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SCE&G®
A SCANA COMPANY

July 3, 2018
RC-18-0082

Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir / Madam:

Subject: VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
DOCKET NO. 50-395
OPERATING LICENSE NO. NPF-12
RELIEF REQUEST RR-4-15, REQUEST FOR ALTERNATIVE TO IMPLEMENT CODE CASE N-513-4, "EVALUATION CRITERIA FOR TEMPORARY ACCEPTANCE OF FLAWS IN MODERATE ENERGY CLASS 2 OR 3 PIPING"

In accordance with the provisions of 10 CFR 50.55a(z)(2), South Carolina Electric & Gas Company (SCE&G), acting for itself and as an agent for South Carolina Public Service Authority (Santee Cooper) requests an emergency relief request to use Code Case N-513-4, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1" for the temporary acceptance of a through-wall leak identified in a Class 3 Service Water branch tee.

SCE&G is requesting this relief until the conclusion of the Virgil C. Summer Nuclear Station (VCSNS), Unit 1 Fall 2018 refueling outage (RF24). The repair will be implemented no later than the completion of the Fall 2018 refueling outage or before exceeding the temporary acceptance criteria specified in this relief request, whichever comes first.

On July 2, 2018 at approximately 1000, a pinhole leak was discovered in the Service Water (SW) system on the branch tee connection below field weld (FW-1), downstream of XVB03123B-SW Component Cooling Water (CCW) Heat Exchanger B SW Return Valve. SCE&G requests the use of Code Case N-513-4 for the analysis of this branch tee connection to allow continued operation.

Enclosed is the relief request.

SCE&G requests NRC approval of the proposed alternative by 0800 on July 5, 2018.

There are no commitments established in this relief request.

Should you have any questions, please call Beth Dalick at 803-605-5428.

Very truly yours,

George A. Lippard For

BAB/GAL/wm

Enclosures:
1) VCSNS Relief Request RR-4-15
2) Design Calculation SW002/04 Revision 0 "Through Wall Leak Evaluation"

c:

J.E. Addison	W.M. Cherry	NSRC
W.K. Kissam	C. Haney	RTS (CR-18-02706)
J.B. Archie	S.A. Williams	File (810.19-2)
J.H. Hamilton	NRC Resident Inspector	PRSF (RC-18-0082)
G.J. Lindamood	K.M. Sutton	

South Carolina Electric & Gas Co. (SCE&G)
Virgil C. Summer Nuclear Station Unit 1 (VCSNS)
Relief Request RR-4-15

1. ASME Code Component(s) Affected

A pinhole leak was identified in the Service Water (SW) System branch tee located in the 20-inch diameter piping downstream of the 'B' Component Cooling Water Heat Exchanger B SW Return Valve (XVB03123B-SW) below field weld (FW-1). The affected piping provides a return path for the safety related cooling water from the 'B' Component Cooling Water Heat Exchanger back to the SW Pond. This Moderate Energy (ME) piping is designed to ASME Section III Sub-Section ND (Code Class 3) criteria and is required to meet all ASME requirements (TS 4.0.5). The branch tee material is SA-234 WPB.

2. Applicable Code Edition and Addenda

ASME Code Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," 2007 Edition through 2008 Addenda. The station is in its 4th 10 year interval effective from January 1, 2014, through and including December 31, 2023.

3. Applicable Code Requirement

ASME Code Section XI, 2007 Edition through 2008 Addenda, Article IWA-4000, Repair/Replacement Activities.

4. Reason for Request

On July 2, 2018 at approximately 1000 hours, a pinhole leak was discovered in a branch connection below field weld (FW-1), downstream of XVB03123B-SW. At the time of discovery, leakage was estimated to be approximately 350 ml/minute (0.092gpm). This leaking location does not meet ASME Section III Sub-Section ND Class 3 requirements because it is a localized flaw that violated the minimum allowed wall thickness criteria for this piping. This degraded condition is not in compliance with ASME Section XI, 2007 Edition through 2008 Addenda, IWA-4000.

