Piping, Revision 2
Unit 1, 1-47W435-284, Problem 0600200-09-09, Analysis Isometric of SIS Piping, Revision 2
Unit 1, 1-47W435-284A, Problem 200-09-09, Analysis Isometric of SIS Piping, Revision 0
Unit 1, 47W435-223, Prob. 0600200-09-10, 6" x 2" Safety Inj from Hot Leg #2 to 09-09 Bk Pt, Revision 5
Unit 1, 1-47W435-220A, Problem 0600200-09-02, Analysis Isometric of SIS Piping, Revision 0
Unit 1, H-435-008-008, DCA 39382-13, Prob. N3-63-R45R, Anal. Isometric for SIS Vent (1-VTV-63-660) Revision 1
Unit 1, H-435-009-017, DCA 39382-16, Prob. N3-63-R45R, Anal. Isometric for SIS Vent (1-VTV-63-659) Revision 1
Unit 1, H-435-007-027, DCA 39382-14, Prob. N3-63-R45R, Anal. Isometric for SIS Vent (1-VTV-63-661) Revision 1
Unit 2, 2-47W435-267, Prob. 0600250-09-02 063 Safety Inj From SCV PEN X-20B to Loops 2& 3 Cold Legs and 2 & 3 Cold Leg Accumulators, Revision 3
115E005, Motor Op Gate Valve 08000GM84FEB01B 8-300 ASME CL.1 GPO Assy, Revision 0

Calculations
CEB850223958, Calculation Of Pipe Support No. 2-63-064, Revision 3

Design Criteria Documents
WB-DC-20-33, Piping And Pipe Support Operability Criteria, Revision 2

Engineering Work Requests
EWR18CIV074252, Civil Evaluation For PDO 1407257, 04/30/2018
EWR18MEC074254, IDO Support For U2 RHR Gas Voids, 04/23/2018
EWR18CIV074251, Civil Evaluation For PDO, 04/23/2018

EWR18CIV074250, Civil Evaluation For PDO 1407257, 04/28/2018
EWR18MEC074258, IDO Support for U1 RHR Gas Voids, on CR 1407257
EWR18CIV074253, Civil Evaluation for PDO 1407257
EWR18MEC063262, Support for U1 SI Gas Voids, dated May 11, 2018
EWR18CIV063264, Civil Evaluation for PDO 1407257 for U1 Safety Injection; dated May 11, 2018

Vendor Manual
WBN-VTD-W120-2958, Westinghouse Motor Operated Gate Valves, Manually Operated Gate Valves, Swing Check Valves, Revision 13

Miscellaneous Documents
NRC Letter, August 23, 2011, Watts Bar Nuclear Plant, UNIT 2 – Closeout of Generic Letter "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment spray Systems" (TAC NO. MD6717), ML112232205
NRC Letter, June 3, 2011, Watts Bar Nuclear Plant, UNIT 1 – Closeout of Generic Letter "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment spray Systems" (TAC NO. MD7895), ML 111520233
March 11, 2011, Watts Bar Nuclear Plant (WBN) Unit 2 –Response after Completion of the Engineering for the, RHR, AND CSS SYSTEMS in UNIT 2 to NRC Generic Letter (GL) "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment spray Systems"
October 11, 2008, Browns Ferry Nuclear Plant (BFN) Units 1, 2 AND 3, Sequoyah Nuclear Plant (SQN) Units 1 AND 2, AND Watts Bar Nuclear Plant (WBN) Unit 1 – 9 Month Response to NRC Generic Letter (GL) 2008-01: "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment spray Systems", dated January 11, 2008
WBN-ENG-F-10-006, Self-Assessment: Readiness for NRC inspection of WBN response to Generic Letter (GL) 2008-01, August 2010
April 30, 2018, Westinghouse letter: Watts Bar Nuclear Plant Units 1 & 2 Gas Voids Operating Experience Summary Information
April 20, 2018 Westinghouse letter (Proprietary) Ref: WAT-D-12424: TENNESSEE VALLEY AUTHORITY WATTS BAR NUCLEAR PLANT UNITS 1 & 2 Gas Intrusion Assessment on the ECCS Pump Discharge Side Piping
MEMORANDUM TO: Thomas Morrissey, Senior Resident Inspector, FROM: Catherine Haney, Regional Administrator SUBJECT: Special Inspection Charter to Evaluate the Watts Bar Units 1 AND 2 Emergency Core Cooling System (ECCS) Void Issues
NRC Inspection Report, Watts Bar Nuclear Plant Unit 2 Construction-NRC Integrated Inspection Report 05000391/2013605, Section OA.1.25, ML13220A640
Report of Calibration, Asset ID E53749, Ultrasonic Flaw Detector, dated 2/13/18
NRC Integrated Inspection Report 05000390/2011005, ML120310076
Certificate of Method Qualification Tennessee Valley Authority dated 3/17/17
Visual Acuity Examination Record for NDE Personnel, EIN 1C2IUW35L, dated 3/15/18
Digital Ultrasonic Calibration Data Sheet, Report Number:BOP-5098, dated 4/23/18
Log Entries Report, Unit 1, for 4/19/18, 4/20/18, and 4/21/18
Log Entries Report, Unit 2, for 4/18/18, 4/21/18, and 4/22/18
Standing Order 18-10; ODMI for ECCS Venting, May 4, 2018
Work Order 119549615; ECCS Ultrasonic Water Level Measurements
WAT-D-12429, Transmittal Of RHR System Discharge Side Non-Condensable Gas Water Hammer Evaluation, 04/27/2018

