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September 24, 2009

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Duke Energy Carolinas LLC (Duke)
Oconee Nuclear Station, Unit 2
Docket No: 50-270
Relief Request No. 09-ON-006
Relief Request from Immediate ASME Code Flaw Repair of Standby Shutdown Facility Auxiliary Service Water Piping

Pursuant to 10 CFR 50.55a(a)(3)(ii), Duke requests relief from specific requirements of the 1998 Edition, through the 2000 Addenda, of the ASME Section XI Code on the basis that compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Duke has determined that performing an immediate code compliant repair/replacement activity on affected portions of the Standby Shutdown Facility Auxiliary Service Water buried piping would be a hardship and defered the code repair/replacement to allow for necessary design, purchase, and installation of new piping but no later than the upcoming Unit 2 EOC24 refueling outage.

Per NRC Inspection Manual, Part 9900 Technical Guidance, "Operability Determinations & Functionality Assessments For Resolution Of Degraded Or Nonconforming Conditions Adverse To Quality Or Safety," Appendices C.11 and C.12, a relief request is necessary.

Specifically, Appendix C.11 Flaw Evaluation states "Whenever a flaw does not meet ASME Code or construction code acceptance standards or the requirements of an NRC endorsed ASME code case, a relief request needs to be submitted in a timely manner after completing the operability determination process documentation."

Similarly, Appendix C.12 Operational Leakage states "The NRC staff does not consider through-wall conditions in components, unless intentionally designed to be there such as sparger flow holes, to be in accordance with the intent of the ASME Code or construction code and, therefore, would not meet code requirements, even though the system or component may demonstrate adequate structural integrity. Thus, unless a through-wall flaw is evaluated and found acceptable using an applicable and NRC endorsed code case, in which all provisions are met including any additional requirements or limitations imposed by the RG endorsing the code case, a relief request is necessary."

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Therefore, Duke submits the attached Relief Request 09-ON-006, and requests that the NRC grant relief as authorized under 10 CFR 50.55a(a)(3)(ii). Further, Duke requests exigent review and approval since the NRC has stated on prior occasions that review after completion of code repairs renders the issue moot.

The NRC was informed of this issue by telephone conference call on August 24, 2009.

The attached relief request contains regulatory commitments as stated in the Proposed Alternative and Basis for Use section of the request. These commitments are for compensatory monitoring during the period prior to completing the code repair and will expire upon completion of the repair.

If there are any questions or further information is needed you may contact Randy Todd at (864) 873-3418.

Sincerely,

Dave Baxter,
Site Vice President

Enclosure with Attachments (2)

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Enclosure

Duke Energy Carolinas, LLC

Oconee Nuclear Station, Unit 2

Relief Request Serial #09-ON-006

Relief Requested in Accordance with 10 CFR 50.55a(a)(3)(ii)

Alternative Requirements for Temporary Acceptance of a Through Wall Flaw in the Standby Shutdown Facility Class 3 Auxiliary Service Water Piping

1. ASME Code Component(s) Affected

Oconee Nuclear Station, Unit 2 ASME Class 3 Standby Shutdown Facility (SSF) Auxiliary Service Water (ASW) System 6" diameter schedule 80 buried piping located between valves 2CCW-117 and 2CCW-287.

The following information is applicable to this piping:

Design Pressure:	1440 psig
Design Temperature:	100° F
Material:	SA106 Grade B
Flow Diagram:	OFD-133A-2.5, Rev 44
Layout Drawing:	O-447C, Rev 3

2. Applicable Code Edition and Addenda

ASME Boiler and Pressure Vessel Code, Section XI, 1998 Edition through the 2000 Addenda.

3. Applicable Code Requirement

The ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWD, IWD-3000. IWD-3000 specifies that the rules of IWB-3000 may be used.

The ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWB, IWB-3522. IWB-3522 specifies acceptance standards for all pressure retaining components. IWB-3522.1 requires that relevant conditions, such as those described in IWB-3522.1(f) [leakages or flow test results from buried components in excess of limits established by the Owner] shall require correction to meet the requirements of IWB-3142 and IWA-5250 prior to continued service.

Because Duke has chosen to use IWB-3522 acceptance standards to address this operational leakage in the Class 3 SSF ASW system, relief is requested from the requirement of IWB-3522.1 that the relevant condition (through wall leakage) be corrected prior to continued service.

4. Reason for Request

On August 18, 2009, a leak was detected in the SSF Unit 2 ASW buried piping between valves 2CCW-117 and 2CCW-287 at a location approximately 23 feet below grade (approximate Elevation 771'-9"), and 5 feet from the exterior surface of the SSF Pump Room south foundation wall. The piping at this location is embedded within compacted backfill.

The portion of SSF ASW piping containing the flaw is considered high-energy Class 3 pipe. Per 10CFR 50.55a(g)(4), ASME Code Class 3 components must meet the requirements of the ASME Code Section XI (Rules for Inservice Inspection of Nuclear Power Plant Components).

Because of the location of the identified leak and the difficulty projected to complete timely repairs to this piping, Duke requests NRC approval of this request to allow continued operation of this system until such time that an ASME Code, Section XI repair/replacement activity can be performed in accordance with IWA-4000.

The following information is provided in support of this request:

NRC Inspection Manual, Part 9900 Technical Guidance, Appendix C.12 Operational Leakage From ASME Code Class 1, 2, and 3 Components, states "The NRC staff does not consider through-wall conditions in components, unless intentionally designed to be there such as sparger flow holes, to be in accordance with the intent of the ASME Code or construction code and, therefore, would not meet code requirements, even though the system or component may demonstrate adequate structural integrity."

The guidance provided in Part 9900 implies that the NRC does not accept that IWD-3000 of the ASME Code, Section XI allows through wall leakage in Class 3 components.

5. Proposed Alternative and Basis for Use

In lieu of the requirement of IWB-3522.1 to correct the degraded condition prior to continued service, Duke proposes the following alternative for temporary acceptance of the through-wall flaw detected in the SSF Unit 2 ASW 6" piping:

1. The structural integrity of the component shall be evaluated in accordance with the guidance of NRC Generic Letter 90-05, as permitted by NRC Regulatory Issue Summary 2005-20, Rev. 1, and NRC Inspection Manual, Part 9900 Technical Guidance, Appendix C.11.
2. The functional integrity of the SSF ASW, Emergency Feedwater (EFW), and Station ASW Systems shall be evaluated to ensure continued operability/functionality of these systems.
3. Pressure testing and ultrasonic testing shall be performed as documented in this request to provide continued assurance of the component structural integrity and system functional integrity until a repair/replacement activity that eliminates the SSF ASW piping flaw can be performed in accordance with IWA-4000.

Duke proposes to satisfy the above alternative requirements as detailed below and as documented in Attachment 1, "Unit 2 SSF ASW Buried Piping Prompt Determination of Operability", and Attachment 2, "Additional Information Pertaining to the Unit 2 SSF ASW Buried Piping Prompt Determination of Operability".

Component Structural Integrity

The structural integrity of the component has been evaluated, and the results of this evaluation concluded the following:

1. The flaw is a pin-hole type flaw that is located within the heat affected zone for the elbow weld and was most likely caused by OD initiated pitting corrosion due to external coatings degradation.

2. Visual examinations and system pressure tests confirmed that the diameter of the through-wall flaw is approximately 0.021 to 0.023 inches.
3. UT examinations performed in the vicinity of the leak identified a single location where a minimum wall thickness of 0.25 inches was measured, with adjacent thicker wall readings of 0.327 and 0.329 inches (located within 0.25 inches of the measured minimum value). These readings support the conclusion that the leak is the result of a flaw with "deep pit" geometry, consistent with general corrosion resulting from damage or degradation of external protective coatings.
4. The structural integrity of the affected pipe will be maintained, provided a maximum flaw size of 1.35 inches (as determined by the GL 90-05 evaluation) is not exceeded. This value is well above the estimated flaw size of approximately 0.5 inches obtained from UT measurements.

Functional Integrity of the SSF ASW, EFW, and Station ASW Systems

The functional integrity of the SSF ASW, EFW, and Station ASW Systems was evaluated, and the results of this evaluation concluded that the critical leakage rate for the SSF ASW system is 4.5 gpm at 1280 psig, when the system is operating in support of the EFW System. At this critical leakage rate, the limiting size (diameter) of the hole in the SSF ASW piping is calculated to be approximately 0.0745 inches. The 1280 psig used in the evaluation comes from the quarterly Turbine Driven Emergency Feedwater (TDEFW) pump test performed in accordance with procedure PT/2/A/0600/012 and was used to determine the limiting hole size for leakage to ensure that the EFW inventory will not be depleted during an EFW actuation.

Because the SSF ASW System cannot be pressurized to 1280 psig during normal plant operation, system leakage testing is proposed to be performed at 850 psig, which corresponds to the pressure at which the system leakage test (IWD-5221) has been performed in accordance with procedure MP/0/A/1720/017. At 850 psig, the critical leakage rate is calculated to be approximately 3.5 gpm, which corresponds to a leak rate of 4.5 gpm at 1280 psig.

Additional Actions to Assure Continued Component Structural Integrity and System Functional Integrity

1. System Pressure Tests

   System pressure tests shall be conducted on the Unit 2 SSF ASW piping monthly at a pressure not less than 850 psig to confirm that the leakage rate has not exceeded the maximum allowable rate of 3.5 gpm, until such time that a repair/replacement activity in accordance with ASME Code, Section XI, IWA-4000 can be completed.

   If measured leakage exceeds the maximum allowable rate of 3.5 gpm prior to completing the required repair/replacement activity, the Operability

Determination Process will be re-entered and Operability/Functionality of the Unit 2 SSF ASW, the Unit 2 EFW, and Station ASW systems shall be determined.

If, based on pressure test data, leakage is projected to exceed 3.5 gpm prior to completing the required repair/replacement activity, the Operability Determination Process will be re-entered and Operability/Functionality of the Unit 2 SSF ASW, the Unit 2 EFW, and Station ASW systems shall be determined, unless additional pressure tests are performed to confirm that leakage is within allowable limits and is projected to remain within allowable limits until the repair/replacement activity can be completed.

2. Ultrasonic Testing

In order to ensure operability of the Unit 2 SSF ASW flow meter, daily ultrasonic testing for water level in the horizontal pipe containing 2CCW-117 will be performed to ensure that the water level remains above the SSF ASW flow meter. This effort will also provide some monitoring of the degradation of the flaw and piping by providing some information on the rate of water loss through the flaw.

Should testing results indicate the piping to be inadequately filled, (indicating a potential increase in leakage rate) a system pressure test shall be performed promptly to confirm the measured leakage rate, as specified above.

Compliance with the requirement of IWB-3522.1 would require that repairs be made to the SSF ASW buried piping, prior to returning the system to service. In order to complete a code compliant repair, the SSF ASW System would have to be declared inoperable, and repairs would have to be completed within 7 days, as required by Condition A of T.S. LCO 3.10.1. Because the through wall flaw is located in a portion of piping that is buried at a depth of approximately 23 feet, immediate repairs cannot be completed within this 7 day LCO limit. Condition F of T.S. LCO 3.10.1 would allow the system to be inoperable for a cumulative (as described in the T.S. bases) total of 45 days per year. While there is a potential that the necessary repairs might be completed within this interval, use of this provision would prevent its use should SSF systems become inoperable for other reasons at any point during the remainder of the year. As a result, compliance with IWB-3522.1 could require a Unit shutdown either if the current repairs extended beyond 45 days from discovery of the leak, or if a significant portion of the 45 day cumulative limit were consumed, followed by an extended period of SSF inoperability for any reason.

The proposed alternative documented above provides reasonable assurance that the structural and system functional integrity of the affected component will continue to be maintained until such time that a code compliant repair/replacement activity can be completed that will eliminate the flaw.

For these reasons, the proposed alternative is acceptable and compliance with the requirements of IWB-3522.1 would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety for the Unit 2 SSF ASW system buried piping at Oconee Nuclear Station.

6. Duration of Proposed Alternative

The proposed alternative is requested until such time that the allowable leak rate of 3.5 gpm (at 850 psig) is exceeded or until the next refueling outage for Unit 2 (currently scheduled to begin in April, 2010), whichever comes first.

7. Related Industry Relief Requests

7.1. McGuire Nuclear Station, Unit 1, Relief Request 07-MN-001, Relief Request from Immediate ASME Code Flaw Repair of Charging Pump Discharge Line Valve 1NV-240, Approved March 26, 2008, TAC No.MD6274.

7.2. Grand Gulf Nuclear Station Relief Request GG-R&R-002, "Request for Use of Non-ASME Code Repair to Standby Service Water Piping in Accordance with NRC Generic Letter 90-05", Approved April 29, 2003, TAC No. MB6970.

7.3. South Texas Project, Unit 2, Relief Request RR-ENG-2-47, Request for Relief from ASME Boiler And Pressure Vessel Code, Section XI Requirements for the Essential Cooling Water System, Approved November 30, 2007, TAC No. MD6189.

7.4. Indian Point Unit 3 Relief Request 3-43 Regarding Temporary Non-Code Repair To Service Water Piping, Approved February 22, 2008, TAC No. MD6831.

7.5. Saint Lucie Nuclear Plant, Unit 2, Relief Request No. 34 Regarding Temporary Non-Code Repairs of Intake Cooling Water (ICW) Class 3 Piping, Approved April 22, 2003, TAC No. MB6927.

8. References

8.1. US NRC Regulatory Issue Summary 2005-20, Rev. 1, Revision to NRC Inspection Manual Part 9900 Technical Guidance, “Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety”.

8.2. NRC Generic Letter 90-05, “Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping”.

8.3. Prompt Determination of Operability for SSF ASW System (Oconee Problem Investigation Process Report #O-09-5808) [Attachment 1].