As a result, a number of limiting conditions for operation (LCOs) of the plant technical specifications were not met, including, but not limited to, LCO 3.7.4, "Service Water System". The action statement requires that with only one service water loop OPERABLE, restore at least two loops to OPERABLE status within 72 hours or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

ASME Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Section XI, Division 1," provides criteria to allow temporary acceptance of flaws, including through-wall flaws in moderate energy Class 2

or 3 piping without performing repair or replacement activities. Code Case N-513-3, (Revision 3, January 26, 2009) is approved for generic use by licensees in Nuclear Regulatory Commission (NRC) Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 18 (ADAMS Accession No. ML16321A336), with the condition that the repair or replacement activity temporarily deferred under the provisions of this Code Case shall be performed during the next scheduled outage.

ASME Code Case N-513-3 does not address the evaluation of flaws in certain locations of moderate energy piping components, such as elbows, bent pipe, reducers, expanders, and branch tees. ASME Code Case N-513-4, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Section XI, Division 1," (Revision 4, May 7, 2014) contains several revisions to ASME Code Case N-513-3 including expanding the applicability of the code case beyond straight pipe to include elbows, bent pipe, reducers, expanders. and branch tees. ASME Code Case N-513-4, Reference 5, has not been approved by the NRC for generic use by licensees. Use of ASME Code Case N-513-4 is proposed to allow temporary acceptance of the through-wall flaw, which is in a moderate energy Class 3 piping branch tee without performing repair or replacement activities, and thereby avoid a plant shutdown. Use of this alternative evaluation method in lieu of immediate action for such a degraded condition would allow time for safe and orderly long-term repair actions.

Code repair is considered a hardship without a compensating increase in the level of quality and safety. A Code repair would require a plant shutdown to replace the branch tee. The branch tee is located between valve XVB03123B-SW and the service water pond. The piping cannot be isolated from other portions of the service water system.

Plant shutdown activities result in additional plant risk. Such a shutdown would be inappropriate when an affected ASME Code component in a degraded condition is demonstrated to retain adequate margin to fulfill the component's function. Accordingly, compliance with the current code requirements results in a hardship without a compensating increase in the level of quality and safety.

5. Proposed Alternative and Basis for Use

In accordance with 10 CFR 50.55a(g)(4), this safety-related piping must meet the requirements applicable to components which are classified as ASME Code Class 3. V.C. Summer proposes a relief request from ASME Code Section XI, IWA 4000 by using the methodology described in Code Case N-513-4 for temporary acceptance of flaws. V.C. Summer will follow all requirements of the code case and will take no exceptions.

The NRC issued Generic Letter, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping (Generic Letter 90-05)," to address the acceptability of limited degradation in moderate energy piping. The generic letter defines

conditions that would be acceptable to utilize temporary non-code repairs with NRC approval. The ASME recognized that relatively small flaws could remain in service without risk to the structural integrity of a piping system and developed Code Case N-513. NRC approval of Code Case N-513 versions in Regulatory Guide 1.147 allows temporary acceptance of partial through-wall or through-wall leaks for an operating cycle provided all conditions of the code case and NRC conditions are met. The code case also requires the owner to demonstrate system operability considering effects of leakage.

The ASME recognized that the limitations in Code Case N-513-3 were preventing needed use in piping components such as elbows, bent pipe, reducers, expanders, and branch tees and external tubing or piping attached to heat exchangers. Code Case N-513-4 was approved by the ASME to expand it for use at these locations and to revise several other areas of the code case. The following list provides a high-level overview of the Code Case N-513-4 changes:

1. Revised the maximum allowed time of use from no longer than 26 months to the next scheduled refueling outage.
2. Added applicability to piping elbows, bent pipe, reducers, expanders, and branch tees.
3. Expanded use to external tubing or piping attached to heat exchangers.
4. Revised to limit the use to liquid systems.
5. Revised to clarify treatment of service level load combinations.
6. Revised to address treatment of flaws in austenitic pipe flux welds.
7. Revised to require minimum wall thickness acceptance criteria to consider longitudinal stress in addition to hoop stress.
8. Dally walkdown requirement for through-wall leaks changed to provide additional flexibility.
9. Other editorial changes to improve clarity.

Significant changes in Code Case N-513-4 when compared to NRC approved Code Case N-513-3 are discussed in Reference 6, "Technical Basis for Proposed Fourth Revision to ASME Code Case N-513."

Enclosure 2 to this letter contains the evaluation of the acceptability of the through wall leak and the UT inspection results. The UT inspection results were obtained by a Quality Control inspector who was qualified as a UT Level II inspector.

