UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
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ATLANTA, GEORGIA 30303-8931

May 31, 2006

Southern Nuclear Operating Company, Inc.
ATTN: Mr. D. E. Grissette, Jr.
Vice President-Vogtle Project
P. O. Box 1295
Birmingham, AL 35201-1295

SUBJECT: VOGTLE ELECTRIC GENERATING STATION UNIT 2 - NRC SPECIAL INSPECTION REPORT 05000425/2006010

Dear Mr. Grissette:

On March 29, 2006, the U. S. Nuclear Regulatory Commission (NRC) completed a special inspection at your Vogtle Electric Generating Station, Unit 2. Based on the criteria specified in Management Directive 8.3, "NRC Incident Investigation Procedures," a special inspection was initiated in accordance with NRC Inspection Procedure 93812, "Special Inspection." This inspection was chartered to inspect and assess the circumstances associated with the repetitive weld failure on a Unit 2 residual heat removal (RHR) system isolation valve bypass line.

The enclosed inspection report documents the inspection results, which were discussed at the exit meeting on March 29, 2006, with Mr. Tom Tynan and other members of your staff. The determination that the inspection would be conducted was made by the NRC and the inspection was started on March 24, 2006.

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, observed activities, and interviewed personnel.

Based on the results of this inspection, no findings of significance were identified.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of the

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Sincerely,

//RA//

Charles A. Casto, Director
Division of Reactor Projects

Docket No.: 50-425
License No.: NPF-81

Enclosure: Inspection Report 05000425/2005010
w/Attachments: 1. Supplemental Information
2. Vogtle Special Inspection Charter
3. Event Time Line

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Report to D. E. Grissette from Charles A. Casto dated May 25, 2006.

SUBJECT: VOGTLE ELECTRIC GENERATING STATION UNIT 2 - NRC SPECIAL INSPECTION REPORT 05000425/2006010

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Sincerely,

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U. S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket No:	50-425
License No:	NPF-81
Report No:	05000425/2006010
Licensee:	Southern Nuclear Operating Company, Inc.
Facility:	Vogtle Electric Generating Station, Unit 2
Location:	7821 River Road Waynesboro, GA 30830
Dates:	March 24 - 29, 2006
Inspectors:	G. McCoy, Senior Resident Inspector (Lead Inspector) S. Vias, Senior Reactor Inspector C. Peabody, Reactor Inspector
Approved by:	Charles A. Casto, Director Division of Reactor Projects

Enclosure

SUMMARY OF FINDINGS

IR 05000425/2006-010; 3/24-29/2005; Vogtle Electric Generating Station Unit 2; Special Inspection.

The inspection was conducted by a senior resident inspector, a senior reactor inspector and a reactor inspector using inspection procedure 93812 for a repetitive weld failure on the Unit 2 residual heat removal (RHR) system isolation valve bypass line. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 3, dated July 2000.

A. NRC-Identified and Self-Revealing Findings

No findings of significance were identified.

B. Licensee Identified Violations

None.

REPORT DETAILS

Event Description

On December 8, 2005 Vogtle Unit 2 received an alarm on radiation monitor 2RE2562A, containment atmosphere air particulate monitor. No increase was noted in noble gasses, and no change was seen in containment sump levels, although a small increase was observed in containment moisture and pressure. Reactor coolant leak rate measurements indicated that total reactor coolant system leakage had increased. Crews entered containment for walkdown inspections and reported no leakage outside the bioshield or in the pressurizer enclosure. Based on the indication that the leak was inside the bioshield, licensee management decided to shutdown the unit. A subsequent robotic inspection inside the bioshield found water running down the bioshield wall but it was unable to identify the location of the source. After the unit was shut down, personnel inside containment reported that the leakage was from the Reactor Coolant System (RCS) loop side of the ¾ inch bypass line around valve 2HV8701B, the residual heat removal (RHR) train A loop suction isolation valve. The weld was ground out, replaced, and the unit was returned to full power operation on December 18, 2005.

On February 1, 2006 at 0007, Unit 2 reduced power to 30% to repair a turbine electro-hydraulic control system leak at the main turbine front standard. At 1912, the control room operators received indication of an increase in radioactivity in the Unit 2 containment atmosphere on radiation monitor 2RE2562A. The repairs on the main turbine front standard were completed and the plant was returned to full power at 0300 on February 3, 2006. During this period, the operators could not obtain an accurate leak rate because of frequent addition of water to the RCS to dilute the boron concentration and raise reactor power. No adverse trends were noted in pressurizer or Volume Control Tank level. At 0235 on February 3, a robotic camera observed leakage inside the bioshield wall in the vicinity of RCS loop 1. The unit was shutdown to allow further investigation of the leakage. Operators found RCS pressure boundary leakage at two welded connections on the bypass line around 2HV8701B. One leak was on a socket weld between the ¾ inch bypass piping and the 12 inch RHR piping on the RHR side of 2HV8701B. The other leak was a butt weld on an elbow on the leg of the bypass line which was not isolable from RCS pressure. In order to repair the leaks, the bypass line was removed and replaced. Once the line was replaced, the unit was restarted and returned to full power operation on February 14, 2006.

On March 20, 2006, control room operators received indication of an increase in radioactivity in the Unit 2 containment atmosphere on 2RE2562A. An inspection team was sent inside containment and leakage was identified inside the bioshield in the area of RCS loop 1 using the robotic camera. The unit was shutdown and subsequent investigation found RCS pressure boundary leakage at a welded connection on the ¾ inch bypass line around 2HV8701B. This was the same weld which was replaced during the December failure. The bypass line around 2HV8701B was removed and plugs were welded into the empty sockets. The plant was restarted and returned to full power operation on April 3, 2006.

Special Inspection Team Charter

Based on the criteria specified in Management Directive 8.3, “NRC Incident Investigation Procedures,” a Special Inspection was initiated in accordance with NRC 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 an integrated sequence of events of each of the three weld failure events. (Section 4OA3.1)

(2) Review for extent of condition on the Unit 1 RHR suction bypass lines and sample for other similar piping configurations in both units. (Section 4OA3.3)

(3) Review the licensee's completed root cause analysis for the earlier weld failure events for sufficiency of scope, depth of analysis, and identification of causal factors. For the current weld failure event, review of the root cause analysis for sufficiency of scope. (Section 4OA3.2)

(4) Review the RHR piping for indications of potential overstress. (Section 4OA3.4)

(5) Evaluate pertinent industry operating experience and potential precursors to the event, including the effectiveness of any action taken in response to the operating experience. (Section 4OA3.5)

(6) Collect data necessary to support completion of the significance determination process. (Section 4OA3.1)

(7) Review the licensee's repair and corrective actions for this latest event. (Section 4OA3.6)

4. OTHER ACTIVITIES

4OA3 <u>Event Followup</u>

1. <u>Chronology of Events (Objectives 1 and 6)</u>

a. <u>Inspection Scope</u>

The inspectors reviewed available plant event data, control room logs, computer data, and interviewed operations personnel to develop a time line for the event. The inspectors were briefed by licensee management and interviewed key event investigation team members as to their findings and conclusions concerning the event. Information was also collected and provided to the Senior Reactor Analysts in order to support an evaluation of the risk associated with this event. The specific documents reviewed are listed in Attachment 1.

b. <u>Observations</u>

At the time of this inspection, there was no single timeline that included all the pertinent aspects of this event. However, the information available from the licensee was adequate and appropriate in scope and depth to develop the timeline which is included as Attachment 3 to this report.