8.4. Oconee Problem Investigation Process Report #PIP O-09-06068.

8.5. Procedure MP/0/A/1720/017, “System Leakage Test Controlling Procedure”

Attachment 1

Unit 2 SSF ASW Buried Piping Prompt Determination of Operability

Note: The following abbreviations and acronyms apply to the following Prompt Determination of Operability (PDO). This page is not documented in, and is not a part of, the PDO.

AP- Abnormal Procedure
CCW – Condenser Circulating Water System
EC – Engineering Change
EFW System - Emergency Feedwater System
EP – Emergency Procedure
EPRI – Electric Power Research Institute
GW – Guided Wave
HPI – High Pressure Injection System
HW – Hotwell
MCE – Mechanical/Civil Engineering
MDEFW - Motor Driven Emergency Feedwater
MIC - Microbiologically Influenced Corrosion
NSD – Nuclear System Directive
OBDN – Operable but Degraded, Nonconforming
OE – Operating Experience
OEDB – Operating Experience Database
ONPR – Oconee Nuclear Problem Report
OP – Operating Procedure
OSC – Oconee Station Calculation
OTSG – Once Through Steam Generator
PDO – Prompt Determination of Operability
PIP – Problem Investigation Process
PRA – Probabilistic Risk Assessment
PT – Periodic Test Procedure
RBS – Reactor Building Spray System
RCS – Reactor Coolant System
SBO – Station Blackout
SG – Steam Generator
SLC – Selected Licensee Commitments
SPR –Station Problem Report
SSF – Safe Shutdown Facility
SSF ASW System – Safe Shutdown Facility Auxiliary Service Water System
Station ASW System – Station Auxiliary Service Water System
TCOA – Time Critical Operator Action
TDEFW - Turbine Driven Emergency Feedwater
TS – Technical Specification
UFSAR – Updated Final Safety Analysis Report
UST – Upper Surge Tank
UT – Ultrasonic Testing
WR – Work Request

Unit 2 SSF ASW Buried Piping Prompt Determination of Operability

Statement of Problem

On 8/18/09 Ops identified that the Unit 2 SSF ASW flow gage was fluctuating between 60 gpm and 109 gpm. A series of troubleshooting steps identified that an apparent leak exists in the buried portion of the piping at elevation 771'9" (+/- 1"). This puts the leak at the bottom of the vertical run on the south side of the SSF ~23 feet below grade and under the south entrance flood barrier foundation. Later visual inspection verified this leak was on the bottom side of the elbow at the lower end of this vertical run, near the elbow to horizontal pipe weld.

These SSF ASW, EFW, Station ASW and the alternate EFW flow path through 2FDW-47 share the piping which contains the leak. Degradation of piping pressure boundary, flow diversion out the leak, water hammers that may result from voids created by draining, and delay in delivery of feedwater to the 2B SG are issues could negatively impact the ability of these systems to fulfill their design or licensing basis requirements.

Extent of Condition

This section prepared by Frank Eppler and checked by Ken Grayson

In the case of buried piping, Operating Experience (both internal and industry) supports that the majority of leaks are pinhole corrosion, initiated on the OD, due to a coating defect or degradation. As shown in the Generic Letter 90-05 these pinhole leaks do not threaten the structural integrity of the piping. The leak identified on the U2 SSF ASW piping, as well as the 2006 leak on U3 SSF ASW substantiate this OE and judgment. There may be other locations on U1, 2, & 3 SSF ASW piping where OD pitting is occurring; however, this does not threaten structural integrity. In addition for Units 1 and 3, there were no fluctuations in SSF ASW flow observed during an inspection on 8/18. Pressure observed at local gauges in the SSF Pump Room for Unit 1 and Unit 3 are within the expected range. Therefore, there is no indication of leakage from the Unit 1 and the Unit 3 SSF ASW piping. The integrity of the remaining portions of the Unit 2 SSF ASW piping is supported by a comparison of the identified flaw size with the estimated flaw based on the identified leak rate. A first leak rate test performed on 8/21/09 identified a leakage value of ~0.31 gpm at 825 psig which corresponds to a flaw size of ~0.023 inches. The flaw identified by video inspection was determined to be ~0.021 inches. A second leak rate test was conducted on 8/26/09 at 850 psig and 1150 psig. The leakage rates were measured to be 0.35 gpm and 0.4 gpm respectively. This indicates that the leak has not changed since the first leak rate test and that structural integrity is confirmed.

In addition to the information above, a pressure test is performed on this piping approximately every 3 years per ASME Section XI. Based on the testing, there have been no indications of any instrument reading anomalies that would indicate a potential leak on Units 1 and 3.

In order to ensure operability of the Unit 2 SSF ASW flow meter, daily ultrasonic testing for water level in the horizontal pipe containing 2CCW-117 will be performed to ensure that the water level remains above the SSF ASW flow meter (WR 987579). This effort will also provide some monitoring of the degradation of the flaw and piping by providing some information on the rate of water loss through the flaw. In addition, a pressure test will be performed monthly to gauge the pipes integrity, monitor any continued degradation and determine the rate of water loss through the pipe flaw (WR 987621).

A modification (EC# 101693) is being implemented on Unit 2 SSF ASW system that will install new piping and abandon the portion with the current leak. This EC will perform a similar scope on Unit 1 & 3 SSF ASW piping. Condition of the remaining SSF ASW buried piping will be addressed by corrective actions determined from a cause investigation into this event.

Current Licensing Basis Requirements or Commitments

SSF Licensing Basis:
The following is excerpted from TS B3.10.1.

The Standby Shutdown Facility (SSF) is designed as a standby system for use under certain emergency conditions. The system provides additional "defense in-depth" protection for the health and safety of the public by serving as a backup to existing safety systems. The SSF is provided as an alternate means to achieve and maintain the unit in MODE 3 with average RCS temperature $\geq 525^{o}F$ (unless the initiating event causes the unit to be driven to a lower temperature) following 10 CFR 50 Appendix R fire, sabotage, turbine building flood, station blackout (SBO) and tornado missile events, and is designed in accordance with criteria associated with these events. In that the SSF is a backup to existing safety systems, the single failure criterion is not required. Failures in the SSF systems will not cause failures or inadvertent operations in other plant systems. The SSF requires manual activation and can be activated if emergency systems are not available.

The SSF is designed to maintain the reactor in a safe shutdown condition for a period of 72 hours. The SSF is also used to mitigate the following: 10CFR50 Appendix R fire, turbine building flood, sabotage, SBO, or tornado missile events. This is accomplished by re-establishing and maintaining Reactor Coolant Pump Seal cooling; assuring natural circulation and core cooling by maintaining the primary coolant system filled to a sufficient level in the pressurizer while maintaining sufficient secondary side cooling water; and maintaining the reactor subcritical by isolating all sources of Reactor Coolant System (RCS) addition except for the Reactor Coolant Makeup System which supplies makeup of a sufficient boron concentration.

The SSF ASW system serves as a backup to the EFW system for events that result in a loss of all EFW and for a single failure that renders condenser hotwell inventory unavailable for the EFW System. The SSF ASW system is also credited in the mitigation of a Turbine Building Flood to:

1- Provide a source of water from the Unit 2 CCW inlet piping for OTSG secondary side cooling.
2- Drive the SSF-CCW suction line air ejector.
3- Use the Submersible pump to replenish the Unit 2 CCW inlet pipe with raw water for the SSF.

The portion of SSW ASW piping that contains the flaw is considered high-energy Class 3; therefore as outlined in NSD-203 (Operability/Functionality) Section F.12 (Flaw Evaluation), 10CFR50.55 provides requirements that structural integrity must be maintained in conformance with ASME Code Section XI. The Code specifies acceptable flaw sizes based on the material type, location, and service of the system within which the flaw is discovered. As documented in NRC Regulatory Issue Summary (RIS) 2005-20, Revision 1 (Operability Determination and Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety) and NSD-203 the NRC has approved the use of the alternate evaluation method documented in Generic Letter 90-05 (Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping) for high-energy Class 3 piping.

EFW Licensing Basis:

The EFW system provides sufficient feedwater supply to the steam generators of each unit during events that result in the loss of condensate/main feedwater in order to remove energy stored in the core and the primary coolant.

Station ASW Licensing Basis:

Station ASW is shared amongst all three Oconee units and is designed for decay heat removal following a concurrent loss of each unit's Main Feedwater, Emergency Feedwater, and Decay Heat Removal systems. Loss of these systems can be postulated as a result of a tornado.

Assumptions, Evaluation Inputs/Methods

Assumptions:

1. Hand calculation methods are sufficient for evaluation of the water hammer loads using appropriate formulas from industry standard references for water hammer.
2. Hand calculation methods are sufficient for evaluation of leak rates through the flaw.
3. Visual and UT inspection is sufficient for characterization of the flaw geometry.
4. Additional assumptions are stated in each section as appropriate.

Methodology:

In order to conservatively bound the impact of the leak in the SSF ASW system, the following issues/activities were resolved/completed.

1. Determine the cause of the piping flaw and examine transportability to Units 1 and 3. Testing/monitoring of Units 1 and 3 may be needed.
2. Characterization of the flaw in the Unit 2 piping so as to determine the leak rate during normal plant operation when there will not be flow in the SSF ASW, EFW and Station ASW systems.
3. Determination of bounding leak rates for the SSF ASW, EFW and Station ASW during event mitigation to ensure that the piping flaw will not result in excessive diversion of flow. Excessive diversion of flow could result in insufficient rate of feedwater delivery to the steam generators and could reduce margin in available feedwater inventory.

4. Determination whether water hammer will occur during actuation of the SSF ASW, EFW and Station ASW systems if the leak creates a void in the piping and perform appropriate stress analysis to ensure piping integrity. The stress analysis must include impact on the overall piping pressure boundary and supports, and evaluation of stress in the vicinity of the flaw.
5. Determination of the growth rate of the flaw during normal operation and during operation of the SSF ASW, EFW and Station ASW systems to ensure that these systems remain capable of event mitigation until the flaw is repaired. Monitoring activities to ensure this PDO remains bounding may be required.
6. Determination of the impact on the SSF ASW flow meter to ensure that existing event mitigation procedures will remain valid and determination of monitoring activities to ensure that the flow meter remains submerged. Exposure of the flow meter to air bubbles during refill of the SSF ASW line or allowing water to drain below the flow meter would negatively impact the flow meter and prevent use of this instrument during event mitigation. Actions to monitor for and correct erratic operation of the flow meter may be needed.
7. Determine the impact of the flaw and stress analysis with respect to compliance with ASME Code and other Regulatory directives.
8. Determine the impact of soil erosion due to operation of the SSF ASW, EFW or Station ASW system which will cause higher rates of leakage due to higher pressures in the piping.
9. Determine if there is an impact on flooding of the SSF or an impact on the Unit 2 siphon capabilities.

Evaluation:

The following sections were prepared and checked as indicated:
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Waterhammer Evaluation
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This determination was needed to ensure pipe integrity was assured if the water in the piping was lost through the hole. This was produced in two stages. The potential loads from the pressure surge were prepared by Mark Smith and checked by David Wilson. The piping stress analysis was prepared by Geary Armentrout and checked by Dave Peltola.

Loads Due to Pressure Surge:
A small leak has been found in the SSF ASW piping at elevation 771'9" that could drain a portion of the FDW, EFW, Station ASW and SSF ASW piping upstream of the Unit 2 B SG due to SSF ASW isolation valve 2CCW-117 being maintained normally open. Draining of this piping will result in formation of a single contiguous void at the low point formed by the common header where the FDW, EFW, Station ASW and SSF join together. The void will extend upstream from the point where each of these flow paths connect to the common header to the 2B SG back to the first normally closed valve or high point (loop seal) in the flow path. The void will extend downstream in the common header up to check valve 2FDW442 The 2A SG is not affected because the cross tie to the 2A SG is downstream of the void location in piping that will remain water solid.

The potentially affected flow paths are as follows. (Isometric drawings showing the elevations stated in this portion of the PDO can be found in the stress calculations documented below. The elevations are also shown on drawing O-1573 B).

1. EFW to the 2B SG via 2FDW-316. The void extends from the discharge side of 2FDW-316 (825.3 ft) to check valve 2FDW 442 (816.5 ft) in the common header to the 2B SG.
2. FDW to the 2B SG via 2FDW-47. The void extends from the loop seal formed by draining the horizontal piping (828 ft) that contains check valve 2FDW-432 to check valve 2FDW-442 (816.5 ft) in the common header to the 2B SG.
3. Station ASW to the 2B SG via 2CCW-116. The void extends from the discharge side of 2CCW-116 (828 ft) to check valve 2FDW-442 (816.5 ft) in the common header to the 2B SG
4. SSF ASW to the 2B SG via 2CCW-117. The void extends from the water surface in the riser to 2CCW-117 (810.25 ft) to check valve 2FDW-442 (816.5 ft) in the common header to the 2B SG. The water surface may be below 2CCW 117 as discussed below.