A flaw evaluation using the “Through-Wall Flaws in Branch Tees” approach from Code Case N-513-4 determined the flaw was acceptable in its current configuration. Further degradation is acceptable as long as the average thickness of the remaining material outside the hole is greater than 0.051 inches within a diameter of 2.5 inches of the hole and a minimum wall thickness of 0.162 inches for all other areas of the pipe tee. Additional evaluations were performed to consider the effects of leakage in demonstrating system operability and flooding analysis. A compensatory action of daily walkdowns of

the area will be completed to quantify the leakage. UT examinations of no more than 30-day intervals will be performed around the degraded area to characterize flaw growth. The monitoring plan will remain in place until the system is removed from service and repaired. A code compliant repair will be completed during the next refueling outage which is scheduled to start on October 6, 2018.

There is currently another pinhole leak, in FW-1, (3.75 inches) above the leak being evaluated, putting the total leakage at approximately 600ml/min. The previous pinhole leak was identified in CR-18-02364 on June 9, 2018 and was temporarily accepted in accordance with the requirements of Code Case N-513-3. The station completed the augmented examination requirements Code Case N-513-3. All 5 locations were satisfactory. For the effects of leakage in demonstrating system operability and flooding analysis, the pinhole leak in the branch tee is combined, as described below with the previously identified pinhole leak in the adjacent weld identified in CR-18-02364. The flaw evaluation calculation verifies that the two leaks are at an acceptable distance to be analyzed individually from a structural perspective.

Additionally, during the inspection of the through wall flaw in the 20-inch Service Water Tee, an external "gouged area" was discovered approximately 80 degrees clockwise from North. This is documented in the Station's corrective action program in CR-18-02718. The external flaw described in Enclosure 2, has a 2.5 inch linear portion that is below the calculated minimum wall thickness of 0.162 inches in Attachment 1. There is no approved ASME Code Case or ASME Section XI/III to evaluate the external gouge. Therefore, the most conservative evaluation would be to analyze the gouge as a separate through wall flaw, in which it would be bounded by the results of this calculation.

5.1 Flaw Characterization: – The flaw was characterized by ultrasonic inspection (UT) under WO# 1813150-001. The UT inspection found a thin area around the pinhole, approximately 0.5 inch above the hole and approximately 45° NE of the pinhole to about 2.5 inches. The flaw has been classified as non-planar through wall and no evidence was found to indicate a "crack" type indication.

5.2 Structural Integrity: Per VCSNS Unit 1 Technical Specification (TS) 4.0.5, the structural integrity of an ASME component is determined in accordance with either the original construction code or the ASME Section XI Code, approved code cases or regulatory-approved methods of evaluation. No NRC approved methodology exists that allows for temporary acceptance of flaws or non-welded repairs for this condition. A flaw evaluation using the "Through-Wall Flaws in Branch Tees"" approach from Code Case 513-4 determined the flaw was acceptable in its current configuration.

Design Calculation SW002/04 Rev. 0 was conducted to evaluate the acceptability of the through wall leak. The evaluation results show the existing defect is structurally acceptable per Code Case N-513-4. Design Calculation SW002/04 Rev 0 allows for

thinning in a 2.5 inch diameter around the hole with a required adjacent thickness of 0.051 inches and a minimum wall thickness of 0.162 inches for all other areas of the pipe tee. The measured wall thicknesses meet these requirements. Further degradation is acceptable if the measured values remain within these criteria.

5.3 SW System Flow Margin: - The pinhole leak is located downstream of the 'B' Component Cooling Water Heat Exchangers downstream of the discharge valve XVB03123B-SW on the discharge line to the SW pond. Therefore, a leak at this location does not affect the ability to provide cooling water to the CC Heat Exchangers. The SW pump is designed to supply 16,800 gpm of flow. A flow of 50.3 gpm from the two separate leaks would not have a significant effect on the performance of the pump. A recent routine code check valve test from STP-230.006J, "Service Water System Refuel Frequency Testing of XVC03130A-SW, XVC03130B-SW, XVC03115A-SW, XVC03115B-SW, AND XVC03115C-SW", on the SW 'B' Train measured the total system flow to be 13,036 gpm (STTS# 1604423). The design minimum required post-accident flow for a train of SW is 12,237 gpm (SW DBD). This check valve testing alignment is comparable to the post-accident SW system alignment. Therefore, there is a flow margin of approximately of 799 gpm. A postulated leakage of 50.3 gpm would not adversely affect SW system flow margin. This is a conservative approach since the 50.3 gpm leak would be located downstream of all cooling loads and throttle valves. Therefore, it would have an insignificant effect on cooling load flow.