2. Assessment of the Root Cause Analyses (Objective 3)

a. Inspection Scope

The inspectors reviewed the condition reports, operability evaluations and root cause evaluations performed by the licensee in order to investigate the causes for the repetitive RCS pressure boundary leaks on the bypass line for RHR loop suction valve 2HV8701B.

b. Findings

December 2005 Forced Outage

A leak occurred on December 9, 2005, in an ASME Class 1 RHR piping system ¾ inch socket weld connection between a ¼ inch flow restrictor and an ANSI half coupling. Visual examinations determined that the leak was from a crack in a weld and actions were initiated to place the unit in cold shutdown. The subject weld had been in service since Fall 2002.

The inspectors reviewed Condition Report (CR) 2005111460, which discussed the several repair options that were developed. The appropriate plant conditions were established and the weld was ground out and replaced. The inspectors reviewed the documentation for the weld and the non-destructive examination exams and found that they met the requirements of ASME code, Section XI. Furthermore, the licensee identified no further leakage when the weld was visually inspected while the unit was at normal operating pressure and temperature.

The inspectors reviewed the preliminary cause determination summary for the potential causes of the cracked weld and subsequent leak in which the licensee discussed the following areas: fatigue, stress, stress corrosion cracking, and weld quality.

The inspectors reviewed the licensee's evaluation of the defect in the socket weld between the half coupling and the flow restrictor on the bypass line for valve 2HV8701B. The defect was found to be a circumferential linear flaw, approximately ¼ to ½ inch long located approximately 1/8 inch from the toe of the weld nearest the half coupling. The root cause of the defect was attributed to a lack of fusion when this weld was installed in October 2002.

The photos of the flaw show it to be located at an apparent start-stop point of a small bore ¾ inch socket weld. The start-stop point in a weld is a common location for a lack of fusion defect. Lack of fusion discontinuities are typically oriented in the direction of welding and can be caused by undesirable manipulation of the welding arc or by inadequate cleaning of contaminants on the weldment surfaces when the weld was performed. Socket welds are examined by surface examination methods, so when the weld was originally accepted there were no flaws open to the surface. A lack of fusion type flaw at the weld root may have existed since installation resulting in a shortened effective weld throat. Such a root anomaly could have propagated to the surface as the result of normal operating conditions.

The inspectors reviewed the documents describing the licensee's December 16, 2005 interview with the welder who removed and replaced the subject weld. During the grinding of the defective weld, the welder described what he characterized as a lack of fusion at the weld root and observed little or no root penetration at the location of the leak. The welder could not directly attribute the lack of fusion to a specific cause. However, there is a pipe clamp adjacent to the location of the leak and it was discussed whether the original welder may possibly have had to adjust his position thereby affecting the quality of the weld. Although recovery and investigation of the failed weld may have provided more information for the root cause investigation, the portions of the weld which might have been recovered and examined were destroyed in the process of removing the existing weld.

An independent evaluation of the initial root cause determination was performed by the licensee after the March 2006 event. This evaluation determined that a causal factor was that the root cause team was not promptly formed. A second causal factor was the lack of independent monitoring to validate the assumptions used to rule out probable causes and to substantiate the determined root cause.

In conclusion, the inspectors found the root cause analysis, scope, depth of analysis, identification of causal factors, operability evaluations, and corrective actions to be reasonably performed for the December 2005 event. The inspectors did not identify any causal factors that were not identified or recognized by the licensee. Compensatory actions taken by the licensee in response to this condition were reviewed and determined to be adequate.

February 2006 Forced Outage

On February 3, 2006, two additional leaks were discovered in the same bypass line. The leaks were identified at welds 238 W 106 (butt welded elbow) and 238 W 101B (socket welded half coupling). The leak which was repaired in December 2005 was at the socket welded half coupling at the opposite end of the bypass line from this socket weld failure. Welds associated with the February 2006 leaks had been in service since plant construction.

A root cause team investigated the cause of the cracks in the 2HV8701B bypass line and determine corrective actions. An investigation summary and list of restart items was developed and presented to the plant review board on February 11, 2006.

The inspectors reviewed the recommended corrective actions which were presented to the plant review board. The bypass line was rebuilt and a majority of the welds were replaced. (See the weld history below.) Since the failure mechanism involved the natural frequency of the RHR bypass line, replacement of the line could have changed the natural frequency and thus the condition where vibration was at its worst. The failure mechanism, although related to this natural frequency, was more a function of an additional driver such as safety injection (SI) check valve re-seating. The plant is designed with check valves to provide an isolation boundary between the RCS and the SI system. Due to problems with leakage from the RCS to the SI accumulators, the licensee performed a series of evolutions which involved venting the piping downstream of these check valves in an attempt to use RCS pressure to better seat the check valve and reduce leakage. This procedure had been performed on the SI check valve 21204U6126 which shared the same RCS penetration multiple times since the last refueling outage. After instrumentation was installed on the bypass line in February 2006, it was noted that there was a significant increase in vibration on the 2HV8701B bypass line. Root cause team analysis indicated that this transient was a factor in the failure of these welds.

Westinghouse determined that removal of one lateral support from the bypass line would reduce thermal and seismic stresses. At the time, the root cause team believed that the orientation of the lateral supports was contributing to the weld failure. Westinghouse performed a review of the removal of support V2-1201-236-H601, and determined that both seismic and thermal stresses were reduced therefore removal this support was acceptable, as documented by Westinghouse letter GP-17876. The inspectors reviewed the analysis and found that the removal of hanger V2-1201-238-H601 was adequately justified.

During the March 2006 root cause evaluation, Structural Integrity Associates (SIA) analyzed the excitation frequencies when the extra lateral support was in place and removed. SIA concluded that the natural frequency of the bypass line actually increased due to the removal of the support and subsequently increased the vibration. Removing the support in and of itself did not cause the weld failures, but it did move frequencies closer together which is now believed to be a contributor to the failure.

A 2:1 weld modification (weld overlay) was made to strengthen the welds at the half coupling/flow restrictor and full coupling/flow restrictor connections during the February 2006 repairs. It is believed that the stresses induced by the weld enhancement accelerated the crack growth that resulted in a leak in March 2006. With the crack being initiated from the interior of the pipe, there was no way to know a crack existed at the time and no reason to question the proposed weld strengthening.

The design objective of DCP 2060240801, which replaced the bypass line, was to provide a reliable repair to address the two leaks in the bypass line around RHR isolation valve 2HV8701B. The DCP provided the design to re-fabricate the bypass line and remove pipe support V2-1201-238-H601. The new piping assembly fit into the same location as the original as assembly, continued to perform its original function of allowing pressure equalization from the downstream to upstream side of 2HV8701B, and was supported by the two remaining original supports. The DCP also provided revised weld details for socket welds on line 2-1201-238-¾, for improved fatigue strength. The new piping assembly was shop fabricated and utilized enhanced weld profiles to minimize local stress. All the new butt welds were radiographically tested.

The inspectors reviewed the film for the welds and found that they met the acceptance criteria for ASME Section XI. The re-fabricated pipe assembly was then welded into its original location. This DCP also provided evaluations for the attachment of temporary instrumentation.

The RHR bypass loop was fabricated from SA-479, Type 304L stainless steel. The loop consisted of a ¾ inch schedule 160 pipe, a socket welded half coupling and butt-welded elbows. The inspectors reviewed the material specifications listed under MWO 2060239301 to verify adequacy and conformance with ASME Section II and Section III code requirements and the NDE records for both the shop welds and the socket welds to verify compliance with ASME Section XI and Section V.