The piping downstream of check valve 2FDW-442 is assumed to remain full of water while any void is being created. This piping is normally filled to the steam generators at the startup from an outage. The leakage from the flaw in the SSF ASW piping could cause the piping upstream of 2FDW-442 to drain and create a void. For this void to extend downstream of check valve 2FDW-442, it would need to leak. Downstream of check valve 2FDW-442 are two additional check valves (2FDW 346 and 2FDW-233) to prevent pressurizing the piping upstream of 2FDW-442. If check valve 2FDW-442 leaks there is a possibility that 12 feet of horizontal piping (approximate) between 2FDW-442 and 2FDW-346 could depressurize to the pressure of the void and potentially partially drain. Once this piping reaches void pressure, the only pressure to cause draining back past 2FDW-442 is the standing head in this horizontal piping (~5.8 inches). This pressure head is not sufficient to drain more than a small amount of water, if any, from this horizontal length of piping. Engineering judgment of the pressure relationships that will result during the formation of the void permits a conclusion that the piping downstream of 2FDW-442 will remain filled with water even if it depressurizes. The piping downstream of check valve 2FDW-442 is fixed at penetration 17 (refer to stress analysis) which is between check valves 2FDW-442 and 2FDW-346. This prevents deflections caused by water hammer upstream of 2FDW-442 from being transmitted to piping inside the Reactor Building. The stress analysis performed for the void formed upstream of check valve 2FDW-442 will remain bounding for a partially filled pipe between check valves 2FDW-442 and 2FDW-346 because the pressure loads due to water slug contact with partially filled piping is a water to water impact which results in differential pressures one-half the magnitude of water to metal impacts. This permits a conclusion that the stress analysis applicable to water hammers due to a void upstream of 2FDW-442 is bounding for a condition where the piping between 2FDW-442 and 2FDW-346 is depressurized or partially drained. Further discussion follows on the potential water hammer mechanisms due to void formation.

The Station ASW flow path is listed for completeness but water hammer loads were not calculated. If the Station ASW system is used to supply the SGs, SG pressure will be low and there are expected to be air voids in the piping, i.e. the system is maintained in a dry state. The discussion below for water hammer bounds the conditions that may be experienced by the Station ASW system if flow via the above EFW, FDW or SSF ASW flow paths occurs with the void filled with air.

In the absence of air inleakage into the void volume, the drainage of water through a hole in the SSF ASW piping at 771'9" elevation would stop when the pressure in the void reached approximately zero psia at the highest elevation, i.e. 828 ft. With zero pressure at 828 ft, the water level will be 33 ft lower or 795 ft. Thirty three feet of water head is equal to atmospheric pressure head. It is not possible to create a pressure lower than zero so the draining will stop at this elevation. The Station ASW system is normally maintained empty which results in a potentially empty volume between 2CCW-116 and the downstream check valve 2CCW-152. The size of this volume is 4.46 ft^3. The potential impact on final level of water in the riser to 2CCW-117 has been evaluated and shows that water would need to drop an additional 2 ft to result in zero pressure at an elevation of 828 ft. Accordingly, if no other source of air inleakage is present, the water could drain to an elevation of 793 ft. An additional source of inleakage is leakage back through 2FDW-442. This leakage is expected to be of very small amounts and to remain in a mostly liquid state with very little flashing. The amount of flashing is so small that it will not contribute to a significant increase in volume.

If air inleakage is possible (inadvertent opening of a vent valve), the drainage could continue down to the flaw elevation of 771'9". Potential sources of air inleakage are vent valves that may be opened or trapped air in a system between an isolation valve and a check valve.

Potential Water Hammer Mechanisms

Initiating flow from EFW, FDW, or SSF ASW will refill any void formed by leakage. Each of these flow paths would be operated independently so the potential water hammers in each flow path will not happen simultaneously. Although EFW actuation could occur when main feedwater is still in service (low SG level), 2FDW-47 would not be open at that time. The reason for 2FDW-47 to be open would be to throttle EFW with the startup control valve (in the event that 2FDW-316 is broken during EFW operation thereby isolating the EFW flow path), and no other situations for flow are credible through this line. Dave Coyle of Operations was contacted to see if any other scenarios were known to cause simultaneous usage, but he validated that there are no known reasons for such an occurrence.

The potential water hammer conditions are bounded by two scenarios. 1) Refill of the void assuming that it does not contain any non-condensible gas such as air, and 2) refill of the void assuming it contains only non-condensible gas. Condition 2 could be created by opening a vent valve to bring the void to atmospheric pressure.

Refill of Void with No Non-Condensible Gas:

The potential water hammer mechanism for this condition is slug flow impacting elbows, bends or other obstacles such as check valves or water located beyond the void. These impacts will result in a pressure spike (differential pressure) and a resulting force on the piping in the direction of flow. The magnitude of the pressure spike determines the resultant force. There will be reflected forces upstream after each water hammer but these loads are lower due to damping and eventually dissipate. Use of the initial loads at each water hammer location is bounding for the reflected loads. Methodology for determining water hammer loads is described in EPRI TR-106438, Water Hammer Handbook, May 1996.

The magnitude of the pressure spike is determined from the Joukowsky Equation:
deltaP = (density, lbm/ft^3) (sonic velocity, ft/s) (flow velocity, ft/sec)/(32.2 (lbm ft)/(lbf s^2)*144 in^2/ft^2)

The magnitude of the resultant force caused by the pressure spike is determined as follows:
Force = (density, lbm/ft^3) (flow area, ft^2) (flow velocity, ft/sec)^2/(32.2 (lbm ft)/(lbf s^2))

The pressure spike is dependent on the fluid density and velocity. Flow velocity has the greatest impact on calculated pressure spike and resultant forces. The potential water hammer forces were conservatively derived using maximum density and flow rate. The sonic velocity in water was conservatively taken to be 4500 ft/second which does not assume any air bubbles that would cushion impact forces (EPRI TR-106438, Water Hammer Handbook, May 1996).

The conditions chosen for calculating water hammer conditions for each system are as follows:

SSF ASW: Pressure = 1080 psia, Temperature = 40 degF, Flow rate = 500 gpm
FDW and EFW: Pressure = 1080 psia, Temperature = 85 degF, Flow rate = 1000 gpm

The pressure condition corresponds to 101% of the lowest MS pressure relief valve setting (1.01 * 1050 = 1060.5 psig which was increased to 1065 psig for conservatism). Use of this pressure is conservative for a void at vacuum but it is realistic for a void filled with air as discussed below. The temperature condition corresponds to a conservatively chosen low temperature to maximize density in the above water hammer equations.

For SSF ASW, the maximum permissible flow rate is 500 gpm as documented in AP/0/A/1700/025 and EP/x/A/1800/001, Rule 7. For the FDW and EFW flow paths listed above, the maximum allowable flow rates are 1000 gpm for both as documented in EP/x/A/1800/001, Rule 7.

The maximum flow rate results in the highest water hammer pressures and forces. Use of the maximum flow rate is also extremely conservative because actual operation of these systems will not result in instantaneously delivering the maximum flow rates. Either manual or automatic operation of throttle valves will be used to initiate flow which will result in filling of the void at a much lower flow rate which will result in much lower actual water hammer loads. Maximum flow rates should not be achieved until the void is refilled if it is a void at vacuum or until the void is pushed into SG if the void is filled with air.

The above pressure and flow conditions resulted in peak pressures and forces as follows:

SSF ASW: pressure spike = 374 psi, resultant force = 13.3 lbf
FDW and EFW: Pressure spike = 745.1 psi, resultant force = 53.1 lbf

Water hammer pressure spikes (differential pressure) were added to the pressure used for calculating density (1065 psig) for input to the piping stress analysis for additional conservatism. This approach is extremely conservatively because, for a void at vacuum, the actual pressure resulting from the impact is not going to be greater than the calculated differential pressure (deltaP). For the condition where the void is filled with air, the void could pressurize to a value greater than 1065 psig depending on flow losses. The temperature used to determine allowable stresses for the stress analysis is system design temperature which is much higher. The use of system design temperature results in a very large amount of conservatism. If pressure conditions are actually higher than 1065 psig at the void, the conservatism afforded by use of design temperature for allowable stresses ensures the stress analysis remains bounding.

The pressure and force inputs to the stress analysis are as follows:

SSF ASW: pressure = 1439.9 psi, resultant force = 13.3 lbf
FDW and EFW: Pressure spike = 1810.8 psi, resultant force = 53.1 lbf

Pipe stress analysis was performed using the above pressure and resultant force conditions in conjunction with the system design temperature in lieu of using the temperature used for determining density. The higher system design temperature in the stress analysis results in lower allowable stresses.

Refill of a Void Containing Non-Condensible Gas (Air):

The EFW, FDW and SSF ASW piping systems discussed above all discharge to the EFW discharge nozzles in the 2B SG. The discharge points are open pipes. If the void is filled with air, operation of these systems would involve admitting flow to the piping and pushing the air void toward the SGs. This will increase the pressure in the void which will tend to push water downstream of check valve 2FDW-442 into the 2B SG followed by the compressed void and water. This condition is very similar to that for a Reactor Building Spray header in which flow is initiated into a horizontal pipe which contains a void upstream of the spray riser. Water hammer issues for RBS headers of this type and other possible RBS voiding situations have been evaluated and documented in Fauske and Associates technical paper FAI/08-78, "Waterhammer Potential in CS Header and HL Switchover Piping", 8/22/08. In that paper, it states that "... there are no significant water hammer events that could be generated from either the header filling or from the compression of an accumulated gas bubble upstream of the riser for any reasonable parameters of piping sizes and gas volume accumulation." The lack of water hammer concerns is due to the ends of the flow path being open which prevents significant accumulation of pressure as flow is admitted to the system. This statement also allows the assumption that the piping is filled with air all the way to the flaw at elevation 771'9".

Operation of the RBS systems evaluated in FAI/08-78 is similar to the manner in which the EFW, FDW and SSF ASW systems would be operated to deliver flow to the 2B SG. What differs is that RBS flow is at a lower pressure but a much greater flow rate than the assumed flow rates for the SSF ASW, EFW and FDW. Also, that the RBS spray header will have more outlet points than the EFW spray ring in the SG. None of these differences prevents extending the conclusions drawn in FAI/08-78 to feedwater flow entering a steam generator via its emergency feedwater ring.

As with RBS flow, feedwater flow would be gradually admitted into the flow path depending on the speed of valve opening. This is consistent with the FAI/08-78 analysis. As flow increases, the pressure in the void will increase and there will be a tendency for the liquid flow to pick up the air as velocity increases and carry it downstream thereby decreasing the void size (compression) or breaking it up to mix in the flow. This process will tend to cushion the impact of water slugs against elbows and reduce the tendency for water hammer. As flow increases, the pressure in a single void or discrete voids mixed with the flow will ultimately increase up to 1065 psig (1080 psia) which is the pressure in the 2B SG. At this pressure, the water downstream of 2FDW-442 will be driven into the SG. The void(s) will follow this water to the 2B SG which will promote further mixing of larger voids into the flow and increase the cushioning effect from air entrainment as the flow proceeds through the flow path to the 2B SG. By the point where flow branches to the cross tie to the 2A SG, the void should be broken up into smaller volumes to the point that the flow has a frothy characteristic. Small amounts of air entrained in water can substantially reduce the sonic velocity which results in much reduced water hammer loads. As little as 0.4% air in water in the form of bubbles can reduce the sonic velocity from 4500 ft/second to 1000 ft/second. (EPRI TR-106438, Water Hammer Handbook, May 1996).

Assuming that the air void remains intact is conservative. In this case, the gas void is flowing at the same flow rate as the water and at steam generator pressure. Any changes in pipe direction encountered by the flow on the upstream end of the water flow in contact with the gas void could result in a pressure spike and resultant force as described previously for filling a void at vacuum conditions. The stress analysis discussed above and provided by MCE/Civil for this PDO is also applicable to these water hammer conditions because it uses realistic pressures for this condition. It remains conservative because it assumes the maximum flow rate immediately begins to compress the void when flow is initiated whereas the increase in flow rate will be mediated by the rate of valve opening either by manual or automatic means. Also, the rate of flow increase will be reduced having to expend flow energy to compress the gas void. The use of system design temperature for determining allowable stresses remains conservative as described before.

Summary (Water Hammer Loads on Piping):

Two potential scenarios for water hammer are bounding for initiating EFW, FDW and SSF ASW to the 2B SG with a void in the flow path. The void could be at vacuum if the system was air tight or contain air (up to atmospheric pressure) all the way to the pipe flaw. Water hammer loads for these scenarios have been determined using extremely conservative conditions and provided to MCE/Civil for pipe stress analysis. The water hammer and stress analyses demonstrate these systems can operate to fulfill their design and licensing requirements for event mitigation. A separate summary is also provided specific to the stress analysis portion.

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End of Section prepared by Smith and checked by Wilson

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Water Hammer Loading of the SSF ASW Flow Meter, 2CCWFE-0226 Due to Leakage through 2FDW-47

This section prepared by Ken Grayson and checked by David Wilson.

The SSF ASW piping will be maintained filled with water above the elevation of the SSF ASW flow meter. Therefore, the only water hammer that could act on the flow meter is due to the leakage through 2FDW-47.

Piping from the EFW system, the SSF ASW system, the station ASW system, and the feed water system all tie into a common header. Small water hammers were observed approximately every 10 seconds in the feed water piping at 2FDW-432.

A 0 to 100 psig test gauge was installed at 2CCWPG0434 in the SSF Pump Room. Pressure recorded at the test gauge with 2CCW-117 open was 26 psig. Approximately every 10 seconds, pressure at the test gauge spiked at 36 psig to 37 psig. This data indicates that pressure surges from the feed water system water hammer were propagating through the U2 SSF ASW system piping that contains the U2 SSF ASW flow instrument. Three leak rate tests have been performed at pressures of 825 psig, 850 psig and 1150 psig. These tests confirm the structural integrity at the flaw location. The magnitude of the water hammer pulses is much lower than the leak test pressure and will not contribute to fatigue at the edges of the leak hole where the flaw is located. The geometry of the flaw is conical which does not present a cantilever geometry that could be subject to bending and fatigue by the low magnitude pressure pulses.

Indicated U2 SSF ASW flow rate returned to approximately 0.1 GPM when piping containing the U2 SSF ASW flow instrument was isolated from downstream piping by closing 2CCW-117. Isolation of 2CCW-117 prevented pressure surges, due to small water hammers that were occurring in feed water piping connected to the EFW system header, from reaching the U2 SSF ASW flow instrument.