WAT-D-12424, Gas Intrusion Assessment on the ECCS Pump Discharge piping, April 20, 2018
Pipe Support Load Capacity Data Sheet Manual, Revision 0
Component Evaluation For Gas Void Transport, Revision 1

Corrective Action Documents
CR 1408251; WBN-1-VTV-063-0101-A, Cold Leg 1 RHR Inj Line Vent; April 24, 2018
CR 1408589; WBN-1-063-0010-A Safety Injection Pump 1A-A; April 24, 2018
CR 1408923; WO Acceptance Criteria Incorrectly Calculated, April 25, 2018
CR 1408948; This CR is to Document NRC Resident Question Regarding ECCS Operability for Condition in CR 1408573; April 25, 2018
CR 1409089; Completed Urgent Change to 2-SI-63-10.1-A, April 26, 2018
CR 1411256; WBN-1-FCV-063-0111, Cold Leg 2 and 3 RHR Check Valve Leak Test Isolation
CR 1411262; WBN-1-FCV-063-0112, Cold Leg 1 and 4 RHR Check Valve Leak Test Isolation
Prompt Determination of Operability Documentation for CR 1135820, March 18, 2016
Prompt Determination of Operability Documentation for CR 1407257, Revision 1 through 6
CR 1378163, Snubber Support Design Legacy Issue, 01/17/2018

ATTACHMENT 1
TIMELINE OF EVENTS

Date	Time	Documentation	Description
2003			Unit 1: Twelve ECCS piping vents were installed
June 3, 2011		NRC Correspondence ML112232205	NRC Letter issued for close out of Generic Letter 2008-01 for Unit 1
August 23, 2011		NRC Correspondence ML111520233	NRC Letter issued for close out of GL 2008-01 for Unit 2 containing 7 commitments
November 7, 2011		EWR MDQ0016320110182	Gas void Acceptance Criteria (AC) set at: RHR 22 ft^3; SI 16 ft^3; performed as a result of CRs 950029, 962314, and 80602.
January 31, 2012		NRC Integrated Inspection Report 05000390/2011005 ML120310076	NRC closeout of Unit 1 Instruction (TI) 2515/177, "Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems (GL 2008-01)", and Violation 2011005-04 for failure to quantify accumulated gas in ECCS
February 12, 2016		CR 1136791	Unit 1 Cold Leg accumulators 2,3,4 are losing 36 gallons per day. This is significant since a source of gas voids is leakage through accumulator isolation valves into the ECCS systems
February 24, 2016		1-SI-63-10.1-A	Started taking Ultrasonic data for ECCS gas void measurement on Unit 1
March 18, 2016		PDO 1134820	Unit 1 ECCS gas void AC: RHR 40 ft^3 SI 40 ft^3; Reference Letter LTR-LIS-08-627
March 31, 2016		2-SI-63-10.1-A	Started taking Ultrasonic data for void measurement on Unit 2
April 1, 2016		PDO 1156054	Unit 2 ECCS void AC: RHR 40 ft^3 SI 40 ft^3 Reference Letter LTR-LIS-08-627
May 10, 2016		LER 390/2016-003-00	Technical Specification Surveillance Requirement Not Met During Emergency Core Cooling System Venting
June 5, 2016		CR 1178400	Unit 2 Safety Injection (SI) during reactor trip due to failure of the linkage in the linear variable differential transmitter in the Electro-Hydraulic Control System. This event and its effect on the plant was used as part of the operability determination on April 19, 2018 for CR 1407257.
August 12, 2016		NRC Integrated Inspection Report 05000390/2016002, 05000391/2016002 ML16228A005	Green NCV 2016002-10; Failure to Maintain an Adequate Surveillance Procedure for Emergency Core Cooling System Venting.
August 2, 2017		Design Change Notice (DCN) 66453	Unit 1, Vendor supplied detailed analysis for loads in ECCS. Design criteria for RHR was 40.0 ft^3 and for SI 27.6 ft^3; Reference Calculation MDQ001106320110182