Westinghouse Letter Report STD-MCE-06-18, “Evaluation of a Failed ¾ inch Sch. 160 Pipe to Elbow Weld in the Vogtle Unit 2 RHR Bypass Line”, was issued to provide the results of the post mortem examination of the failed pipe. The inspectors determined that this report supported the conclusion that weld 238-W-101B failed through a fatigue mechanism which is supported by the presence of striations and indications that the crack progressed from the inside surface to the outside in nearly a straight line. The crack initiated at the 3 o’clock outboard position of the elbow due to improper welding of the root pass, i.e., the welder failed to successfully tie in to a stopping point when continuing with the root weld, which created a notch that became a stress concentration. While the overall deep penetration of the root pass and half moon profile contributed to initiating a crack to nearly a full inner circumference of the weld joint, a particular notch at one location created a condition for a deep crack to initiate and to then become unstable. Cracking did not only progress radially but circumferentially as well, presumably due to the non-axial loading of the pipe. This fatigue assessment is also supported through the absence of other modes of failure or influence: cracking was not typical of stress corrosion cracking; corrosion did not appear to be a factor in the initiation or growth of the crack; microstructures of the pipe, elbow, and weld were sound and did not contain any anomalies that would influence cracking or crack growth; other than the unfavorable penetration of the root pass the weld was sound in that it did not exhibit porosity, inclusions, or hot cracks; the fracture surface did not exhibit any brittle features; and the crack was ductile throughout its fatigue propagation regime indicating that stress overload was not a factor.

Compared to weld 238-W-101B, all of the butt welds from the bypass line exhibited similar bead profiles and small corner cracks emanating from the intersection of the weld bead and the pipe and elbow. These cracks were not believed to be active. The presence of the specific notch in weld 238-W-101B is believed to be the determining factor in its ultimate failure.

The three welds of a ¾ inch socket weld tee joint installed in the bypass line in 2002 were bisected and examined for evidence of cracking. No cracking was identified in any of the welds, even in a weld in which the pipe was butted tight to the bottom of the socket.

In conclusion, the inspectors found the interim root cause analysis' scope, depth of analysis, identification of causal factors, operability evaluations, and corrective actions to be acceptable for the February 2006 event. The inspectors concluded that the actions taken for the February 2006 event were more in-depth than those taken for the December 2005 occurrence. Additional actions were put into place (linear displacement and vibration sensors) to gather further information to ascertain what actually happened to the piping in question. Compensatory actions taken by the licensee in response to the February 2006 event were reviewed and determined to be adequate. The root cause evaluation report for the February 2006 event had not been formally issued prior to the occurrence of the March 2006 event.

March 2006 Forced Outage

A fourth leak (CR 2006103407) was discovered on March 20, 2006 in the socket welded connection between a ¼ inch flow restrictor and an ANSI half coupling. This leak was detected in the same weld and at approximately 180 degrees away from the December 2005 flaw.

The failed weld was cut out with the entire ¾ inch RHR bypass line and the ½ inch RHR 2HV8701B valve bonnet leak-off line and shipped to the Westinghouse Materials Center of Excellence (MCE) forensic metallurgical analysis.

The inspectors reviewed Westinghouse MCE Report STD-MCE-06-25 that noted that the RHR bypass line socket to flow restrictor weld most likely failed due to fatigue. Although fatigue striations were not readily visible (possibly due to the surface damage during removal), no other failure mechanism appeared relevant. The fatigue assessment is also supported through the absence of evidence of other modes of failure or influence. The flaw was not typical of stress corrosion cracking nor did general corrosion appear to be a factor in the initiation or growth of the crack.

Dye penetrant testing revealed a circumferential crack which ran approximately from 3 o'clock to approximately 4 o'clock. The crack was approximately 5/8 inch in length and approximately 3/16 inch from the toe of additional weld reinforcement that was applied in February to improve the weld profile to a 2:1 profile. Radiographic testing (RT) of the failed weld was not able to adequately reveal the extent of cracking in the socket weld as it may have run subsurface circumferentially.

The evaluation noted that dark bands on each fracture surface of the failed socket weld seem to indicate that the crack had existed some time before ultimate failure, due to the presence of oxidation on the inside fracture surface and the lack of oxidation on the other side. This also indicates that cracking had initiated at the root of the weld and progression was toward the external surface of the socket weld.

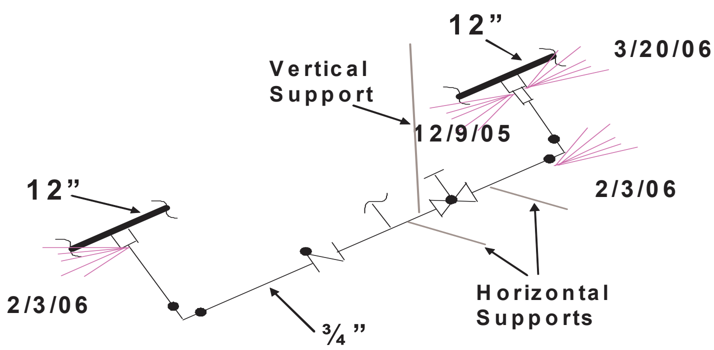
A possible mechanism for the formation of this oxide is that when the reinforcement weld was applied on top of the original socket to flow restrictor weld in to make the weld a 2:1 taper, the nickel-rich coolant product that was trapped in the crack would have been heated to a temperature high enough to deposit on the fracture surface in solid oxide form. A mechanistic explanation for the formation of the dark oxidized region is that the crack had propagated to this point when the February 2006 failure occurred. When the reinforcement weld was placed on the existing socket weld the crack faces became oxidized. It is also theorized that the shrinkage stresses induced by the reinforcement weld may have contributed to the overall stress state at the crack tip. Upon plant restart the added residual stress may have provided a jump past the stopping point, as shown by the transition line. A number of other fittings from the bypass line and the leak-off line were also examined. Weld root anomalies such as linear type features and evidence of lack of fusion were seen in many of the welds.

The inspectors reviewed Southern Nuclear Operating Company report SIR-06-047, "Evaluation of Potential Degradation Mechanisms for the Vogtle Unit 2 RHR Bypass Line" to evaluate the rigor of the possible degradation mechanisms and the conclusions and recommendations. The evaluation covered the following possible degradation mechanisms: thermal fatigue, stress corrosion cracking, localized corrosion, flow sensitive mechanisms, mechanical/vibration fatigue, weld related defects, creep, plastic deformation, and fabrication related mechanisms. Based on their evaluation it was determined that the root cause of the cracking was waterhammer loads caused by steam bubble collapse associated with the check valve depressurization procedure as described above. A contributing casual factor was identified of weld defects and acoustic vibration in the RHR suction line.

In conclusion, with this third event on the same segment of piping, the inspectors found that the licensee formed an extensive team to review not only this event but the previous two events and all the actions taken to date. The inspectors found the more rigorous methodology and breadth of the interim root cause evaluation's scope, depth of analysis, identification of causal factors, operability evaluations, and corrective actions reasonable for the review of all three events. The inspectors did not identify any causal factors that were not identified or recognized by the licensee at that time. Compensatory actions taken and plant modifications performed by the licensee in response to this condition were reviewed and determined to be through and adequate. The root cause evaluation report for this event had not been formally issued prior to this inspection being completed and will be reviewed at a later date.