The observed fluctuation in U2 SSF ASW flow rate is caused by periodic water hammers that are occurring in downstream feed water system piping that is connected to a common header with the SSF ASW System. During an accident that requires operation of the U2 SSF ASW System, flow from the SSF ASW pump will pass the U2 SSF ASW flow instrument to the U2 SGs. Pressure in the common SSF ASW System and EFW System piping will be determined based on the pressure in the steam generators (~ 1050 psig) and friction losses in the piping. Since pressure during an accident that requires operation of the U2 SSF ASW System in the common SSF ASW System/EFW System piping is expected to be >= to the pressure in feed water system piping connected to the EFW system, leakage from the feed water system to the EFW system piping is not expected to occur while the U2 SSF ASW System is operating. Therefore, condensate induced water hammers caused by leakage from the feed water system to the EFW system are not expected to continue, and are not expected to impact indicated SSF ASW flow rate once SSF ASW flow to the U2 SGs has been established. This issue will not prevent the U2 SSF ASW System from performing its required safety function.

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End of Section prepared by Grayson and checked by David Wilson.

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This paragraph was prepared by Terry Harbinson, checked by Greta Sparks and approved by Bill Edge

With respect to the instrumentation, flow transmitter 2CCW FT 0225 is a Rosemount Model 1153 DB3RB. Per Rosemount's Product Data Sheet PDS 4302 (Reference OM-267A-0053) 1153 transmitter is rated as follows: "0.5psia to 2000 psia maximum rated static pressure for operation within specifications. Overpressure limit is 2000 psig on either side without damage to the transmitter."

[Accordingly, the pressure spikes calculated for the water hammer loads are well below the capability of the transmitter maximum differential pressure ratings. Prepared by Mark Smith and checked by David Wilson.]

Pipe Stress Analysis for Water Hammer Loads:

This section was prepared by Geary Armentrout and checked by David Peltola

Due to the hole in the underground (buried) SSF ASW piping, there is the possibility of water hammers. Mark Smith, System Engineering, provided the following waterhammer scenarios:

1- SSF Auxiliary Service Water (ASW) Waterhammer – a waterhammer initiating from the SSF Auxiliary Service Water Pump P-2 in the SSF basement towards the Steam Generator 2B Emergency Feedwater Header (Mark stated the piping at the Penetration 17 would be water-solid; hence, the waterhammer loads would not enter the Reactor Building which is applicable to the other cases as well)

Water hammer load = 13.3 lbf; Max pressure = 1439.9 psig ; Code allowable stress values to be based on design temperatures

2- Feedwater (FDW) Waterhammer – a waterhammer initiating from the second pipe elbow upstream of valve 2FDW-432 towards the Steam Generator 2B Emergency Feedwater Header. This event also includes the Station Auxiliary Service Water (ASW) piping upstream of valve check valve 2CCW-152.

Water hammer load = 53.1 lbf; Max pressure = 1810.8 psig; Code allowable stress values to be based on design temperatures

3- Emergency Feedwater (EFW) Waterhammer – a waterhammer initiating from the pipe elbow downstream of valve 2FDW-316 towards the Steam Generator 2B Emergency Feedwater Header.

Water hammer load = 53.1 lbf; Max pressure = 1810.8 psig; Code allowable stress values to be based on design temperatures

Case 1 Evaluation:

The subject 6 inch Sch. 80 piping is already qualified for the design pressure of 1440 psig; therefore, the lower waterhammer pressure of 1439.9 psig is obviously acceptable. The 13 lbs loads on the downstream elbows are trivial and of no consequence (note: these are separate loads which would occur at separate time steps and not concurrently).

It should be noted that 'evaluation of the existing stresses using the cracked section' portion of the GL 90-05 Analysis does evaluate the piping stresses at design pressure with the reduced pipe wall thickness of 0.322 inches (i.e., 0.327 inches - 0.005 inches for the coatings) identified by UT.

Case 2/3Evaluation:

The subject piping is qualified within calculation OSC 1224-21. The maximum gravity and pressure pipe stress (based on the design pressure of 1440 psig) is only 8000 psi. The increase of 370.8 psig (i.e., 1810.8 - 1440) will result in a longitudinal pressure stress increase of 1150 psi. The maximum stress with the waterhammer pressure stress will be 9150 psi which is still well within the Code allowable value of 15000 psi for sustained (Eq. 8) loading. This is conservative as the Code permits allowables to be increased by 20% for occasional loads, which apply for waterhammer loadings. It should be noted this is does not consider the cascading waterhammer load of 53.1 pounds on each elbow, which are not significant by Engineering Judgment.

In support of this judgment, the SUPERPIPE piping computer model from calculation OSC 1224-21 was updated to include waterhammer pressure of 1810.8 psig and the waterhammer load of 53.1 lbs on the appropriate piping locations. The maximum computed stress is 9298 psi which only 62% of the B31.1 sustained allowable of 15000 psi (conservative as previously discussed). As also noted the Code allowable stress values were based on the design temperatures. All support/restraint (hanger) loads for this occasional load of gravity, thermal and waterhammer were less than the occasional design loads based on the gravity, thermal and OBE seismic. Therefore, clearly the waterhammer support loads are acceptable.

Circumferential (Hoop) Pressure Stress:

The Code required minimum pipe wall thickness for a 6 inch pipe with an internal pressure of 1810.8 psig is 0.381 inch. This schedule 80 pipe has a nominal wall thickness of 0.432 inch and is therefore acceptable for the circumferential pressure stress. This pressure stress evaluation does not apply to the flaw in the piping. Additional analysis for the flaw location is provided in the GL 90-05 Analysis section. This pressure stress also does not apply to Unit 2 SSF ASW piping segments that are buried for reasons discussed in the water hammer analysis.

Conclusion (waterhammer pipe stress):

The SSF ASW, FDW, Station ASW and EFW systems will remain Operable for the projected waterhammer events as the ASME and B31.1 Piping Codes are satisfied and the support/restraints are capable of withstanding the waterhammer loads. In addition, the piping has sufficient wall thickness to endure the waterhammer pressures (relative to hoop stress).
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End section prepared by Armentrout and checked by Peltola
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End of Waterhammer Analyses
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Impact of Air in the Steam Generators:
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This paragraph was prepared by Greg Byers and checked by Mark Smith.

The purging of air present in the SSF ASW piping into the SGs will not degrade the heat transfer from the SG tubes to the SSF ASW water when it enters the SGs. Subcooled water flowing down the outside of the SG tubes will heat up and flash regardless of whether there is an air environment or steam environment present in the secondary. It is expected that this air volume will quickly be expelled from the SGs after SSF ASW flow begins entering the SGs and vaporizing. Based on this, the ability of the SSF ASW system to promote natural circulation and provide RCS heat removal will not be affected by this concern.

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End of Impact of Air in the Steam Generators:
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ASME Code and Regulatory Compliance
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Determination of Hole Size Based on Measured Flow Rate

This analysis was required to demonstrate pipe integrity with the presence of a flaw. This analysis is based on Generic Letter 90-05 requirements, which is a structural integrity evaluation approach permitted in RIS 2005-20, Revision 1 for high energy Class 3 piping.

This was produced in two stages. The determination of the hole size based on the calculated leakage rates was prepared by Brian Richards and checked by Bill Eister. The GL 90-05 analysis was prepared by Dave Peltola and checked by Geary Armentrout.

Determination of Hole Size:

Eq 1 (Crane Equation 3-16): Q = Cv * sqrt(ΔP)
Eq 2 (Crane Equation 3-16): Ktot = K(entrance) + K(exit) + K(length) = 891d^4/(Cv)^2
Eq 3 (Crane Equation 3-15): K(length) = fL/D

When performing the leak rate test on the Unit 2 SSF-ASW piping, the system was filled and pressurized to 825 psig. It is conservative to assume that the leak is exiting the piping at atmospheric pressure (0 psig). The test determined that the leak rate was 0.31 gpm.

From using Eq 1, Cv = 0.0.010793

In order to determine the hole diameter, a K-value for the hole must be determined. Conservatively, the through-wall hole is assumed to be a small pipe, with an entrance, an exit, and a hole length. Per the Crane manual, these K-values are as follows:

K(entrance)		= 1
K(exit)		= 0.5
K(length)		= Eq 3
	f	= 0.04 (conservatively rough)
	L	= 0.432 inches (wall thickness of 6" Schedule 80 piping)

Eq 2 and Eq 3 both use a diameter (d and D, respectively). By using Excel to iterate until the two values are equal, a flaw diameter of 0.0233 inches is found. This hole size is equivalent to 1/43 of an inch.

Visual inspection performed on 8/24/09 by GE Inspection Technologies measured the hole diameter to be 0.021 inches. This shows the above approach has good correlation between hole size and leak rate.

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End of section prepared by Richards and checked by Eister
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GL 90-05 Analysis:

This section prepared by David Peltola and checked by Geary Armentrout

The determination of the limiting flaw allowed by Generic Letter (GL) 90-05 criteria has been completed and checked. No assumptions or exceptions were taken with the GL 90-05 "Through-Wall Flaw" methodology.

System ONS2 SSF ASW Piping
Piping is 6" schedule 80
Design Pressure: 1440 psi
Design Temperature: 100 degF
Material: SA106 Grade B

Flow diagram: OFD-133A-2.5, Rev 44
Layout drawings:O-447C, Rev 3

The results show that the maximum flaw size that meets all the GL 90-05 criteria is 1.35 inches. The fracture mechanics criteria are more limiting than the stress criteria. That is, the flaw stability analysis for the 1.35 inch circumferential flaw results in a stress intensity of 34.9 ksi-root-inch as compared to an allowable stress intensity for carbon steel of 35.0 ksi-root-inch, a 0.997 ratio. The Faulted condition stress ratio is 0.38 for the un-cracked pipe section and 0.50 for the cracked pipe section. The Code allowable for the stress ratio is 1.0, so the stress ratio has considerably more margin (a factor of 2) than the fracture mechanics stability analysis. This GL 90-05 analysis is based on a "through wall" piping model that has no wall thickness (i.e., conservatively a thru-wall hole) in the area containing the limiting flaw and uses actual pipe stresses for the buried pipe elbow taken from calculation OSC-1147, Rev 10.

Ultrasonic Testing (UT) was performed on the 6 inch sch. 80 piping (0.432 inch nominal wall thickness, 0.378 inch minimum wall thickness)near the leak and at other relevant locations on the piping to support the wall thickness and the flaw length used in the GL 90-05 analyses. The UT method used the water in the pipe as a couplant, and therefore the areas of inspection were limited to the piping under the standing water, but did include the leak location. The minimum pipe wall thickness of 0.25 inches was observed for only one instance during the scan right at the leak location. Away from the minimum wall value, the UT wall thickness value rapidly increased up to the 0.327 to 0.329 inch thick range, supporting a deep pit geometry scenario. The UT Tech reported that the wall thickness increased to the higher values within 0.25 inches on either side of the minimum wall value. The actual UT "2a" value is therefore about 0.5 inches; the GL 90-05 allowed "2a" value is 1.35 inches, with a resulting margin of 2.7 (1.35/0.5). Although the UT technique was not qualified, it was considered to be a 'best effort' examination. Also, it was performed by experienced, qualified personnel with calibrated equipment. The margin between measured and allowable GL 09-05 flaw size provide an adequate basis for reasonable assurance of structural integrity.

Therefore, the "2a" flaw length determined by UT is 0.5 inches, and is less than the allowed GL 90-05 value of 1.35 inches (in "2a" length), and the flaw is acceptable based on GL 90-05 criteria. Note that a leakage test and calculation has determined that the leak is 0.3 GPM at 825 psi pressure. Therefore, the flaw is obviously much less than that allowed by GL 90-05 criteria. The largest allowable leak from a system operation standpoint is 9 GPM at system operating pressure. This corresponds to an 0.1069 inch hole diameter. Therefore, the allowed system leakage is a more limiting condition than the structural stability of the flaw.

<u>Guided Wave UT</u> - Structural Integrity was contracted to perform a guided wave UT inspection to determine the condition of the piping. The elbow adjacent to the structural anchor (O-14C-447A-H7039) was removed and a 5 foot section of straight pipe was welded to the SSF ASW pipe to allow the attachment of the Guided Wave (GW) UT collar. Several different attempts were made to develop data, but the GW signal would not go past the structural anchor. Therefore, no data was obtained from the GW UT examination.

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End of section prepared by Peltola and checked by Armentrout

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End of ASME Code and Regulatory Compliance

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Degradation Mechanism

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Based on guidance from, RIS 2005-20 Revision 1 (Section C.11 and C.12), GL 90-05 and NSD-203 (Section F.12) the "degradation mechanism must be readily apparent". The following items were complete in support of this effort:

<u>Potential Degradation Mechanisms and Applicable OE</u> - Prepared by Basil Carney and Geary Armentrout, checked by Aaron Best.

Video and individual pictures taken on 8/24/09 by GE Inspection Technologies clearly identify this leak as a pinhole. Groundwater inleakage was observed coming from a hole approximately 0.021 inch diameter near the horizontal pipe to elbow weld (elbow side) - likely in the heat affected zone. This thru-wall flaw is clearly not a crack.

Pinholes can be caused by a wide variety of mechanisms, impingent (cavitation), weld porosity, galvanic corrosion, general corrosion and Microbiologically Influenced Corrosion (MIC). However, Oconee and industry OE reveal that the majority of buried piping leaks are pinholes, created by local coating degradation on the piping OD. This is the apparent cause of this leak. UT performed adjacent to the leak location supports a deep pit geometry, as well as general corrosion occurring due to coating degradation. This piping is coated internally and externally, and does not have cathodic protection. Coating holidays 'focus' or localize general corrosion. The leak is near a weld, where the coating was likely field applied; hence, the coating application may not have been as precise.