The SW pond contains approximately 38.5 x 10^6 gallons of water and has the capability of being filled by a cross-tie valve from the circulating water system if water level drops below the alarm limit. A postulated leak of 50.3 gpm would not significantly affect the SW pond level.

5.4 Spray Effects: – The current stream from the pin hole leak is directed toward the middle of the Intermediate Building (IB) 412' room and is spraying at a distance of approximately 7 feet. There is no equipment in the spray path that would be impacted by the leakage. From visual observation, the closest equipment in the path of the spray is RML0002A (liquid rad monitor, component cooling), located approximately 20 feet away from the pin hole leak. At the current diameter opening, the spray cannot reach RML0002A and if the pin hole were to further develop, the spray would travel an even shorter distance. Furthermore, the Radiation Monitor is raised above the IB floor which would prevent potential impacts from spray pooling.

5.5 Building Flooding: - If it is assumed that the existing defect in the weld opens to a 3/8-inch diameter hole (for conservativism), and the defect in the pipe tee opens to a 1/2-inch diameter hole, the discharge would be approximately 50.3 gpm (at system pressure of 50 psig, for conservatism) and would have a negligible effect on the flood level in the IB 412'. The IB 412' cannot exceed greater than 874 gpm leakage from

the Component Cooling system per design calculation DC03490-003 Rev 1. There is 271 gpm of margin for leakage in the SW system. Therefore, a 50.3 gpm leak would fall within the limits of the margin.

Under normal operating conditions, the Intermediate Building sump pumps have a 75 gpm capacity each. There are six redundant 100% capacity sump pumps (3 total sump pits) which can be used during normal plant operations. These pumps may not be available during a loss of offsite power since they are supplied by non-safety related power. The water from the spray will collect at the floor near the pipe and drain to a nearby floor drain which goes to the Intermediate Building sump pumps. Therefore, IB building sump pumps would have sufficient capacity to prevent building flooding from the postulated 50.3 gpm leak rate.

5.6 Extent of Condition: - An Augmented Examination will be performed in accordance with Section 5.0 of Code Case N-513-4.

5.7 Compensatory Monitoring Plan:

CR-18-02706-002 – Interim Action: Operations to quantify the leakage from the pin hole leak at least once every 24 hours until the leak is repaired. Note: If significant change in leakage is noted (a measurement of 1000 ml/min or greater), additional UTs are required to characterize the flaw growth.

CR-18-02706-003 – Interim Action: Gather UT data to characterize flaw growth prior to 8/01/2018.

CR-18-02706-004 – Interim Action: Gather UT data to characterize flaw growth prior to 8/31/2018.

CR-18-02706-005 – Interim Action: Gather UT data to characterize flaw growth prior to 9/30/2018.

CR-18-02706-006 – Interim Action: Determine 5 susceptible locations within the service water system to examine.

CR-18-02706-007 – Interim Action: Perform UT Examination on the areas identified in CR-18-02706-006.

CR-18-02706-008 – Interim Action: Using the periodic UT data gathered by QC, determine if the flaw is growing, and if so, establish the time at which the detected flaw will reach the allowable size (N-513-4, 2(e)).

5.8 Conclusion - Although the structural integrity of the degraded pipe cannot be demonstrated in accordance with a regulatory-approved methodology, it is concluded the integrity and functional requirements of the pipe will be maintained. SW will continue to be capable of providing required cooling water flow to meet the required cooling loads including the Component Cooling Water Heat Exchangers. There will be no adverse impact on neighboring equipment due to either spray or flooding.

VCSNS will implement the compensatory monitoring plan above to ensure any growth of the flaw is identified and assessed for its impact on structural integrity. A code compliant repair will be completed during the next refueling outage which is scheduled to start on October 6, 2018.