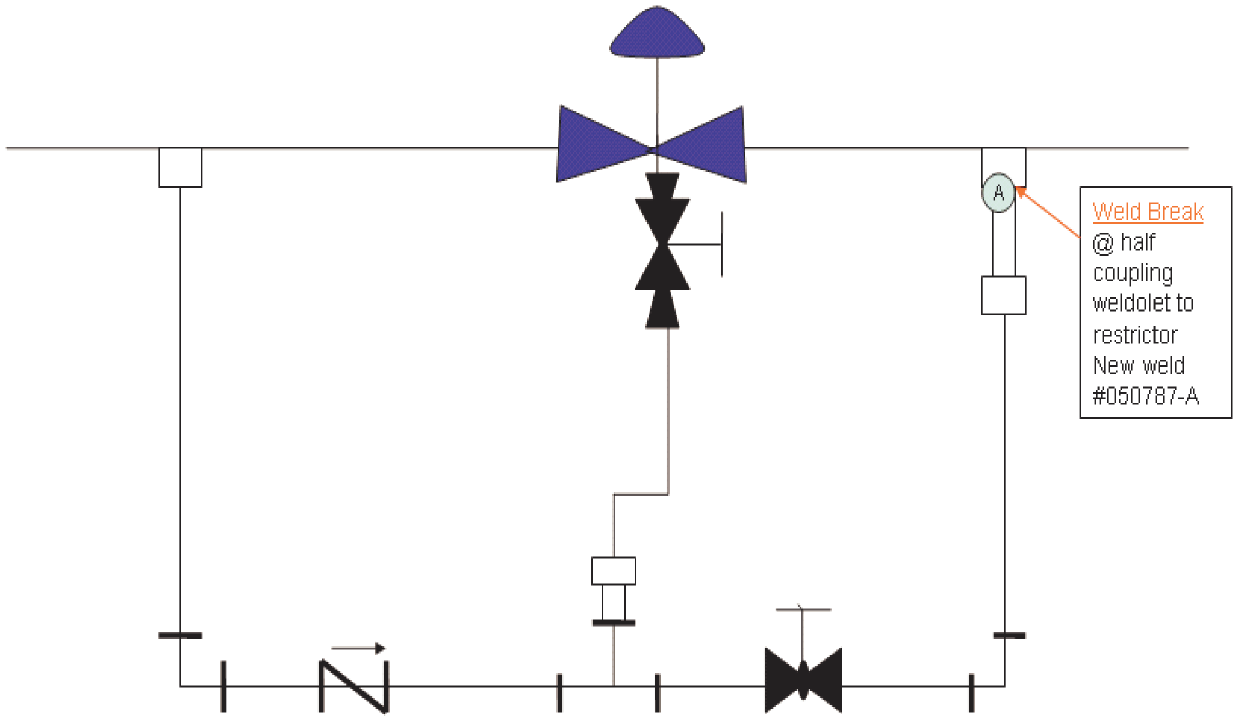
Welding History of RHR Bypass Line (2-1201-238-¾) and Leakoff Line (2-1201-249-½)

RHR Bypass Line Leak Locations



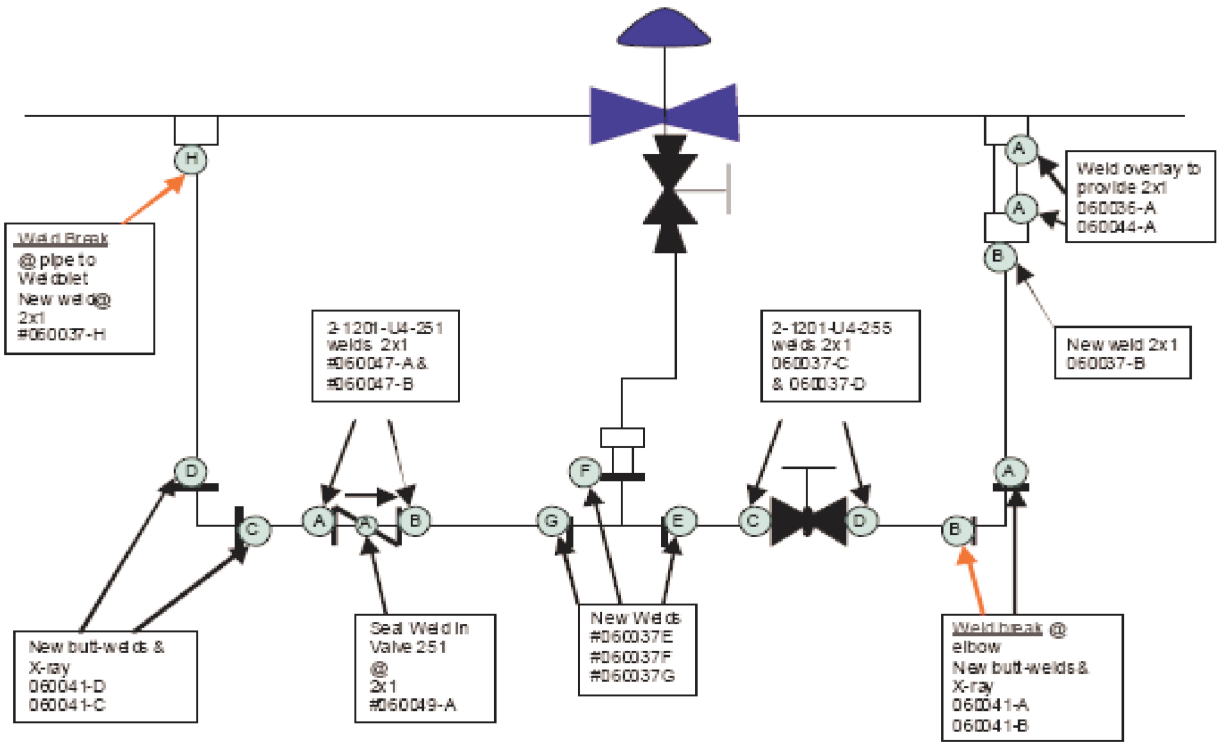
The RHR Loop Suction Valve (2HV8701B) bonnet vent line was first installed during the 2R8 (April 2001) refueling outage to equalize the valve bonnet pressure with the upstream pressure to prevent pressure locking of the valves. This was accomplished by installing 3/8 inch stainless steel tubing that attached to the original packing leakoff port of the valve and connected to the upstream (RCS) side of the valve. During subsequent operations, a leak developed at the valve connection to the leakoff line and the modification was removed.

During 2R9 the bonnet vent line was modified and reinstalled. The ⅜ inch tubing was replaced with ½ inch schedule 160 piping, the check valves were eliminated and additional flow restrictors were added.