Cavitation is not a credible mechanism at this location because this line is stagnant the vast majority of time (flow has never been put through this line). The leak location is near the elbow to pipe weld, but not in it. Therefore, corrosion of weld porosity is not credible either.

Galvanic corrosion typically occurs when dissimilar metals are electrically connected in the presence of an electrolyte. For the pipe OD to be electrically connected to the soil, a holiday (gap) in the coating is required. The subject 6 inch SSF ASW pipe is carbon steel. There are 2 large stainless steel pipes (16 inch and 12 inch diameter) buried on the south side of the SSF (elevation 793 ft and ~ 780.5 ft per drawing O-447C). The leak location is near elevation ~772 ft. Although not completely implausible, it is judged unlikely that this leak is the result of galvanic corrosion.

MIC is localized corrosion caused by the presence and activities of microorganisms, including sulfate-reducing bacteria and fungi. Secretions from these microorganisms can be acidic or may include other aggressive chemical species (e.g., sulfides, ammonia) and influence the rate of corrosion as the name implies. Microbiological activity may also alter the anodic and cathodic reactions. Most often, the microorganisms develop colonies and pitting occurs beneath these biofilm formations [3]. EPRI does note that for buried pipe "the likelihood of ID-induced leak should consider pitting related to microbiologically influenced corrosion (MIC)... that may be present" [2]. However, per System Engineering (Ken Grayson), the SSF ASW piping carries demin water; hence, likelihood of MIC is decreased dramatically. Visual inspection performed by GE Inspection Technologies also supports that this pinhole leak was OD initiated. There is some possibility of MIC on the outside the piping; however, this is remote, due the low soil temperature around this pipe and the overall excellent Oconee water quality. MIC is judged not credible as the cause of this leak.

Visual inspection by GE Inspection Technologies also substantiates that this leak is not the result of a crack. Prior to the GE Inspection Technologies visual inspection, walkdowns were performed by Civil Engineering to look for evidence of excessive ground settlement, which would be a likely cause for crack development (overload). No indications were observed in the areas near the SSF. In addition, there are at least 4 other pipes in this same area, none of which have any indication of leakage.

Operating Experience Review:

Using the available leak history for buried pipes at Oconee there have been 8 possible leaks. Two leaks were due to cavitation caused by a nearby butterfly valve. 4 leaks are known to have been caused by corrosion from the outside of the pipe inward. This type of corrosion occurs at locations where there are holidays in the coating and the defect tends to be a circular hole. There is little information available on the remaining two leaks.

A search of the OEDB found several references for pipe leaks. Most of the documents indicated that the most likely cause for these leaks is "anodic dissolution resulting from poor application of coating". See list below.

OEDB Results:

1- SPR 3247 Unit 2 CCW Discharge Pipe (unknown)
2- ONPR 3524 Unit 1 CCW Discharge Pipe (unknown)
3- PIP 1-O-92-475 Unit 1 ECCW Pipe
4- PIP O-94-519 Keowee Service Water (cavitation)
5- PIP 1-O-97-3602 Unit 1 CCW Discharge Pipe
6- PIP O-99-4561 Unit 2 CCW Discharge Pipe
7- PIP O-06-4101 & O-06-4103 Unit 3 SSF-ASW Pipe
8- PIP O-08-5841 Keowee Service Water (cavitation)
9- PIP O-09-5808 Unit 2 SSF-ASW Pipe (?)
10- OEDB 06-44291 INPO SER based on WANO SER 2006-2
11- OEDB 09-52257 Indian Point 2
12- OEDB 09-52120 Oyster Creek
13- PIP C-96-2073 RN System at Catawba
14- PIP C-97-3013 RN System at Catawba

15- PIP C-02-4100 RL System at Catawba

In summary, OE documents the majority of buried piping leaks are due to localized pitting, OD initiated, at coating defect/degradation. Visual and UT inspection performed of U2 SSF ASW pipe leak confirm that this leak is likely caused by similar OD initiated pitting corrosion.

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End of Degradation Mechanism prepared by Carney and Armentrout and checked by Best
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Visual Examination
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This section was prepared by Basil Carney and checked by Aaron Best

GE Inspection Technologies was contracted to perform an internal visual inspection of the SSF-ASW pipe to attempt to find and characterize the flaw. This inspection was performed using an Everest model XL G3 videoprobe with a 6.1 mm probe. The following results were provided by Basil Carney and reviewed by Aaron Best.

For the inspection on August 22, 2009 the videoprobe was inserted through the 3/4" half coupling for 2CCWPG434. The horizontal section of pipe was about half full of water so an inspection of the bottom half of the pipe and welds in the horizontal section was not done. Based on information as to the approximate location of the leak and the fact that the pipe was about half full of water this inspection focused on the area above the water line and the vertical section of pipe above the elbow. (Note this elbow is in the buried section of pipe outside the SSF.) This inspection identified 3 rust blooms. Based on the inspection of the pictures of these rust blooms, they were determined to not be significant. From this inspection several bubbles were seen in the lining in the pipe. Due to the small number of bubbles and the overall condition of the lining these bubbles were also determined not to be an issue

On August 23, the 6 inch elbow above valve 2CCW-287 inside the SSF was cut off. With the water drained from the pipe a small fountain of water could be seen coming from the 6 o'clock position on the elbow outside the SSF. On August 24 GE Inspection Technologies returned to the site for another inspection. This inspection focused on the lower portion of the pipe to elbow weld and a small, 0.021 inches, irregular shaped hole could be seen as the source of water. Based on the shape of the area around this hole, the hole was due to OD initiated corrosion.

Additionally, no water could be seen coming down the vertical section of pipe or from any other location on the elbow. Based on the results of these two inspections the leak in the elbow was the only leak source found.

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End of Visual Examination prepared by Carney and checked by Best
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Impact of Potential Transport of Coating Particles/Flakes to the Steam Generators

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This section was prepared by Brian Richards and checked by Brian Pipkin.

If the SSF-ASW pump is actuated, the areas of blistered coating on the inside of the SSF-ASW piping (approximately 1 inch across) are expected to flake off the piping wall and be transported toward the steam generator. No blockage in flow is anticipated from the transport of these coating flakes because they are expected to further break apart or crumple into smaller balls (if the coating is rubberized) before reaching the Aux Feedwater header ring to the steam generator. Further, the largest postulated flake (1 inch across) could not fully obstruct even one of the six steam generator entrances in the header ring (3" Schedule 80 piping, OM-201-S-0147.001). Based on the weight and density the paint it is not expected to damage the SG tubes.

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End of Transport of Coating prepared by Richards and Pipkin.

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SSF-ASW System Function

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The evaluation was performed to ensure that the SSF-ASW system will continue to fulfill its design function to supply the Unit 2 SG

SSF ASW Water Supply Evaluation:

This section prepared by Ken Grayson and checked by Mark Smith

In OSC-4171, Rev 30, Section 9.2, the SSF service water system flow model is used to determine if the SSF ASW system is capable of providing adequate flow for decay heat removal to all affected units' SG's during an accident that requires operation of the SSF. Results from this calculation indicate that the SSF ASW pump is capable of providing at least 359 gpm to all Unit 2 SG's, 401 GPM to the Unit 1 SGs, and 404 GPM to the Unit 3 SGs during an accident that requires operation of the SSF when all three units are being fed (worst case) and the SSF ASW throttle valves for all three units are fully open. Based on an end of cycle heat load, a 350 GPM flow rate is required for decay heat removal at the start of the event. Based on a 350 GPM required flow rate, there is 9 GPM of margin for Unit 2, 51 GPM of margin for Unit 1, and 54 GPM of margin for Unit 3. . Therefore, OSC-4171 calculation results support operability of the SSF if flow diversion through the pinhole leak of the U2 SSF ASW system is less than or equal to 9 gpm.

The following conservatisms apply to the 9 GPM of margin for flow to the U2 SSF ASW system

- The 350 gpm minimum required SSF ASW flow rate is based on an end of cycle decay heat load. Earlier in a Unit's cycle, the minimum required flow rate for decay heat removal is less. Only one of the three units is expected to be at an end of cycle decay heat load due to the spacing of the refueling outages. Therefore, as flow is throttled back to the Units with lower decay heat loads, more flow will be available to Unit 2.

- Since only 350 GPM of flow is required for an EOC decay heat load, flow will be throttled to the U1 and to the U3 SGs as needed to provide adequate decay heat removal. As flow to the U1 and to the U3 SG's is reduced, the SSF ASW pump will operate further back on its head curve and will therefore be capable of providing more pressure to drive flow to the U2 SGs.
- The minimum acceptable SSF ASW pump head curve is used as an input to the calculation. Actual developed head delivered by the SSF ASW pump is higher, and therefore, the flow rate that the SSF ASW system is capable of providing to the SG's will also be higher. On 6/1/09, the SSF ASW pump delivered 1152 PSID @ 2000 GPM during pump performance testing. These results are approximately 74 psig higher than the minimum allowed head curve used in the analysis used to determine U2 SSF ASW flow margin. (Ref OSC-3233, Input 5.5, & PT/0/A/400/005)
- A three unit event is chosen for the analysis. If the actual SSF event is only a one or two unit event, the SSF ASW pump will be capable of providing more flow to the affected unit's SG's than was predicted by the OSC-4171 analysis.
- The 350 gpm minimum required flow rate is only required at the start of the event. Following a unit trip, RCS decay heat begins to decrease over time and the flow rate required to match RCS decay heat also decreases. Therefore, as the event progresses, the flow rate required to match decay heat on Unit 2 will decrease.
- The flow rate provided to the U2 SGs is chosen based on RCS parameters (initially RCS pressure, then SG level) Therefore, instrument uncertainty for the SSF ASW flow instrument will not affect the flow rate chosen to feed the U2 SGs.

SSF ASW System Inventory Evaluation:

Water for the SSF ASW System is supplied by the embedded portion of the U2 CCW inlet pipe. During an accident that requires operation of the SSF, the SSF submersible pump is installed to replenish this water supply in this pipe. For an SBO Event, installation of the SSF submersible pump is not credited.

Per results documented in calculation OSC-2322, there is adequate margin to support feeding all three unit's SG's with a 9 GPM leak present in the U2 SSF ASW piping if the SSF submersible pump is installed within the required time limit or if a gravity-induced reverse flow path is aligned. For the SBO event where the SSF submersible is not credited and gravity induced reverse flow is not aligned, there is adequate inventory to support a 4.5 GPM leakage rate from the U2 SSF ASW pipe.

Impact on Delay in Delivery SSF ASW to the SG:

With respect to SSF ASW, the time at which SSF ASW is initiated is not governed by automatic action. The potential delay in flow reaching the steam generators due to presence of a void is small compared to the time it will take to staff the SSF and initiate SSF ASW flow. Therefore, there will be no impact on the SSF's ability to perform its event mitigation function. [Prepared by Mark Smith and checked by Ken Grayson].

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End of SSF ASW System Function prepared by Grayson and checked by Smith

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EFW System Function

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Water Supply Evaluation

This section was prepared by Brian Richards and checked by Brian Pipkin.

A postulated increase in leakage from 0.3 gpm to 9.0 gpm through the hole in the SSF-ASW piping would divert additional EFW flow during an actuation event. The question is whether the 2B MDEFW and U2 TDEFW pumps can still provide the required flow to the 2B SG given this additional leakage. Note that the 2A MDEFW pump capacity is not a concern because it is not tied into the B header and would not be affected by the SSF-ASW leak.

ONTC-2-121D-0001-001 states that the safety analysis for scenarios with a MDEFW actuation requires 375 gpm to be delivered to a steam generator of the affected unit (at SG pressure of 1050 psig); this also includes a 30 gpm leakage consideration per EFW header. ONTC-2-121D-0002-001 states that the TDEFW pump must provide at least 435 gpm plus recirculation flow at 1050 psig SG pressure. This includes the system leakage between pump and SG that is assumed to be a maximum of 30 gpm per header. The most recent performance of the quarterly TDEFW pump test (PT/2/A/0600/012), run on 6/10/2009, had an as-left recirculation flow of 182 gpm.

From above, the required capacity for a MDEFW pump (including the 30 gpm assumed leakage) is 405 gpm. Likewise, the required capacity for the TDEFW pump is 617 gpm (total of 435 gpm plus 182 gpm recirculation flow).

Although the Emergency Feedwater system DBD lists a certain design flow for the various EFW pumps, full-flow test data provides a better estimate of pump capacity. From system testing trend data, the 2B MDEFW pump capacity has been shown to be at least 470 gpm at approximately 1180 psi of developed head (PT/2/A/0600/013). Likewise, the U2 TDEFW pump has a test capacity of at least 780 gpm at about 1265 psi of head (PT/2/A/0600/012).

If the required capacity (including assumed system leakage) is subtracted from the test capacity, the margin for pump capacity is obtained. For the 2B MDEFW pump, the margin is 470 – 405 = 65 gpm. For the TDEFW pump, the margin is 780 – 617 = 163 gpm. Given this information, an increase in SSF-ASW leakage, resulting in EFW flow diversion, would not prevent adequate EFW flow to the 2B steam generator.

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End of section prepared by Richards and checked by Pipkin
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EFW Inventory Evaluation:

This section prepared by Brian Richards and checked by Beau Abellana.

The largest allowable leak for the SSF ASW system is 9 gpm, which would occur at a system pressure of 1104 psig; the corresponding Cv would be 0.270868 (Q = Cv sqrt(delta P)). The largest leakage for EFW at this Cv would be when the TDEFW is running at 1280 psig discharge pressure. This would equal a leakage of 9.69 gpm. The question arose whether the Unit 2 UST/HW has adequate inventory such that this leakage would not impair the ability of the system to mitigate the required design basis events.