ATTACHMENT 1
TIMELINE OF EVENTS

April 28, 2017		Plant Process Computer data	Accumulator #3 leakage after outage repairs is minimal
June, 2017		Plant Process Computer data	Accumulator #3 leakage starts increasing to about 20 gallons per day
October 3, 2017			Check Valve 63-555, Accumulator #3 valve found to be leaking into ECCS, scoped into next outage
2018			
February 8		CR 1127959	An error was discovered during reviews for a DCN to the AFW system on Unit 2. Specifically, it was planned to replace both motor driven AFW pump discharge pressure control valves with cavitating flow venturis to provide more reliable pressure control. The DCN required a review of the design bases piping stress analyses for the purposes of assessing the impact of this change. During these reviews, a CR was written to capture errors discovered in the way the analyses were used by the vendor during the original development of the Watts Bar design bases. An extent of condition (EOC) action was created in order to evaluate if the errors also resulted in a challenge to the maximum allowable pipe stresses in other systems across both units.
April 19	1000		As part of the EOC evaluation from the 2016 AFW issue, a request made to Fauske Associates, Inc (FAI) to provide an assessment by the end of the day of what the acceptable void sizes could be for both units at WBN, to support an Immediate Determination of Operability (IDO).
April 19	1822		Draft assessment is provided by FAI that concluded the following based on comparisons between Watts Bar plant specific parameters and a Westinghouse 4-loop PWR: • RHR system for each unit can tolerate up to 1.3 ft^3 of total non-condensable gas. Any void size larger than 1.3 ft^3 may potentially cause a relief valve lift. • SI system for each unit can tolerate up to 5 ft^3 of total non-condensable gas. Five cubic feet is the maximum void size that is allowed to be injected into the primary system for Westinghouse plants. • It is not expected to have a catastrophic failure of the RHR or SI piping due to the hydrodynamic loads generated for the circumstance listed above. This is based on the experience with the operating fleet and the analysis performed for the sample Westinghouse 4-loop plant. It was noted that the conclusions above were to be considered as professional opinion based on experience to support a short term decision. However, it was

			recommended that Watts Bar should establish their discharge side non-condensable gas acceptance criteria based on engineering analysis, which should be acceptable to US NRC rules and regulations.
April 19	1944	CR 1407257	A condition report was generated that identified the current acceptance criteria for gas accumulation in the WBN Unit 1 and Unit 2 SI system and RHR system discharge piping may have been non-conservative. A sensitivity run of the piping analyses was performed by Engineering, and for the worst case piping analysis, the loads provided by the vendor would have to be reduced by up to 65% in order for the piping and supports to pass the operability allowable limits. The IDO concluded the ECCS for both units were operable based in part on the draft assessment from FAI.
April 19	2216	Operating Logs	Unit 2 entered TS 3.0.3 due to low head RHR voiding measured at 1.302, exceeding the acceptance criteria of 1.300
April 20	0018	Operating Logs	Unit 2 retracted LCO 3.0.3 based on Engineering Work Request (EWR) 18MEC063243 provided by Engineering.
April 20	0055	EN 53349	On April 19 at 1944, WBN determined that a preliminary analysis shows current acceptance criteria for gas accumulation in the WBN Unit 1 and Unit 2 SI and RHR discharge piping may be non-conservative. The surveillances that check void values and allow venting of the systems are to be performed utilizing conservative criteria at more frequent intervals to ensure gas void volumes remain under acceptable limits. Additional analysis is being performed to determine final actions
April 20	1513	WAT-D-12424	Westinghouse submitted the formal Gas Intrusion Assessment on the ECCS Pump Discharge Side Piping. The three draft conclusions remained the same but an additional conclusion was added that these limits will still be applicable under increased pressures in RHR (greater than the hydrostatic pressure from Refueling Water Storage Tank).
April 21	0105	Operating Logs PDO Rev 0	The PDO was issued by Engineering that determined the Unit 1 and Unit 2 ECCS were operable but non-conforming. Compensatory measures were made to increase the frequency of the ECCS void surveillance as necessary.
April 21	2152	Operating Logs CR 1407731	Unit 1 entered Technical Specification (TS) Limiting Condition for Operation (LCO) 3.0.3 due to void size of 5.632 ft^3 in the low pressure portion of ECCS (RHR) on piping common to both trains of ECCS exceeding the allowable void size of 1.302 ft^3.
April 21	2222	Operating Logs	Unit 1 exited LCO 3.0.3 after venting to an acceptable void volume of the affected piping.