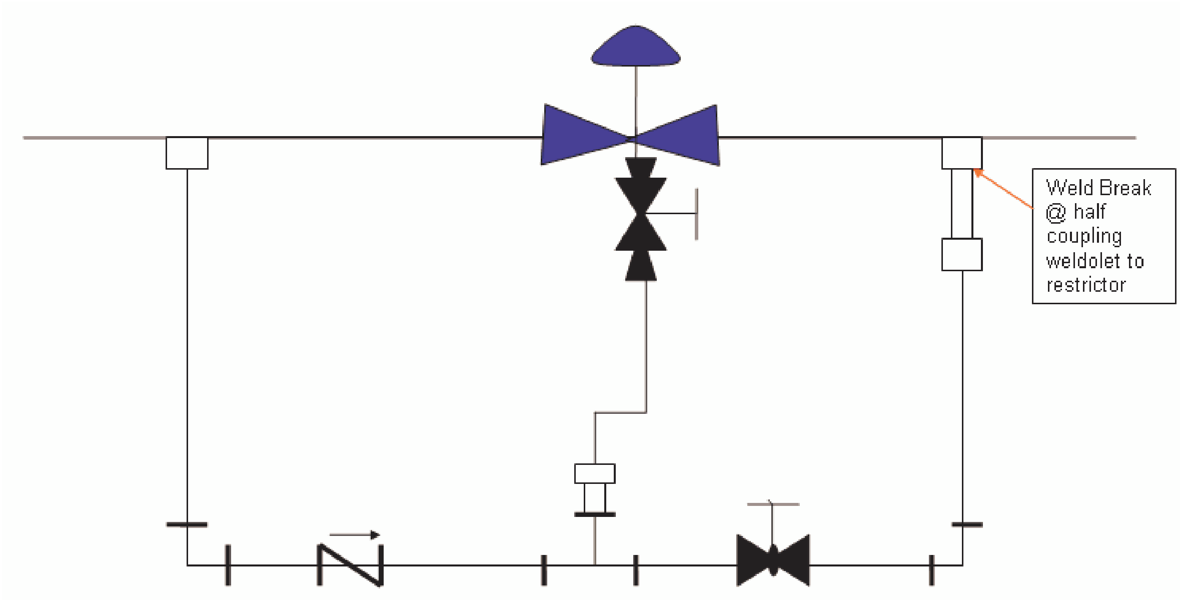
December 2005 bypass line weld failure and repair.

The December 2005 failure developed in a ¾ inch socket weld connection between a ¼ inch restrictor and an ANSI half coupling (Figure 12). This weld was fabricated during 2R9 when the flow restrictor was installed.



February 2006 weld failures and repairs.

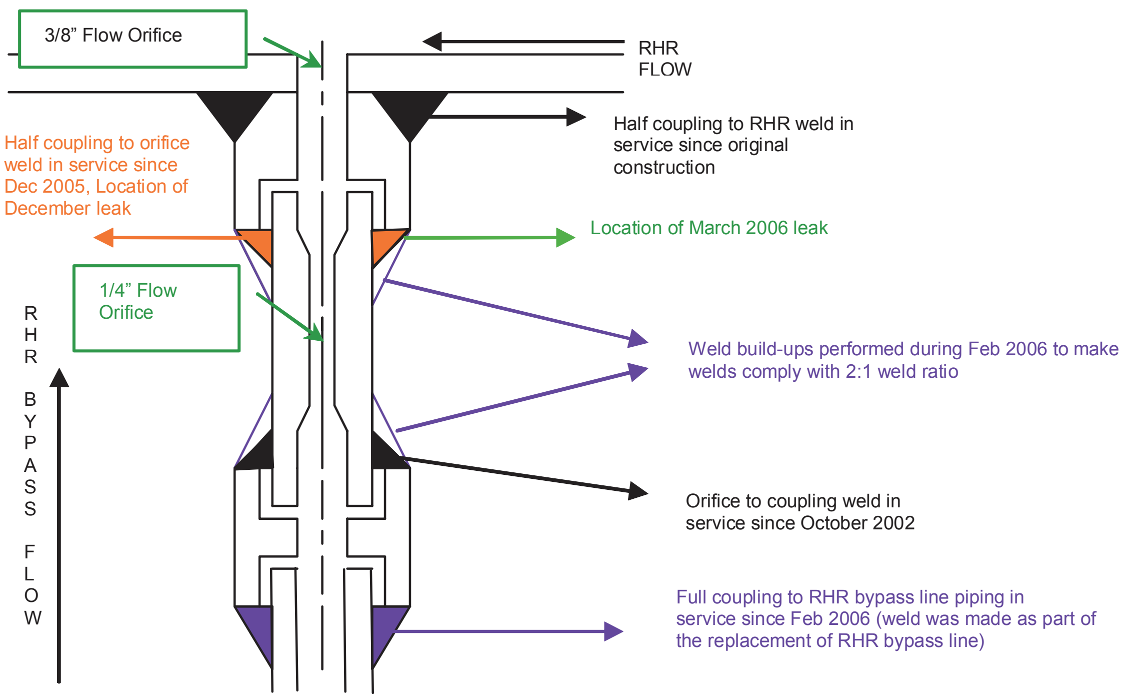
The entire bypass line was replaced with the exception of the two half-couplings, flow restrictor and full-coupling. The February 2006 failures occurred in welds 238-W-106 (butt welded elbow) and 238-W-101B (socket welded half coupling). The previous leak that was fixed in December 2005 was at a coupling at the opposite end of the bypass line from the leaks that occurred in February 2006.



March 2006 Weld Failure

The March 2006 failure was in a ¾ inch socket weld connection between a ¼ inch restrictor and an ANSI half coupling. This weld was the same weld that failed in December 2005. The metallurgical analysis of the failed socket weld indicated that the weld may have already been cracked when the February 2006 failure occurred.

During the March 2006 forced outage the RHR Bypass Line and the RHR 2HV8701B leak off lines were removed. The entire bypass line was removed and the empty half-couplings were plugged.



Weld Repair History for 2HV8701B flow-restrictor

3. Assessment of the Extent of Condition (Objective 2)

a. Inspection Scope

The inspectors applied the causes identified in the Unit 2 loop 1 RHR isolation valve bypass line evaluation to the other Unit 1 and Unit 2 RHR loop isolation valve bypass lines to evaluate the susceptibility of the piping to a similar failure. The inspectors also reviewed plant documentation, performed a walkdown inside containment and evaluated the bypass lines and bonnet vents for the RHR suction isolation valves for any evidence of a similar type of failure as the bypass line to 2HV8701B. In addition, the inspectors searched for other small-bore piping which was attached to RCS piping to determine whether a similar failure process was evident.

b. Observations

The loop 4 RHR isolation valves on both units have a different piping configuration than the loop 1 RHR isolation valves. The different length of piping and the different configuration of the bypass lines change the natural resonant frequencies of this piping, such as the vibrational frequency of the bypass line, the "organ pipe" tonal of the piping attached to the RCS system. If the resonant frequencies of the piping are separated, as they are in the loop 4 configuration, the resulting total stress on the piping is reduced.

Another possible contributing factor to the Unit 2 loop 1 bypass line failure is the additional stress induced from the water hammer produced by the procedure used to seat the safety injection hot leg check valve, 21204U6126. Although there is a similar check valve on the loop 4 RHR line, 21204U6125, records indicate that the reseating procedure has not been performed as frequently on this check valve.

The Unit 1 loop 1 RHR isolation valve had a similar configuration to the Unit 2 loop 1 RHR isolation valve. There are slight differences in the configuration of the piping which may have caused the resonant frequencies to further separate when compared to Unit 1. The largest difference between the condition of the two bypass lines is that the SI check valve seating procedure has not been performed as frequently on Unit 1 as on Unit 2. A review of the Unit 1 operator's logs indicates that the check valve seating procedure had not been performed since 2000. The procedure had been performed on the loop 1 injection valve eight times since the 2005 refueling outage. Unit 1 was operating at the time of the inspection, so the Unit 1 RHR isolation valves were not available for inspection. However, there has been increased plant leakage which could be attributed to a similar failure in Unit 1.