During a worst-case scenario, a minimum TS-required inventory is maintained in the UST/HW, and the event requires EFW. The combined EFW inventory calculation (OSC-5964) does not contain enough margin to cover the loss in inventory described above.

OSC-2426 has a hotwell level vs. volume spreadsheet. This file indicates that there are 2305.33 gallons per inch of hotwell level.

OSC-5964 provides the chart used to determine acceptable combined inventory for EFW (UST plus hotwell). This chart is used during operations surveillances (OP/0/A/1108/001) to ensure 155,000 gallons are present for EFW use, as required by TS 3.7.6. Design Input 5.5 states that an instrument uncertainty of 4 inches is applied to the Hotwell level instrument loop (OSC-6038), but this is outdated. The most recent revision to OSC-6038 (Section 7.3) has a loop uncertainty of 2 inches, which is due to the installation of more accurate level instrumentation. Therefore, there is margin in the total inventory available for EFW. This margin is equivalent to the volume of water present in two inches of the hotwell (4610.66 gallons).

OSC-8770 (EFW PRA calculation) states in the System Design Assumptions that the inventory in the UST and hotwell (approximately 17 hours worth of water) is sufficient for steaming through the relief valves without replenishment. Therefore, the allowable leakage rate through the SSF ASW piping hole must be less than 4610.66 gallons in 17 hours to ensure adequate EFW inventory is available for an event. This corresponds to a leakage rate of 4.52 gpm. By limiting the allowable leakage through the SSF ASW piping flaw to 4.5 gpm, the margin contained in OSC-5964 will not be exceeded.

If 4.5 gpm is allowed at 1280 psig, the Cv is 0.125779. Via the same method originally used to estimate the existing hole diameter, an allowable hole size is found to be 0.0745 inches. As long as the hole is repaired before the flaw grows this large, there is no concern about a shortfall in EFW inventory, when starting an event at the TS-required minimum.

UFSAR Section 10.4.7.1 references alternate methods of providing EFW inventory to the steam generators, including cross-connecting to another unit's EFW supply. This further supports the adequacy of EFW inventory for the above leakage conditions.

Normally, the UST/HW levels are well above and to the right of the curve for 155,000 gallons. The UST level is normally maintained at 11 feet (69,000 gal per OP/0/A/1108/001), and the HW level is maintained at 63 inches (157,000 gal), which puts the EFW inventory well above TS 3.7.6 requirements.

The above shows that adequate EFW inventory is maintained, as long as the leakage through the flaw in the SSF ASW piping is limited to 4.5 gpm. Per discussion with Safety Analysis (see paragraph below), this leakage away from the steam generators has no impact on accident analyses.

This paragraph was prepared by Greg Byers and checked by Christy Ray.
Safety Analysis has evaluated what impact a small reduction in EFW flow (< 5 gpm) would have on the accident analyses. The limiting events with regard to this concern are those that assume minimum EFW flow, such as loss of feedwater events. A small reduction in EFW flow would have a negligible effect on the accident analysis. The EFW flow boundary condition in these analyses is not a sensitive parameter relative to the acceptance criteria, thus small variations in this boundary condition will not have a noticeable impact on the analyses results. Based on this, a reduction of up to 5 gpm in EFW flow is acceptable with respect to the accident analyses.

Preparer: Greg Byers
Reviewer: Christy Ray

Impact on Delay in Delivery EFW to the SG:

Depending on the reason for EFW actuation (dryout protection versus loss of main feedwater), the EFW control valves may or may not be open. In the case of a dryout protection actuation, 2FDW-315, -316 will have opened at 30 inches SG level, which is prior to actuation at 21 inches. Per OSC-4478, the low level actuation setpoint does not guarantee that the steam generator will not dry out; rather it is intended to minimize the duration of dryout conditions by providing timely EFW actuation. The postulated void in the 2B EFW header due to the SSF-ASW leak event would only take seconds to collapse at full EFW flowrates, so any additional delay in EFW reaching the SG is not a major concern.

For loss of main feedwater events (without anticipatory trip), OSC-8271 discusses the assumed delay between EFW actuation signal and the time EFW begins to enter a SG. Appendix B states that a total of 87 seconds are required for the SG to boil down to 30 inches and for EFW to fill those portions of the header that may initially contain only steam. The calculation then conservatively rounds the delay time up to 120 seconds. The rounded value bounds any increase in delay attributed to filling a void in the 2B EFW header. Furthermore, since the EFW control valves (FDW-315, -316) are not of a leak tight design, any voiding may begin collapsing prior to the valves actually opening.

The portion of piping that may be voided and would have to be filled before water could be supplied to the 2B steam generator is bounded by the following valves: 2FDW-316, 2FDW-48, 2FDW-442, and the elbow in the SSF ASW piping that goes through the floor of the U2 West Pen Room. UT inspections at 2CCW-117 will be performed to ensure that the SSF ASW piping is maintained full below the bottom of that horizontal section of piping along the floor of the U2 West Pen Room. These are all 6 inch sections of piping, and although there are portions of Schedule 80 and Schedule 160 piping, it is conservative to assume all portions are Schedule 80 (higher internal area) to maximize the postulated void volume.

From a review of drawings O-1573B and O-2AB-203A14-01, there are a total of 45.5 linear feet of piping assumed to be voided. For conservatism, the length of piping is increased to 50 feet. With an internal area of 0.181 square feet for 6 inch Schedule 80 piping, the total void volume is 9.05 cubic feet, or 68 gallons.

From a review of the IST stroke time data for 2FDW-316, the EFW control valve opens in an average time of 20 seconds. Quarterly pump test data shows that the 2B MDEFW pump provides at least 470 gpm. At 470 gpm, the 68 gallons of void would be filled in 8.7 seconds. The 120 second time delay assumed in OSC-8271 (Loss of Main Feedwater without Anticipatory Trip) implicitly includes the time required for the EFW control valves to open (Item 4 of Appendix B). The additional 8.7 seconds to fill the void is bounded by this calculation.

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End of section prepared by Richards and checked by Abellana
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EFW Alternate Path:

The flow path through 2FDW-47 is discussed in the UFSAR as an alternate path but it is not a Technical Specification credited flow path for EFW, nor is it safety related, therefore, discussion of any potential delay in delivery of flow because of a void is not pertinent. This flow path is not covered by the requirements of NSD 203 because it is a SSC not covered by TS or SLC, therefore, this PDO will not address this flow path and a Formal Functionality Assessment will also not be developed. [Prepared by Mark Smith and checked by Brian Pipkin.]

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End of EFW System Function
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Station ASW System Function
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Water Supply Evaluation:

This section prepared by Jon Hill and checked by Brian Richards.

A leakage increase from 0.3 gpm to 9.0 gpm through the hole in the SSF-ASW piping would reroute flow from the Station ASW pump upon the concurrent loss of each unit's Main Feedwater, Emergency Feedwater, and Decay Heat Removal Systems. A conservative pressure that Station ASW could operate at is 150 psig, (max discharge pressure in last 2 years has been 126 psig). Assuming a maximum hole size of 0.1069 inches (SSF ASW operable limit) and a Station ASW pressure of 150 psig, the leakage rate would be 3.315 gpm.

It is not possible to simulate full flow testing data for Station ASW (PSW to correct this problem). Since no full flow data exist, OSC-4989 (ASW System Hydraulic Model) is used to attain flow requirements. ASW can supply all three Units' HPI Pump Motor coolers at 9 gpm per Unit (total 27 gpm). If both SGs on all three units require Station ASW, a flow of 1605 gpm at 60 psig would be generated. The previous flow assumes the recirculation path is fully open and the ASW pump head curve is degraded by 10%. This flow combined with the 27 gpm to HPI equals a total of 1632 gpm. The required flow of 1632 gpm at 60 psig is well below the actual flow shown by the pump curve at 60 psig (at 69.4 psig the flow is 3550 ref. OM 208.-0344.002). Therefore a leakage of 3.315 gpm will not affect the ability of Station ASW to supply its required flow.

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End of section prepared by Hill and checked by Richards
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Inventory Evaluation:

The following information was prepared by Brian Pipkin and checked by Brian Richards.

The inventory evaluation shows that the Station ASW system cannot be considered functional in the presence of a 4.5 gpm leak when adjusted for EFW operating parameters. Because of this a Formal Functionality was required and is captured in PIP 09-6068.

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Auxiliary Service Water System Formal Functionality Assessment
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EXTENT OF CONDITION
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A leak exists in the SSF ASW piping between 2CCW-117 and 2CCW-287 which will reroute Auxiliary Service Water flow, thus reducing available inventory. The hole size is limited (monitored by monthly system pressure tests) to 0.0745 inches, or that corresponding to a leak of 4.5 gpm at Emergency Feedwater Operating parameters. At ASW system operating parameters (conservatively assumed to be 150 psig, max discharge pressure in previous 2 years of testing has been 126 psig), this corresponds to a leak of 1.54 gpm (no additional hole growth occurs as a result of SSF ASW operation).

UFSAR Section 9.2.3 "Auxiliary Service Water System" states that the Auxiliary Service Water System is designed for decay heat removal following a concurrent loss of the main feedwater system, Emergency Feedwater System, and Decay Heat Removal System for a minimum of 37 days.

Due to the addition of the 1.54 gpm leak, there is not sufficient inventory in the ASW/CCW to provide for 37 days of operation for the Case assuming two unit operation with one unit shutdown.

SLC COMMITMENT
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SLC 16.9.9 "Auxiliary Systems" requires the ASW system to be Operable.

JUSTIFICATION
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OSC-864 "RCS Decay Heat Removal Following Loss of Intake Canal/Structure" Rev 3 calculates the required inventory for 37 day operation of ASW System to provide decay heat removal. The ASW system suction source is the water contained in the CCW system piping. Two cases are modeled; Case 1 is for 3 units in operation and Case 2 is for two units in operation with one unit shutdown. Additional leakage as the result of ASW Pump recirculation and SSF Diesel Engine Service water is also included. Time Critical Operator actions are currently required within 4 hours (open required valves) to stop the additional leakage mentioned above to prevent exceeding the available CCW inventory (Reference OSS.0254.00-00-4003 Design Basis Events, TCOA to perform CCW valve alignments required in 4 hours).

Due to the hole in the CCW piping (0.0745 inch diameter as limiting case), an additional 1.54 gpm of flow rate must be included for the time the ASW system in operation. The required time for operator action was held constant (4 hours) to prevent impacting currently accepted operator action times. Based on inventory requirements to provide cooling as calculated in OSC-864 Rev 3 (Section 9.1 Table 1) and the addition of the 1.54 gpm leak, adequate inventory exist for 37 days of cooling water for case modeling 3 Units in operation. However, the addition of the CCW piping leak exceeds the capacity of the ASW/CCW inventory to provide for 37 days of operation for Case 2 modeling two unit operation with one unit shutdown as inventory will only last 36.1 days.

Therefore, the Auxiliary Service Water system should be declared Non-Functional and SLC 16.9.9 Action A should be entered to restore the ASW system to Operable status in 30 days.

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End of Station ASW System Function
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Erosion/Corrosion Rate of Hole in SSF ASW Pipe
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Corrosion section prepared by Geary Armentrout and checked by Mark Smith
Erosion section prepared by Greg Saxon and checked by David Wilson

Corrosion: The rate of general interior corrosion for Oconee Service Water (raw water) piping systems averages 1 to 2 mils per year based on data recorded in the Service Water Piping Inspection Program database [59]. EPRI guidance notes as general information that unprotected carbon steel piping in acid soils have a corrosion rate of 2 to 20 mils per year [57]. The Oconee average soil pH is 5.8, which is mildly acidic based on samples taken over the past two years [59]. Groundwater inleakage was observed coming from the leak location; therefore, this piping at this elevation is submerged below the water table. This also impacts the rate of corrosion. EPRI documentation identifies the rate of general corrosion as typically low; in the range of a few mils per year within fresh water [58]. The actual corrosion rate at the subject location cannot be determined as the exact time of coating failure is not known. However, corrosion is slow degradation mechanism as supported by Oconee experience and EPRI guidance. Therefore, there is reasonable assurance, that a dramatic step change in the hole diameter will not occur. The planned monthly pressure tests are adequate to ensure this pinhole size will not grow to the size needed to produce 4.5 gpm before this piping can be repaired / replaced.

Erosion: In addition, flaw degradation must be addressed while the pipe pressurized for the duration of an SSF event (72 hrs). In other words, the hole size will increase due to erosion while the piping is pressurized. Westinghouse document WCAP-16406-P [NRC approved document] Section 7.3.2.1, Constant Debris Size Model, provides a diametrical wear rate of 2.8E-07 in/hr. This rate does not vary significantly for the sizes under consideration. Therefore, the hole diameter will increase by 0.00002016 inches (i.e., 0.00000028 in x72 hr) by the end of an SSF event. This wear is obviously inconsequential.

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End of Corrosion/Erosion prepared by Armentrout/Saxon and checked by Smith/Wilson.

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Flow Gauge Availability

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This section was prepared by Ken Grayson and checked by David Wilson.

Per guidance contained in AP/0/A/1700/25, SSF ASW flow is established and controlled to the U2 SGs as needed to reduce and maintain RCS pressure within a required pressure range during an accident that requires operation of the SSF ASW System. The SSF ASW flow rate provided to the U2 SGs is controlled in this manner until a level is established in the SG's. Once a SG level has been established, SSF ASW flow provided to the SG's is controlled to maintain SG level within a required range.