ATTACHMENT 1
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April 22	0222	Operating Logs	Unit 2 entered TS 3.0.3 due to void size of 1.367 ft^3 in the low pressure portion of ECCS (RHR) on piping common to both trains of ECCS exceeding the allowable void size of 1.302 ft^3.
April 22	0234	EN 53355	On April 21 at 2152, WBN Unit 1 entered TS LCO 3.0.3 due to both trains of the RHR becoming inoperable. During surveillance testing, the gas void values on ECCS piping common to both trains did not meet acceptance criteria. This caused both RHR trains to become inoperable. Operations subsequently vented the RHR to meet the acceptance criteria and exited TS LCO 3.0.3 at 2222 EDT. More frequent surveillances will be conducted to monitor gas void volumes while additional analysis is being performed to determine corrective actions.
April 22	0428	EN 53356	On April 22 at 0222, WBN Unit 2 entered TS LCO 3.0.3 due to both trains of the RHR becoming inoperable. During surveillance testing, the gas void values on ECCS piping common to both trains did not meet acceptance criteria. This caused both RHR trains to become inoperable. Operations subsequently vented the RHR to meet the acceptance criteria and exited TS LCO 3.0.3 at 0227 EDT. More frequent surveillances will be conducted to monitor gas void volumes while additional analysis is being performed to determine corrective actions
April 24		PDO Rev 1 CR 1407257	Revision 1 to the PDO was issued containing a recommended change to the frequency of the SI performances for both Unit 1 and Unit 2, to once per 12 hour shift as driven by CR 1407801 and as a result of unexpected TS 3.0.3 entry on April 4, 2018, when following the guidance provided in Revision 0 of this PDO.
April 25		Procedure 1-SI-63-10.1-A; Urgent Change #1	Change venting process to static and dynamic venting for Unit 1 in 1-SI-63-10.1-A ECCS Discharge Pipes Venting – Train A Inside Containment
April 25	1538	Chemistry data sheet	Chemistry sampling determines void does not contain Hydrogen which is an indication that RCS fluid is not back-leaking into ECCS systems as a source of the voids.
April 26	0849	Chemistry data sheet	Chemistry sampling results confirm ECCS gas voids do not contain Hydrogen
April 27	1113	Chemistry data sheet	Chemistry sampling results confirm ECCS gas voids do not contain Hydrogen
April 27			Pressurized the Unit 1 Cold Leg accumulator with Nitrogen (N2), no significant void growth observed.
April 27		PDO Rev 2 CR 1407257	This revision changed the acceptance criteria for U2 RHR gas void acceptance criteria to 4 ft^3
April 28		EWR 18MEC0635256,	Changed Unit 2 venting to once per day
April 28			Pressurized Unit 1 Cold Leg accumulator with N2, no significant void growth