The inspectors verified that visual examinations (VT-1) were performed on the other Unit 2 field welds associated with design change DCP 00-V2N0017 for valves 2HV8701B and 2HV8702B after the December 2005 shutdown. These welds were all made during the same time frame, and no defects were noted. Based on discussions with the site technical staff and field observations, the licensee determined that there were no other RCS pressure boundary leaks. This bypass line is a unique joint configuration in the Vogtle design; the only similar installations are on the opposite train and on the Unit 1 RHR isolation valve bypass lines . Because of the strict ASME material and process requirements for this design, as well as the rigorous stress analysis used, this issue is isolated to this particular 2HV8701B bypass weld.

The welder who performed the original weld in 2002 was a contract welder and was qualified in accordance with Southern Nuclear procedures. The welder has welded at both Plant Hatch and Plant Vogtle and was well-experienced and previously performed welds accepted by radiography. The root cause investigation team eliminated welder qualification as a broadness issue. Therefore, the licensee did not consider looking at other similar socket welds that might have been made by the welder in question.

The inspectors walked down the bonnet vent and bypass lines on the other three RHR suction isolation valves, 2HV8701A, 2HV8702A and 2HV8702B . No indication was found that these lines had the same failure mechanism as 2HV8701B. A search for other similar types of bypass lines and bonnet vents was conducted inside containment for other small bore piping connected to the RCS system. No further cases of this piping were identified. The search was expanded to include the drain line attached to the safety injection lines that share a RCS connection with the RHR system. There was no indication that these lines were experiencing the same type of failure as the 2HV8701B bypass line.

4. Indications of Potential Overstress (Objective 4)

a. Inspection Scope

The team performed a walkdown of the available RHR piping inside containment for indications of potential overstress. This review was expanded to include other small bore piping systems inside containment which were connected to the RCS piping.

b. Observations

The inspectors inspected the RHR piping which was connected to either RCS loop 1 and RCS loop 4. No indications of overstressed or deformed piping was identified. The inspectors were also unable to find any impressions in the insulation around the piping which may indicate that thermal growth or other piping displacement could have caused problems when the reactor plant was at normal operating pressure and temperature. There was no evidence that pipe hangers had been overstressed. The inspectors evaluated the bypass lines and/or bonnet vent lines for 2HV8701A, 2HV8701B, 2HV8702A and 2HV8702B and found no indications of leakage or overstress. The review was expanded to include various vent and drain connections to other systems connected to RCS piping such as safety injection piping, and no indications of overstress were detected.

5. Operating Experience (Objective 5)

a. Inspection Scope

Inspectors reviewed the operating experience provided by the licensee and the NRR Operating Experience group to evaluate the applicability to the leaks identified in the Vogtle RHR system. The inspectors also evaluated whether the licensee's use of operating experience could have prevented or mitigated the failure.

b. Observations

The inspectors performed a review of similar operating experience issues. St. Lucie Unit 1 observed an issue with hot cracking due to weld contamination of a socket weld of a 1 inch vent line of a safety injection line. This is documented in LER 50-335-97-005. Hatch Unit 1 experienced a socket weld crack caused by weld contamination and high cycle fatigue. This is documented in LER 50-321-97-001. The licensee also determined that the Palo Verde units are experiencing the same type of failures on their penetrations to the RCS. The licensee had a representative from the Palo Verde root cause evaluations participate as part of their team. The inspectors found that the licensee had reviewed these events during their root cause evaluations.

6. Corrective Actions (Objective 7)

a. Inspection Scope

Inspectors reviewed the design change package which affected the repairs for the March 2006 failure for completeness and applicability to the observed failures. This review included the supporting reports prepared by Westinghouse and the supporting 10CFR 50.59 evaluation. The inspectors compared the planned repairs with the applicable ASME code and NRC requirements.

b. Observations

The inspectors reviewed DCP 206523401, “Removal of RHR Bypass Lines 2-1201-038-¾" and 2-1201-039-¾" from RHR Hot Leg Suction Line Piping" which included the 10 CFR 50.59 evaluation. This design modification proposed removal of this bypass line to eliminate it as a source of RCS leakage.

The design change involved the removal of the RHR loop 1 suction isolation valve bypass line and the associated valve bonnet depressurization line for Vogtle Unit 2. The design change also included removal of associated pipe supports and valves. This design change and supporting evaluations prepared by Westinghouse refer to the removal of both the loop 1 and loop 4 bypass lines. However, the scope of the 10 CFR 50.59 Evaluation and design documentation was specific to the removal of the Unit 2 loop 1 bypass components.

The design function of this bypass line was to prevent binding of the isolation valve from either pressure buildup upstream of the valve or inside the bonnet. Licensee calculations demonstrated that the pressure upstream of the isolation valve would not build up to the point that it could bind the valve during a design basis accident due to thermal expansion of the water trapped between the two isolation valves. The licensee’s calculations also demonstrated that if a delay of six hours was allowed between the initiation of RCS depressurization and the opening of the RHR isolation valves, the residual pressure inside the bonnet of the valve would be insufficient to bind the valve. The licensee modified their operating procedures to account for this delay. One result of this six hour delay was that it increased the amount of water required by technical specifications in the condensate storage tanks. An emergency technical specification change was approved by the NRC to address this issue prior to the restart of Unit 2. The inspectors determined that the 10 CFR 50.59 evaluation performed provided adequate justification for the elimination of the bypass line.

The inspectors reviewed the administrative controls that needed to be in place for this temporary modification to assure that they were consistent with the assumptions made in the Westinghouse 50.59 Screening/Evaluation and letter GP-17902. The repair plan reviewed by the inspectors included the total removal of the bypass line around 2HV8701B and the associated valve bonnet depressurization line and the fabrication of pipe plugs to be welded into the empty penetrations. The inspectors verified that the repairs met all ASME Section III and Section II requirements, and were examined per ASME Section XI requirements.

4OA6 Meetings

On March 29, 2006, the inspectors presented the inspection results to Mr. Tom Tynan and other members of the licensee staff who acknowledged the findings. The inspectors reviewed proprietary information during the inspection, but this information is not specifically referenced in this report.

SUPPLEMENTAL INFORMATION
KEY POINTS OF CONTACT

Licensee Personnel:

R. Brown, Training and Emergency Preparedness Manager
C. Buck, Chemistry Manager
R. Dedrickson, Assistant General Manager - Operations
K. Dyar, Security Manager
D. Jones, Vice President, Engineering
I. Kochery, Health Physics Manager
J. Robinson, Operations Manager
S. Swanson, Engineering Support Manager
T. Tynan, Nuclear Plant General Manager
J. Williams, Assistant General Manager - Plant Support

NRC Personnel

C. Casto, Director Division of Reactor Projects Region II

LIST OF ITEMS OPENED , CLOSED, AND DISCUSSED

Opened or Closed

None

LIST OF DOCUMENTS REVIEWED

Design Change Packages:

DCP 00-V2N0017	RHR Valve Bonnet Venting
DCP 00-V2N0016	Provide Vent Path for RHR Loop Suction Isolation Valves to Preclude Pressure Locking
DCP 00-V1N0016	Venting of 1HV8701A, 1HV8701B, 1HV8702A, and 1HV8702B Valve Bonnets to Preclude RHR Loop Suction Valve Pressure Locking
DCP 2060523401	Removal of RHR Bypass Lines 2-1201-038-¾" and 2-1201-039-¾" from RHR Hot Leg Suction Line Piping
DCP 2060523401	10CFR50.59 Evaluation, Rev. 1.0, 3/25/06
DCP 2060240801	2HV8701B Bypass Line Support Structures, 2/7/06