While providing flow to the U2 SG's, a 500 GPM maximum allowed flow rate limit to the SG's is provided in AP/0/A/1700/25. The purpose of this limit is to protect the SSF ASW pump from inadequate NPSH due to excessive SSF ASW flow through the SSF ASW supply line, and to protect the SG tubes from flow induced vibration. The SSF ASW System DBD describes this limit and the purpose for the limit. The U2 SSF ASW flow instrument is used to ensure that the 500 GPM maximum allowed flow limit is not exceeded.

Effects of leakage from the underground portion of the U2 SSF ASW pipe on the U2 SSF ASW flow instrument are discussed and evaluated below:

a. Excessive leakage allows air to be introduced into instrument tubing for flow instrument

With the flaw present in the underground portion of the U2 SSF ASW line, it is possible that the U2 SSF ASW flow instrument may not function properly because air could be introduced into the instrument tubing for this instrument if water level in the U2 SSF ASW pipe falls below the level of the flow instrument tap.

Based on data collected when this problem was identified, in-leakage into the U2 SSF ASW system discharge pipe from the FDW system piping was high enough to offset leakage through the pinhole leak in the underground U2 SSF ASW pipe. Water level in the U2 SSF ASW system discharge pipe remained above the instrument tap for the U2 SSF ASW flow instrument and no air was introduced into the instrument tubing for this flow instrument. It is expected that the U2 SSF ASW system will return to these same equilibrium conditions with the feed water system once the system is returned to service.

When the U2 SSF ASW System is returned to service, the system will be vacuum filled so that the system is water solid prior to returning the system to service. Periodic monitoring of water level in piping located downstream of the flow instrument and also located at a higher elevation than the flow instrument will be performed to ensure that the system remains water solid at the flow instrument tap. If water level in downstream piping located upstream of 2CCW-117 decreases to half way below the center line of the pipe, the system will be filled and vented per guidance contained in IP/0/A/0375/001C. Periodic refilling of the U2 SSF ASW system pipe is not expected to occur unless leakage from the U2 SSF ASW system pinhole leak increases or if feed water system water in-leakage decreases. The actions to return the SSF to service, refill the SSF ASW piping and monitor water level in the piping will be performed using existing procedures and are not Compensatory Actions.

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End of Flow Gauge Availability prepared by Grayson and checked by David Wilson.
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Potential for Soil Erosion
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Civil Engineering Evaluation of the effects of leakage on the surrounding soil---
Soil Evaluation By: Zachary Ashcraft
Piping Stress Evaluation By: David Peltola
Soil Evaluation Checked by: Austin Burns
Piping Stress Evaluation Check By: Geary Armentrout

This portion of the evaluation addresses the effects of leakage from the Unit 2 ASW line on the surrounding soil and the ultimate structural support of the piping in the affected area.

Based on construction photographs and input from personnel present during construction there is reasonable assurance that the area surrounding the leak was back filled with washed stone of #57 size for approximately 8 feet from the base of the structure and then filled with qualified soil to the surface. The suspected location of the leak is estimated to be contained completely within the back filled stone area.

Based on the estimated size, source, and pressure of the leak, the water resulting would have a path to permeate downward to lower elevations due to gravity and eventually flow into an underground aquifer. The stone back fill would not be subjected to erosion in the immediate area surrounding the ASW lines for either Unit 1, 2, or 3.

Due to lack of documentation of the specific height and material used to back fill the south end of the SSF it can be conservatively assumed that the SSF ASW Unit 2 line is producing 9 gallons per minute(gpm) of water into the surrounding soil and the leak has eroded the soil. It has been confirmed that the leak is in the horizontal portion of the pipe where the pipe exits the SSF wall at elevation ~772' for approximately 6 feet before reaching an elbow rising in elevation. Conservatively considering the surrounding soil to have eroded away there would be avoided area surrounding the horizontal section of piping at elevation ~772'. The upper elevation of piping would still be compacted and able to support the pipe laterally. The consideration of a void along the entire length(approximately 6') of the horizontal portion of the pipe at elevation ~772' is evaluated below for the possible resulting stresses on the pipe.

The 6 foot piping length from the SSF wall anchor to the first elbow where the leak is located has a combined weight (pipe plus water) of 40 lbs per linear foot. Modeling this as a 6 ft cantilever with a 40 lb/ft distributed load results in a maximum moment at the anchor of M = w*l^2/2 = 40 * 6^2/2 = 720 ft-lbs, or 8640 in-lbs. The section modulus for the 6 inch sch. 80 pipe is 12.22 in^3, so the maximum bending stress at the SSF wall anchor is M/Z = 8640/12.22 = 707 psi. The moment at the elbow at the end of the cantilever is negligible. Therefore, compared to the actual calculated stress in the vicinity of the leak of about 10,000 psi, the stress impact due to the possible void is not significant.

In Summary:

There is a reasonable expectation that the ASW piping is sufficiently supported by the soil and stone used as back fill and that any leakage would have drained into local aquifers and not caused erosion. Conservatively a leak rate of 9 gpm and complete soil erosion around the horizontal length of pipe at ~772' was considered. The resulting pipe stresses from this scenario are within allowable code limits and the soil above would still be capable of laterally supporting the pipe and the anchor (concrete wall embedment) would provide vertical support.

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End of Soil Erosion prepared by Ashcraft/Peltola and checked by Burns/Armentrout
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RIS 2005-20 Operational Leakage and Flaw Evaluation
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The portion of SSW ASW piping that contains the flaw is considered high-energy Class 3; therefore as outlined in NSD-203 (Operability/Functionality) Section F.12 (Flaw Evaluation), 10CFR50.55 provides requirements that structural integrity must be maintained in conformance with ASME Code Section XI. The Code specifies acceptable flaw sizes based on the material type, location, and service of the system within which the flaw is discovered. As documented in NRC Regulatory Issue Summary (RIS) 2005-20, Revision 1 (Operability Determination and Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety) and NSD-203 the NRC has approved the use of the alternate evaluation method documented in Generic Letter 90-05 (Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping) for high-energy Class 3 piping.

NSD-203, Section F.12 summarizes required evaluations from the NRC RIS that must be completed in order to return a system to an operable status with an existing flaw. The following sections list each requirement and the evaluation performed:

1- The degradation mechanism must be readily apparent and described
This section was prepared by Geary Armentrout and checked by David Peltola

On 8/24/09 GE Inspection Technologies performed a video inspection of the leak. This video clearly identifies this leak as a pinhole. Groundwater in leakage was observed to be coming from a hole approximately 0.021 inch diameter near the horizontal pipe to elbow weld (elbow side) - possibly in the heat affected zone. The apparent cause of the pinhole is pitting corrosion created by local coating degradation on the piping OD. UT performed adjacent to the leak location supports a deep pit geometry, as well as general corrosion occurring due to coating degradation. This thru-wall flaw is clearly not a crack.

2- The mechanism must be discernable from visual examination or there must be substantial operating experience with the identified mechanism in the affected system

With the assistance of GE Inspection Technologies two inspections of the SSF-ASW pipe were performed. The inspections were performed using an Everest XL G3 Videoprobe using a 6.1 mm probe with measurement capabilities to characterize the size of the hole.
With the elbow removed it was easy to see the location of the leak, bottom center on the elbow side of the weld. The videoprobe was used for a close up view of the leak. Using the videoprobe the size of the hole was determined to be 0.021 inches (21 mils) in diameter. The hole's shape clearly indicates this leak is from an OD initiated pinhole and not a crack.
The holes exact location could not be measured, but from the inspection pictures taken it is likely in the heat affected zone for the elbow weld. This type of corrosion damage is a common cause in a majority of industry buried piping leaks.

3- If these above (Items 1 and 2) means of discerning the degradation mechanism are not known or need augmentation, additional volumetric examination may be required to characterize the flaw.

Based on the information presented in Item 1, there is reasonable assurance that the flaw is a pin-hole leak adjacent to the lower weld of the elbow. In addition, UT examination of the 6 inch sch. 80 piping performed in the vicinity of the leak in support of the GL 90-05 evaluation, as well as relevant adjacent locations support, a "deep pit" geometry, where a single minimum wall thickness value of 0.25 inches was identified, with adjacent thicker wall readings of 0.327 and 0.329 inches. Results from the visual inspection by General Electric (GE) personnel also confirmed this leak was a pin hole, with a measured diameter of 0.021 inches on the pipe inside surface.

4- Perform a flaw evaluation using a NRC approved method.

As discussed previously, one NRC approved method for evaluation of high-energy Class 3 flaws is contained in Generic Letter 90-05. This methodology was utilized (without exception) to determine the maximum allowable flaw size of 1.35 inches. This value is well above the estimated size from UT measurements (of about 0.5 inches), which is greater than the calculated leak rate size of 0.023 inches and greater than the video-measured size of 0.021 inches. The maximum allowable flaw size is also above the estimated hole size of 0.1069 inches required to produce the system outflow of 9 gpm.

5- Establish any augmented inspections or other actions prescribed by the flaw evaluation method guidance document (ex. Code Case, Generic Letter, etc.).

Augmented examinations are normally performed on piping with similar service conditions as the one with the leak. Since this piping is buried, it is inaccessible for traditional UT and visual examinations. Due to the structural anchor at the ONS1, 2 and 3 SSF ASW piping penetrations in the South wall of the SSF building, and the distance and the number of elbows from where this pipe is accessible from the Cask Decontamination Tank Room, Guided Wave (GW) UT is not a viable inspection technique. Therefore, monitoring for leakage and periodic pressure testing are the only viable examinations for these buried piping segments.

As discussed in the Immediate Actions, Work Requests have been written to check the comparable ONS1 and ONS3 SSF ASW piping for leaks.

Since the guided wave examination was not able to provide relevant data due to the adjacent structural anchor, MCE recommends that the ONS2 SSF ASW piping have periodic pressure tests performed monthly. WR 987621 has been issued to perform this monthly testing.

6- The effects of any leakage on systems, components, materials and system performance where applicable.

The following additional evaluations were performed to support operability of the Unit 2 SSF ASW system:

Waterhammer:

Based on the pressure test, the leakage through the flaw was estimated to be ~0.31 gpm at 825 psig. Leakage in this line would result in void accumulation that has the potential to produce a waterhammer event if the Unit 2 SSF ASW, EFW or FDW systems were required to deliver feedwater to the steam generators during an accident. Based on the waterhammer forces, it was determined that there would be no damage to the support/restraints and the ASME and B31.1 Piping Codes are satisfied.

SSF ASW Design Flowrate:

In addition to void creation, any leakage out of the system reduces the amount of water delivered to the Unit 2 SG's. An analysis was done to determine the maximum amount of leakage that can occur without impacting the ability of the SSF ASW system to perform its design function. The calculated value of 9 gpm is well above the estimated value of ~0.31 gpm at 825 psig. Note that the 825 psig excludes the elevation head of water; this is conservative, as a higher dP will result in a smaller hole diameter. At normal accident pressure of 1104 psig (SSF ASW system pressure), the current hole size will yield a flow of 0.359 gpm, given a constant Cv.

SSF ASW Flow Indication:

The identified flaw was discovered based on the Unit 2 SSF ASW flow indication being erratic and fluctuating between 60-109 gpm initially. The waterhammer analysis for determining structural reliability assumes that the piping is not fully filled with water. The presence of air would render the flow meter inoperable causing the Unit 2 SSF ASW to be inoperable. To avoid this potential risk, the SSF ASW piping will be maintained full of water above the elevation of the flow meter with the intent of maintaining water at the elevation of the horizontal piping containing 2CCW-117. This will prevent water hammers due to SSF ASW flow from affecting the flow meter. The flow meter and its associated instrumentation are able to tolerate any overpressure and water hammer that may result from check valve action due to leakage through 2FDW-47. Accordingly, the SSF ASW flow indication will remain operable. The SSF will remain operable.

Soil Erosion:

The potential for soil erosion causing a loss of pipe support was also reviewed. It was determined that since the area around the piping was likely filled with washed stone. Since this type of material produces very good drainage, there is reasonable expectation that the support provided would not be affected. The pipe was also evaluated assuming a void formed under the entire length of the horizontal run containing the leak. This evaluation showed the impact on pipe stress was minimal.

Impact on the Unit 2 Siphon:

The location of the leak cannot affect flow rate provided by the First Siphon.

Flooding:

The leak is below grade and outside of the SSF building and can not affect equipment important to SSF operation. The leak is too small to have any impact on any other plant structures.