ATTACHMENT 1
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April 30	1900	PDO Rev 3 CR 1407257	This revision changed the Unit 1 RHR gas void acceptance criteria to 3.5 ft^3 and clarified that the Unit 2 limit of 4.0 ft^3 was an alert criteria limit only.
May 1	1030	EWR 18MEC063256	Changed Unit 2 RHR venting frequency to 1 time every two days.
May 3	1700	PDO Rev 4	This revision clarified that the Unit 1 RHR void volume criteria of 3.5 ft^3 was an alert level only. Also changed Unit 1 venting frequency to once a day
May 4		EWR 18MEC0635256, rev 1	Unit 2 changed venting frequency to once every three days as allowed by the EWR.
May 4	1455	EN 53356	This event was retracted. The initial report was based on a conservative acceptance criteria for gas accumulation adopted on April 19, 2018, when it was determined that the previously used acceptance criteria for gas accumulation in the ECCS was non-conservative. Additional analysis has subsequently been performed and determined that a higher gas accumulation acceptance criteria does not challenge operability. With a void of less than the acceptance criteria, in the event of ECCS actuation, the system piping support loads will remain within structural limits and the piping system will remain operable. Therefore, both trains of Unit 2 RHR were operable and the previously reported 10 CFR 50.72(b)(3)(v)(B) event is being retracted.
May 7	1600	EWR 18MEC0635256	Unit 1: Changed to daily monitoring of voids with a venting frequency change to vent once every 2 days
May 7		CR 1407257	Root Cause Charter Issued
May 9		PDO Rev 5	This revision changed the gas void volume criteria for Unit 2 SI to 1 ft^3 for an alert limit and 27.5 ft^3 as the operability limit
May 9	1310	EN 53355	This event was retracted. The initial report was based on a conservative acceptance criteria for gas accumulation adopted on April 19, 2018, when it was determined that the previously used acceptance criteria for gas accumulation in the ECCS was non-conservative. Additional analysis has subsequently been performed and determined that a higher gas accumulation acceptance criteria does not challenge operability. With a void of less than the acceptance criteria, in the event of ECCS actuation, the system piping support loads will remain within structural limits and the piping system will remain operable. Therefore, both trains of Unit 1 RHR were operable and the previously reported 10 CFR 50.72(b)(3)(v)(B) event is being retracted.
May 10		EWR 18MEC063268	Recommended weekly venting on unit 2 ECCS based on the trend results of 2-SI-63.10.1-

May 11		PDO Rev 6	This revision changed the gas void volume criteria for Unit 1 SI to 2.5 ft^3 for an alert limit and 16.6 ft^3 as the operability limit alert limit and 16.6 ft^3 as the operability limit

ATTACHMENT 2
Charter

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
245 PEACHTREE CENTER AVENUE NE, SUITE
1200 ATLANTA, GEORGIA 30303-1257

April 26, 2018

MEMORANDUM TO: Thomas Morrissey
Senior Resident Inspector
Division of Reactor Projects

FROM: Catherine Haney ***/RA Laura A. Dudes Acting for/***
Regional Administrator

SUBJECT: SPECIAL INSPECTION CHARTER TO EVALUATE THE WATTS BAR UNITS 1 AND 2 EMERGENCY CORE COOLING SYSTEM (ECCS) VOID ISSUES

You have been selected to lead a Special Inspection to assess the circumstances surrounding ECCS void issues which resulted in both residual heat removal (RHR) trains being inoperable for Unit 1 on April 21, and Unit 2 on April 22, 2018. Your onsite inspection should begin on April 30, 2018. John Jandovitz will be assisting you in this inspection.

A. Basis

On April 19, 2018, the Watts Bar Nuclear Plant (WBN) Operations Superintendent called the WBN NRC resident inspector to report that WBN was notified by their contractor of errors in calculations relating to the acceptable ECCS void size. The calculations were being reviewed as part of an extent of condition for an auxiliary feedwater stress analysis. The initial acceptance criteria was based on an acceptable delay, due to voiding, in injecting water into the reactor coolant system (RCS). The new void volumes are based on stresses from a water hammer event when ECCS is initiated with voids present. This new criteria is significantly lower than the previous acceptance criteria. Specifically, the RHR void limit was reduced from 40 ft^3 to 1.3 ft^3 and the safety injection (SI) void limit was reduced from 27.6 ft^3 to 5 ft^3. These reduced values were provided to WBN by Westinghouse on April 19, 2018, and were based on their experience with similar plants and were not specific to either unit at WBN.

An immediate determination of operability was completed on April 20, 2018, and determined that the affected ECCS systems on Units 1 and 2 were operable but degraded with interim compensatory measures established. The interim compensatory measures included increased frequency of void measurement and increased venting of ECCS from monthly to daily.