Engineering Calculations and Evaluations:

EVAL-06-20 Vogtle Units 1 & 2 Bypass Line and Valve Bonnet Depressurization Line Removal, Rev. 0
SIR-06-047 Structural Integrity Associates, Inc Report SIR-06-047, Rev. B, "Evaluation of Through-Wall Cracking and Leakage in the Vogtle Unit 2 RHR Bypass Line, March 2006
STD-MCE-06-18 Evaluation of a Failed ¾" Sch. 160 Pipe to Elbow Weld in the Vogtle Unit 2 RHR Bypass Line, 3/7/06
2J4-1201-251-01 Pipe Stress Evaluation - Reactor Coolant System, Rev. 0
2J4-1201-249-01 Pipe Stress Evaluation - Reactor Coolant System, Rev. 0
REA 02-VAA603 RHR Leakoff Line Metallurgical and Vibration Analysis, 3/24/2006
REA 01-VAA060 RHR Loop Suction Valve Pressure Locking Evaluation, SNC 9/14/2001
V-EC-1618 Thermal Binding Threshold Estimation delta-T and System Temperature Limits, Westinghouse 1996 (Proprietary)
V-EC-1619 Bonnet Depressurization Rate, Westinghouse 1996 (Proprietary)
V-EC-1620 Thermally Induced Pressurization Rates in Gate Valves, Westinghouse 1996 (Proprietary)
X4C1000U18 Rev. 3 RHR Loop Suction Valves' Pressure Locking Evaluation, SNC 8/25/2003
X4C1302V06 Rev. 1 Condensate Storage Tank Verification, SNC and Bechtel 3/24/1995.
Vogtle Unit 2 Loop 1 RHR Bypass line Failure Stress Evaluation Summary - Old Configuration

Procedures:

13105-2 Safety Injection System, Rev. 37
58007-C Design Change Packages, Rev. 10 (2001 version)
58007-C Design Change Packages, Rev. 16 (2006 version)
85050-C Visual Examination, Rev. 10
85050-C Visual Examination, Rev. 12
85062-C Penetrant Examination, Rev. 7
GEN-25 VEGP Welding Manual - Piping System Weld Matrix - Appendix D, Rev. 7
NMP-GM-002-GL03 Corrective Action Program, Root Cause Determination Guideline, Rev. 5.0

Drawings & Diagrams:

Diagram - RHR Bypass Line Break Weld Number History - December 2005, February & March 2006
Diagram - RHR Bypass Line Break Locations - December 2005, February & March 2006
Drawing - Weld Repair History for RHR Bypass Flow Restrictor (March 2006)
Drawing - December 2005 RHR Bypass Failure Weld Repairs
Drawing - February 2006 RHR Bypass Failure Weld Repairs
Drawing - March 2006 RHR Bypass Failure Weld Repairs
Drawing - 2K4-1201-036-01, Reactor Coolant System Fabrication Isometric Ctmt. Bldg. Area 4A, LVL. B & C, Ver. 19
Drawing - 2K4-1204-023-03, Safety Injection System Fabrication Isometric Ctmt. Bldg. Area 4A, LVL. B & C, Ver. 6
Drawing - V2-1201-238-H001, Rev. 2
Drawing - V2-1201-238-H002, Rev. 3
Drawing - V2-1201-238-H601, Rev. 2
Drawing - V2-1204-023-H001, Rev. 4

Drawing - V2-1204-023-H002, Rev. 4
Drawing - V2-1204-023-H003, Rev. 3
Drawing - V2-1204-023-H004, Rev. 3
Drawing - V2-1204-023-H005, Rev. 4
Drawing - V2-1204-023-H009, Rev. 3
Drawing - V2-1204-023-H601, Rev. 0
Drawing - V2-1204-023-H602, Rev. 0

Condition Reports (CRs):

2005111460	During a Unit 2 Containment Entry on 12/9/2005 a stream of steam was identified around valve 2HV8701B (12/9/05)
2006101340	Investigation of 2HV8701B Bypass Line found the following welds leaking (238-W101B & 238-106) (2/4/06)
2006101660	The U-Bolt associated with support V2-1204-023-H601 is broken (2/9/06)
2006101687	The Unit 2 RCCA team requires the following work be added to the forced outage (2/10/06)
2006103498	Item 52A, Structural attachment is 90 degrees out of orientation (3/23/06)
2006103516	CR to document a walkdown of the as-found conditions at 2HV8701B. (3/21/06)
2006103524	2HV8701B has small packing leak (3/23/06)

Other:

Letter Bechtel to Southern Nuclear Operating Company, March 20, 2006, "RHR Suction Valve Bypass Line Water Hammer/Root Cause Assessment Report"

Letter Bechtel to Southern Nuclear Operating Company, March 27, 2006, "Plant Vogtle Unit 2 - Residual Heat Removal (RHR) System; Pipe Supports - Review of As-Found Information"

Letter Bechtel to Southern Nuclear Operating Company, March 28, 2006, Vogtle Unit 2, Loop 1, RHR Suction Valve Bypass Line Water Hammer/Root Cause Assessment Report.

Letter Westinghouse to Southern Nuclear Operating Company, March 24, 2006, "Transmittal of 10CFR50.59 Evaluation - RHR Bypass Line and Valve Bonnet Depressurization Line Removal"

Letter from Westinghouse to SNC, GP-17902, Impact of Imposing a 40 Deg F/hour Cooldown Rate on the 12 Hour Delay Time to Open the RHR Suctions Isolation Valves, 3/27/2006

RHR Bypass Line Pipe Support As-Built Measurements - March 2006

Weld Process Control Sheet (WPCS), Weld 020340A, MWO 20101597, October 19, 2002

WPCS, Weld 060036A, February 9, 2006

WPCS, Weld 060037A (060044A), February 9, 2006

WPCS, Weld 060037B, February 9, 2006

WPCS, Weld 060037C, February 6, 2006

WPCS, Weld 060037D, February 6, 2006

WPCS, Weld 050787A, January 6, 2006

WPCS, Weld 060112A (Weld Plug), March 25, 2006

Vogtle 2 RHR Bypass Pipe, Final Thermal Growth Data, March 23, 2006

MWO 20101597 00, 05/23/02, "Install New Bonnet Vent Line of RHR Valves 2HV8701B", DCP 00-V2N0017

MWO 2060523403 00, "Remove 2HV8701B Bypass Line and Leak-off Line per DCP 2060523401, 3/26/06

MWO 2060241601 00, “Pins need to be removed from each end of strut and inspected for indications of wear due to vibration”

MWO 2060241701 00, “Pins need to be removed from each end of strut and inspected for indications of wear due to vibration”

MWO 2060241801 00, “Pins need to be removed from each end of strut and inspected for indications of wear due to vibration”

Corrosion Assessment - Leak No.: 1205-2005-009, WO No.: 2054225501 CR:2005111460, Equip. Tag: 2-1205-PIPE & 2HV8701B, 12/16/05

Welder Qualification Test Record (RF-2583)

Plant Review Board (PRB) 2006-026, Approval for DCR 2060523401, Version 3.0

Troubleshooting Plan - Weld Failure and/or Pipe Break (CR 2006103407) 3/21/06

Radiographic Examination Report, Weld 060041A, 2/8/06

Radiographic Examination Report, Weld 060041B, 2/8/06

Radiographic Examination Report, Weld 060041C, 2/8/06

Radiographic Examination Report, Weld 060041D, 2/8/06

NDE Qualification Verification: DT

CN-SEE-06-19 Rev. 0, RHR Cool Single Train Analysis of Vogtle Units 1 and 2, Westinghouse 2006 (Proprietary)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
SAM NUNN ATLANTA FEDERAL CENTER
61 FORSYTH STREET, SW, SUITE 23T85
ATLANTA, GEORGIA 30303-8931

March 24, 2006

MEMORANDUM TO: Gerald J. McCoy, Senior Resident Inspector, Vogtle Electric Generating Plant, Reactor Projects Branch 2, Division of Reactor Projects

FROM: William D. Travers, Regional Administrator **//RA//**

SUBJECT: SPECIAL INSPECTION CHARTER TO EVALUATE REPETITIVE RESIDUAL HEAT REMOVAL SYSTEM WELD FAILURES AT VOGTLE ELECTRIC GENERATING PLANT

In response to several weld failures that have occurred at the Vogtle Electric Generating Plant, a Special Inspection is being chartered. You are hereby assigned to conduct the Special Inspection. Steve Vias and Charles Peabody are also assigned to the team.