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End of RIS 2005-20 Operational Leakage and Flaw Evaluation
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References:

1- Email from George Licina, Structural Integrity, to Geary Armentrout, MCE/Civil, dated 08/24/09 which provided general comments on Microbiologically Influenced Corrosion (MIC)
2- EPRI Report 1016456: Recommendations for an Effective Program to Control the Degradation of Buried Pipe
3- Corrosion and MIC Control Training Seminar by presented by George Licina, Structural Integrity Associates, Inc.
4- O-1573 B, Isometric Arrangement of Turbine Driven Emergency Feedwater Pump Discharge Piping.
5- EPRI TR-106438, Water Hammer Handbook, May 1996
6- AP/0/A/1700/025, Standby Shutdown Facility Emergency Operating Procedure.
7- EP/1,2,3/A/1800/001, Rule 7, SG Feed Control.
8- Fauske and Associates Technical Paper FAI/08-78, "Waterhammer Potential in CS Header and HL Switchover Piping", 8-22-08
9- Flow Diagram OFD-133A-2.5, Condenser Circulating Water System (SSF Aux. Service)
10- Flow Diagram OFD-121D-2.1, Emergency Feedwater System
11- Flow Diagram OFD-121D-1.2, Emergency Feedwater System (Aux. Service Water)
12- ASME Code, Section III, 1974 Edition with Addenda thru the Summer 1975 Addendum (applicable to the SSF piping and piping upstream of valve 2CCS-117 including the buried pipe)
13- Power Piping - USAS B31.1 1967 Edition.
14- USAS B31.7, Nuclear Power Piping, 1968 Edition including Errata of June 1968.
15- OSC-1224-26, Piping Analysis Problem 4-14-12, qualifies the SSF Bldg portion of the subject pipe
16- OSC-1224-21, Piping Analysis Problem 2-03A-14, qualifies the Aux Bldg portion of the subject pipe
17- OSC-1224-17, Piping Analysis Problem 2-03A-13, qualifies the Rx Bldg portion of the subject pipe
18- Specification No.: OS-027B.00-00-0001, Specification for Class A, B, C, D, E, F, G and H Piping Analysis for Code Compliance

19- Flow of Fluid through Valves Fittings and Pipe, Crane Technical Paper 410, 24th printing, 1988
20- Generic Letter 90-05, Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, 3 Piping.
21- OSC-1147, Standby Shutdown Facility Buried Piping Analysis.
22- ASME Code, Section XI
23- NSD-203, Operability/Functionality
24- Operating Experience Database
25- OSC-4171, SSF ASW Design Inputs
26- 10-CFR 50.55, Conditions of Construction Permits
27- NRC Regulatory Issue Summary 2005-20, Revision 1, Operability Determination and Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety.
28- OSC-2310, SSF Design Bases Evaluation
29- OSS-0254.00-00-1005, Standby Shutdown Facility Auxiliary Service Water System, Revision 25
30-EPRI TR-1030403, Service Water System Corrosion and Deposition Sourcebook
31- OSC-4478, Steam Generator Emergency Range Level Uncertainty and EFW Low Level Actuation Set, Revision 6.
32- OSC-8271, ROTSG Loss of Main Feedwater Without Anticipatory Reactor Trip, Revision 3.
33- OM-267-1126, O/L - ANF-75-IVK Annubar - 1,2,3 CCWFE226, Revision 0
34- OM-267A-0053, Shutoff Valve Outline/Service with Flow Nozzles, Revision 0
35- IP/0/A/0375/001C, Standby Shutdown Facility (SSF) Auxiliary Service Water Flow Instrument Calibration, Revision 26
36 - Technical Specification 3.10.1, TS B3.10.1.
37 - Selected Licensee Commitments 16.7.13, 16.9.21
38 - UFSAR Sections 9.6.1, 9.6.2, 9.6.3.3, 9.6.3.5.2, 9.6.4, 9.6.5, Table 9-16, Figure 9-36
39 - OSC-4989 Rev 10
40 - OSC-3174 Rev 0
41 - OSC-5125 Rev 6
42 - Station ASW ESD
43 - OSC-864 Rev 3
44 - TS 3.7.5 (EFW system)
45 - TS 3.7.6 (UST/HW inventory)
46 - UFSAR Section 10.4.7
47 - PT/2/A/0600/012 (TDEFW quarterly pump test)
48 - PT/2/A/0600/013 (MDEFW quarterly pump test)
50 - OSS-0254.00-00-1000 Rev 46 (EFW/ASW system DBD)
51 - ONTC-2-121D-0001-001 (MDEFW pump TAC)
52 - ONTC-2-121D-0002-001 (TDEFW pump TAC)
53 - SLC 16.9.9
54 - TS 3.7.4
55 - UFSAR Section 3.2.2, 9.2.3
56 - Westinghouse document WCAP-16406- Evaluation of Downstream Sump Debris Effects in Support of GSI-191
57 - EPRI Report 1016687, Plant Support Engineering: Buried Pipe End-of Expected-Life Considerations and the Need for Planning

58 - EPRI Report 1016276, An Assessment of Industry Need for Control of Degradation in Buried Pipe

Immediate Actions:

This section prepared by Ken Grayson and checked by David Wilson.

a. In order to ensure that the U2 SSF ASW System piping remains water solid to an elevation above the instrument tap for the Unit 2 SSF ASW flow instrument, ultrasonic testing will be periodically performed in a horizontal run of downstream piping to determine water level in the pipe. Specifically, ultrasonic testing of piping located upstream of 2CCW-117 will be performed once per day to determine when water level falls below a half filled pipe. (Ref WR 987579) Results from this ultrasonic testing will be recorded in autolog for trending. If the flow balance between water in-leakage from the Feed water system and water out-leakage through the flaw in the SSF ASW pipe has not changed, it is expected that refill of the SSF ASW pipe using IP/0/A/0375/001C will not be required. Trending of the ultrasonic test data and the pipe refill frequency is planned to identify any significant changes in the leakage rate from the flaw in the underground U2 SSF ASW pipe.

b. OSC-4171 calculation results support operability of the SSF if flow diversion through the pinhole leak of the U2 SSF ASW system is less than or equal to 9 gpm. Monthly pressure testing will be performed on Unit 2 SSF ASW piping to ensure that the hole size or leakage rate is not increasing. WR 987621 has been written for this testing. This will also ensure that the allowable leak rate of 4.5 gpm for EFW is not exceeded.

c. U2 SSF ASW flow instrument indication

During operations rounds of the SSF, U2 SSF flow indication in the SSF Control Room will be checked to verify that indicated flow remains within the following limits:

> If reading is >= 115 GPM operability limit (Ref PIP 06-4546) and steady, SSF ASW System is inoperable. This limit ensures that air in the U2 SSF ASW flow instrument tubing will not prevent the flow instrument from performing its required function. Note that oscillations in indicated SSF ASW flow which may periodically peak at a flow rate > the 115 GPM limit are not applicable to this limit because they are associated with a known periodic water hammer which is occurring in downstream piping.

d. Work Requests have been written (987553, 987600) to install necessary gauges on Units 1 and 3 to provide information on possible loss of water level. This is in addition to Operations rounds which check the flow gauge to ensure prior operation. This will involve isolating the Unit 1 and Unit 3 SSF ASW piping one time each which will cause the SSF to inoperable for that unit and result in a small amount of unavailability.

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End of section prepared by Grayson and checked by Wilson.
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Conclusions

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Unit 2 SSF ASW System

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Per the guidance of NSD-203, Section F.12, for cases where the flaw evaluation is used to defer the completion of a fully Code qualified repair, the SSC should be classified as OBDN.

NRC Part 9900 Technical Guidance, Appendix C.12 Operational Leakage From ASME Code Class 1, 2, and 3 Components, states "The NRC staff does not consider through-wall conditions in components, unless intentionally designed to be there such as sparger flow holes, to be in accordance with the intent of the ASME Code or construction code and, therefore, would not meet code requirements, even though the system or component may demonstrate adequate structural integrity."

Additionally, per RIS 2005-20 (NRC Inspection Manual Part 9900, Appendix C.12), if the flaw meets the GL 90-05 criteria, a relief request from the ASME Code requirement is needed, and must be submitted in a timely manner after completing the operability determination process and prior to implementing a non-code repair (which is not being perform due to inaccessibility).

As documented in this PDO, the most limiting factor for the U2 SSF ASW System associated with the flaw size is the Inventory Evaluation which determined an allowable leakage of 4.5 gpm (for SSF ASW operating parameters) for the specific case of a Station Blackout event where the SSF submersible pump is not credited and gravity induced reverse flow is not aligned. As detailed in the Extent of Condition and Immediate Action sections, actions are being put in place to monitor the degradation. Should a determination be made that the system cannot meet the 4.5 gpm requirement then the Operability Determination Process will be re-entered per NSD-203 and Operability of the Unit 2 SSF ASW will be determined.

As additional information, hydrostatic testing at 850 psig and 1150 psig was performed as part of the Post Maintenance Testing. This test confirmed that the hole size remains ~ 0.021".

The Unit 2 SSF ASW system is declared OPERABLE BUT DEGRADED/NON-CONFORMING with respect to the ASME Code as documented in RIS 2005-20 Revision 1.

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End Conclusion for Unit 2 SSF ASW System

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Unit 2 EFW System

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As documented in this PDO, the most limiting factor for the U2 EFW System associated with the flaw size is the Inventory Evaluation which determined an allowable leakage of 4.5 gpm (at EFW operating parameters). As detailed in the Extent of Condition and Immediate Action sections, actions are being put in place to monitor the degradation. Should a determination be made that the system cannot meet the 4.5 gpm requirement then the Operability Determination Process will be entered per NSD-203 and Operability of the Unit 2 EFW will be determined.

As additional information, hydrostatic testing at 850 psig and 1150 psig was performed as part of the Post Maintenance Testing. This test confirmed that the hole size remains ~ 0.021".

The Unit 2 EFW system is declared OPERABLE

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End Conclusion for Unit 2 EFW System

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Station ASW System

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As documented in this PDO, the most limiting factor for the Station ASW System associated with the flaw size is the Inventory Evaluation which determined the system will be non-functional with a limiting leak rate of 4.5 gpm when adjusted to Station ASW operating parameters.

See PIP 09-6068

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End Conclusion for Station ASW System

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Review of Compensatory Actions

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As addressed in the PDO for PIP O-09-5808, the most limiting factor for the flaw is the SSF ASW Water Supply Evaluation which determined an allowable leakage of 9 gpm. In order to verify that Unit 2 SSF ASW discharge piping upstream of 2CCW-117 is maintained in an adequately filled condition and that leakage remains bounded by this PDO, daily UT of the header piping near vent 2CCW-484 and monthly pressure/leakage testing to is being performed. Evaluation of these actions with respect to NSD-203 (Operability/Functionality), NSD-209 (10 CFR 50.59 Process), and NSD-228 (Applicability Determination) leads to the conclusion that the 10 CFR 50.59 process does not apply. Although these actions can technically be considered as compensatory actions, they are simply confirmatory in nature and have no ancillary affect on the operation or mission of any SSC described in the UFSAR. Therefore, there is no impact with respect to the safety analyses. Existing procedures are being used for the UT and pressure/leakage testing for which the 10CFR50.59 process was applied. Additionally, facility procedures associated with normal as well as emergency conditions are not affected. Should testing results indicate the piping to be inadequately filled or experiencing excessive leakage, the Operability Determination Process will be re-entered per NSD-203 and Operability of the Unit 2 SSF ASW will be determined. Entry into applicable Technical Specifications LCOs is required to restore the system to a water solid condition but no actions associated with performing the UT or pressure/leakage testing directly or indirectly affect restoration to operability of the SSF or any other system. With these considerations, preparation of a 10 CFR 50.59 evaluation for this activity is not determined to be required.

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End of Compensatory Action
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As additional information in support of the planned Unit 2 monthly pressure test, acceptance criteria was developed to ensure the flaw size remains within the criteria established in this PDO.

Leakage Acceptance Criteria for Monthly Pressure/Leakage Testing:
Prepared by: David Wilson, Checked by: Ken Grayson

SSF ASW Leakage is limited to 4.5 gpm at 1280 psid based on EFW limitations. The allowable leakage at test pressures other than 1280 psid is determined as follows (based on the methodology in SLC 16.6.4):

Q_{allow} = 4.5 gpm * sqrt (P_{test} / 1280 psig)

Planned monthly leakage tests will be conducted at a pressure of ~850 psig. The allowable leakage would be

Q_{allow} = 4.5 gpm * sqrt (850 psig / 1280 psig)
Q_{allow} = 3.67 gpm

For conservatism, the allowable leakage during monthly leakage tests will be rounded down to 3.5 gpm.

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End of section prepared by Wilson and checked by Grayson.
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Additional Reviews:
Randy Todd, Regulatory Compliance
Jim Fisicaro, Director Nuclear Regulatory Relations
Jeff Thomas, Manager, Nuclear Fleet Regulatory Compliance
Randall Hart, Manager, CNS Regulatory Compliance
Oconee Site PORC

Attachment 2

Additional Information Pertaining to the Unit 2 SSF ASW Buried Piping Prompt Determination of Operability

1. In Attachment #1, page 29 of 40, Westinghouse document WCAP-16406-P [NRC approved document] Section 7.3.2.1, Constant Debris Size Model, was used to evaluate erosion of the pipe wall opening during system operation. The basis for using WCAP-16406-P for this evaluation is as follows:

   Appendix F, Section F.5 of WCAP 16406-P (Evaluation of Downstream Sump Debris in Support of GSI-191) develops erosive wear correlations for components (valves, orifices, etc.) that must pass process fluid which contains debris at various concentrations. While the WCAP developed the correlations for the express purpose of predicting wear while processing post-LOCA sump debris, the experimental data the correlations are based on come from studies on the wear resistance of various types of pipe (carbon steel, stainless steel, aluminum, etc.) when handling water/sand mixtures of various concentrations. From the available data, the WCAP authors determined that erosive wear rate is a function of material hardness (the material being worn and not the hardness of the debris), debris concentration, and flow velocity. The correlations published in the WCAP were conservatively based on wear of carbon steel (stainless steels, which comprise the ECCS flow paths, were found to be more wear resistant). The NRC issued a SER on the WCAP (ADAMS Accession Number ML073520295, dated 12/20/07). In Section 3.2.12 of the SER, the NRC concluded that the erosive wear correlations reasonably predicted wear rates with debris concentrations below 18 mass percent (several orders of magnitude higher debris than that present in raw water at Oconee) and was acceptable to use for “valve surfaces, heat exchangers, piping, tubes, orifices, and other similar components.”

   The hole analyzed in the PDO was assumed to behave like an orifice plate. Based on the observed leak rate and pressure differential across the hole, a flow velocity was conservatively computed (discharge coefficients chosen to result in higher velocities). Debris concentration (suspended solids) was taken from recent Oconee raw water quality reports. Since the pipe is carbon steel, the resulting wear rate (based on the computed velocity and debris concentration) was directly applicable.

2. In Attachment #1, page 36 of 40, the list of references failed to include Reference #59, which is the “Oconee Nuclear Station, Service Water Piping Inspection Program - Engineering Support Document”. Reference #59 is cited in Attachment #1, on pages 28 and 29 of 40.