On April 21, 2018, WBN contacted the resident inspector to inform him that, for the most recent void determination on Unit 1, the accumulated gas in RHR was found to be greater

than the 1.3 ft^3 limit (approximately 5 ft^3). Unit 1 then entered Technical Specifications (TS) Limiting Condition for Operation (LCO) 3.0.3 and exited once RHR was vented.

On April 22, 2018, WBN contacted the resident inspector to inform him that, for the most recent void determination on Unit 2, the accumulated gas in RHR was found to be greater than the 1.3 ft^3 limit (approximately 1.367 ft^3). Unit 2 then entered TS LCO 3.0.3 and exited once RHR was vented.

In accordance with Management Directive (MD) 8.3, "NRC Incident Investigation Program," deterministic and conditional risk criteria were used to evaluate the level of NRC response for this operational event. Through review of the MD 8.3 deterministic criteria, the staff concluded that this event involved technically complex void issues in the ECCS systems with both RHR trains inoperable for both units. The conditional core damage probability (CCDP) for this event was in the overlap region between a Special Inspection and No Additional Inspection. Region II determined that the appropriate level of NRC response is a Special Inspection.

This Special Inspection is chartered to identify the circumstances surrounding ECCS void issues and assess the adequacy of the licensee's actions to address the causes of these issues.

B. Scope

The inspection is expected to perform data gathering and fact-finding in order to address the following:

1. Develop a complete sequence of events related to the discovery that the acceptance criteria for gas accumulation in the WBN Unit 1 and Unit 2 SI system and RHR system discharge piping may be non-conservative, which resulted in both Units' RHR system being inoperable as well as follow-up actions taken by the licensee.

2. Determine if the licensee's acceptance criteria for surveillance requirements to minimize voids in the ECCS are consistent with the plant licensing basis and as-built design.

3. Review drawings, walkdown portions of the RHR and SI systems, and determine if the vent locations enable system venting to meet void size acceptance criteria.

4. Review licensee procedures and processes for identifying, quantifying, trending, and venting the gas.

5. Evaluate the licensee's venting process activities to ensure that there is no adverse impact to plant operations. Review the configuration control and circumstances surrounding the Unit 1 RHR over-pressurization event that occurred on April 24, 2018.

6. Review the licensee's adherence to commitments and guidance associated with Generic Letter (GL) 2008-01. Compare operating experience involving gas voiding of ECCS discharge piping to actions implemented at WBN. Determine if there are any generic issues related to the design and operation practices that resulted in the voiding of the ECCS discharge piping beyond those already described in GL 2008-01. Promptly communicate these issues to NRC regional management.

7. Review the licensee's calculations relating to ECCS void size. Review key assumptions and facts. Determine if the licensee's root cause analysis and corrective actions have addressed the extent of condition for gas accumulation in ECCS systems.

8. Assess licensee's actions to capture and evaluate the differences between Unit 1 and Unit 2 as they relate to conclusions of the root cause evaluation.

9. Assess the licensee's operability evaluation, including compensatory measures. Review actions against applicable procedures and 10 CFR 50.59, if applicable.

10. Collect data necessary to support a risk analysis. Specifically obtain information associated with the degree to which the SI and RHR systems were affected, extent of damage from a potential water hammer, and the ability to recover from damage.

C. Guidance

Inspection Procedure (IP) 93812, "Special Inspection," provides additional guidance to be used during the conduct of the Special Inspection. Your duties will be as described in IP 93812. The inspection should emphasize fact-finding in its review of the circumstances surrounding the event. Safety or security concerns identified that are not directly related to the event should be reported to the Region II office for appropriate action.

You will report to the site, conduct an entrance, and begin inspection no later than April 30, 2018. A daily status briefing of Region II management will be provided beginning the first day onsite at approximately 3:00 p.m., Eastern Daylight Time (EDT).

In accordance with IP 93812, you should promptly recommend a change in inspection scope or escalation if information indicates that the assumptions utilized in the MD 8.3 risk analysis were not accurate. A report documenting the results of the inspection should be issued within 45 days of the completion of the inspection. The report should address all applicable areas specified in Section 3.02 of Inspection Procedure 93812. At the completion of the inspection, you should provide recommendations for improving the reactor oversight process baseline inspection procedures and the Special Inspection process based on any lessons learned.

This charter may be modified should you develop significant new information that warrants review. Should you have any questions concerning this charter, contact Anthony Masters at 404-997-4465.

Docket Nos.: 50-390, 50-391

License No.: NPF-90, 96

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