A. Basis:

In December 2005, a weld on the Unit 2 residual heat removal (RHR) system bypass line failed. The unit was shutdown, as required by Technical Specifications for reactor coolant system pressure boundary leakage, and the weld repaired. In February 2006, two additional welds on the RHR bypass line failed resulting in a Technical Specification unit shutdown for reactor coolant system (RCS) pressure boundary leakage. The licensee replaced the entire RHR bypass line which included rewelding of three additional locations. On March 20, 2006, a weld on the RHR bypass line again failed resulting in a Technical Specification required unit shutdown for RCS pressure boundary leakage.

In accordance with Management Directive 8.3, "NRC Incident Investigation Program," deterministic criteria were used to evaluate the level of NRC response for this safeguards event. Based on the fact that the latest event involved a repetitive failure of safety-related components, Region II determined that the appropriate level of NRC response was the conduct of a Special Inspection.

This Special Inspection is chartered to identify the circumstances surrounding these events and review the licensee's actions following discovery of the conditions.

CONTACT: Curtis W. Rapp, RPB2/DRP
(404) 562-4674

Attachment 2

B. Scope:

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

1. Develop an integrated sequence of each of the three weld failure events.

2. Review for extent of condition on the Unit 1 RHR suction bypass lines and sample for other similar piping configurations in both units.

3. Review the licensee's completed root cause analysis for the earlier weld failure events for sufficiency of scope, depth of analysis, and identification of causal factors. For the current weld failure event, review of the root cause analysis for sufficiency of scope.

4. Review the RHR piping for indications of potential overstress.

5. Evaluate pertinent industry operating experience and potential precursors to the event, including the effectiveness of any action taken in response to the operating experience.

6. Collect data necessary to support completion of the significance determination process.

7. Review the licensee's repair and corrective actions for this latest event.

C. Guidance:

Inspection Procedure 93812, "Special Inspection," provides additional guidance to be used during the conduct of the Special Inspection. Your duties will be as described in Inspection Procedure 93812. The inspection should emphasize fact-finding in its review of the circumstances surrounding the event. It is not your responsibility to examine the regulatory process. 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 March 25, 2006. It is anticipated that the on-site portion of the inspection will be completed during the week of March 27, 2006. A status briefing of Region II management will be provided each day while on-site at 4:00 p.m. A report documenting the results of the inspection should be issued within 45 days of the completion of the inspection.

This Charter may be modified should you develop significant new information that warrants review.

Docket Nos.: 50-424, 50-425
License Nos.: NPF-68, NPF-81

cc: W. Kane, OEDO
S. Lee, OEDO
J. Dyer, NRR
C. Haney, NRR
R. Zimmerman, NSIR
L. Plisco, RII
C. Casto, RII
V. McCree, RII

Event Time Line

Date	Event
Construction (Pre-1989)	A bypass line is installed on valve 2HV8701B to relieve binding caused by the pressure differential between the reactor coolant system and the residual heat removal system.
8/17/1995	NRC Issues GL 95-07, “Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves.”
4/01/2000	In response to GL 95-07, Southern Nuclear (SNC) determines that 2HV8701B is susceptible to thermal binding issues.
3/19/2002	SNC installs a bonnet leak-off line on 2HV8701B. Bonnet leak-off line drains into containment during the next cycle.
10/19/2002	SNC connects the 2HV8701B bonnet leak-off line into the bypass line to prevent further leakage into containment.
10/2005 - 3/2006 (Current Cycle)	The frequency of draining and sampling the safety injection (SI) accumulators to restore level jumps to 8 to 10 times per month as compared to three to four times per year prior to the refueling outage. This is attributed to backleakage of the SI primary check valves.
10/13/2005	Procedure 13105 is performed to reseat the SI primary check valves in response to rising accumulator levels.
11/10/2005	Procedure 13105 is performed to reseat the SI primary check valve in response to rising accumulator levels.
12/8/2005	The containment radiation monitors alarm on Unit 2.
12/9/2005	A containment entry identifies primary leakage inside the bioshield. Unit 2 is shutdown to Mode 5.
12/10/2005	A failed weld is identified on the 2HV8701B bypass line on the RCS side connection (RCS-side socolet) at 10 o’clock.
12/10-15/2005	The weld failure is diagnosed as insufficient weld penetration, the weld is ground out and re-welded.
12/15/2005	Unit 2 is placed online after the weld is repaired.
12/29/2005 - 1/16/2006	Procedure 13105 is performed 4 times to reseat the SI primary check valves.
2/1/2006	The containment radiation monitors alarm on Unit 2.

2/3/2006	RCS pressure boundary leakage is identified during a containment walkdown. Unit is shutdown to Mode 5.
2/3-5/2006	Cracks are discovered in the welds at the RHR-side weldolet and RCS-side elbow.
2/5/2006	Check valve 21204U4251 was inspected and the seat is found damaged less than 5 months after satisfactory completion of a previous inspection.
2/5-14/2006	SNC decides to replace the entire bypass line on 2HV8701B except for the flow restrictors. The leakoff line and the bypass line are replaced. All welds replaced except the socket root weld and restrictor inlet and outlet welds. Vibration and displacement instrumentation installed on the bypass line.
2/14/2006	Unit 2 is placed online after the installation of the new bypass line.
2/22/2006	Procedure 13105 is performed to reseat SI primary check valve. Vibration/displacement instrumentation indicate that piping was perturbed and continued moving for about 10 minutes. A night order was issued to discontinue the performance of procedure 13105.
3/20/2006	The containment airborne radiation monitors alarm on Unit 2.
3/20/2006	Unit 2 is shutdown to Mode 5. Leakage is discovered at the 3 o'clock position on the RCS side socolet weld (same weld that failed in December.)
3/24/2006	NRC Special Inspection Team is chartered and arrives onsite.
3/27-28/2006	The bypass line and bonnet leakoff lines are removed and the sockets are plugged per DCP 2060523401.
3/28/2006	Licensee root cause teams postulate that the failure was caused by the superimposing of multiple 30 Hz harmonic resonances that lead to excessive vibration in the vicinity of the bypass line. The final perturbation was caused by seating the SI primary check valves to restore the SI accumulators to the proper levels. Repeat failure is precluded by removal of the bypass line. The B train RHR bypass line is not susceptible to this mode of failure because its harmonic resonances are not all concentrated at the same frequency.
4/3/2006	Unit 2 is restarted and placed online