CR-18-02706-009: Evaluate the repair. WO# 1813154 written to Repair the through-wall leak identified in CR-18-02706 downstream of field weld FW-1 shown on 1MS-22-018 spool piece 1-SW-01-01 (continued on 1MS-22-385). The flaw may be repaired by any ASME Code approved method for Section III Class 3 piping. This WO is required to be performed during RF24.

6. Duration of Proposed Alternative:

A code compliant repair will be completed during the next refueling outage which is scheduled to start on October 6, 2018.

7. Precedents:

There have been several submittals approved for N-513-4 in specific applications. The table below lists several Safety Evaluation Reports as precedents for use of Code Case N-513-4.

SER Accession No	Plant	Application	Additional Requirement
ML17270A030	Perry	Leaking Elbow	None
ML 15070A428	ANO	Leaking Sweepolet	5 gpm leakage limit
ML 14231B310	Fort Calhoun	Leaking Elbow	None
ML 14335A551	Peach Bottom	Leaking Elbow	5 gpm leakage limit

8. References:

1. ASME Code Section XI, Division 1, 2007 Edition through 2008 Addenda
2. GL 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1,2, and 3 Piping" (ADAMS Accession No. ML031140590)
3. Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 18, March 2017. (ADAMS Accession No. ML16321A336)
4. Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping", Section XI, Division 1, January 26, 2009.
5. Code Case N-513-4, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping", Section XI, Division 1, May 7, 2014.(Previously enclosed in ML17232A000)
6. Technical Basis for Proposed Fourth Revision to ASME Code Case N-513. (Previously enclosed in ML17232A000)
7. VCSNS Design Basis Document, "Service Water System (SW)", Revision 15.

VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1

ENCLOSURE 2

DESIGN CALCULATION SW002/04 REVISION 0 "THROUGH WALL LEAK EVALUATION"

Subject Code 560	SOUTH CAROLINA ELECTRIC AND GAS COMPANY CALCULATION RECORD			Page 1 of 4
Calculation Title: Through Wall Leak Evaluation		Calculation Number: SW002/04	Revision: 0	Status: A BCB 7/3/18
Parent Document: ECR72389	System: SW	Safety Class: ☐ NN ☐ QR ☒ SR	☐ Partial Calc. Revision ☒ Complete Calc. Revision	
Originator: B. Starbuck	Discipline: PS	Organization: SCE&G-DE	Date: 7/2/18	XREF Number: N/A

CALCULATION INFORMATION

Content Description: Evaluation of the acceptability of a through wall leak in the 20" Service Water tee downstream of valve XVB03123B-SW.

Affected Components/Calculations/Documents:
SW002

Piping Reconciliation Completed per QA-CAR-0089-18: ☐ This Revision ☐ Previous Revision ☒ N/A

Contains Preliminary Data/Assumptions: ☒ No ☐ Yes, Affected Pages: _____

Computer Program Used: ☐ No
☐ Yes, Validated per _____ (vendors name) computer program validation process (others)
☒ Yes, Validated in accordance with SAP-1040 (Ref. 3.11)
☐ Yes, Validated [ES-0412]
☐ Computer Program Validation Calculation

D

VERIFICATION ☐ Continued, Attachment

Scope: Verify correct inputs, methodology, computations, and completeness of scope.

Verifier: T. Wood
Assigned by: B. Brown

B. Starbuck 7/3/18
Engineering Personnel /Date

Verifier/Date 7/3/18

Owner's Acceptance Review

N/A
Responsible Engineer/Date
Required for all engineering work performed by contractor personnel not enrolled in the VCSNS Engineering Training Program

A

Brenda Brown 7-3-18
Approval/Date

RECORDS

To Records Mgmt: _____
Initials/Date

Distribution: Calc File (Original)

SOUTH CAROLINA ELECTRIC & GAS COMPANY REVISION SUMMARY	Page 2 of 4

Calculation Number
SW002/04

Revision Number.	Summary Description
0	Initial Issue to accept through pipe wall flaw utilizing ASME Code Case N-513-4.

PURPOSE

The purpose of this calculation is to document the evaluation of the acceptability of a through wall leak in the 20 inch Service Water tee downstream of valve XVB03123B-SW.

REFERENCES

1. NRC Generic Letter 90-05
2. ASME Code Case N-513-4
3. ASME B&PV Code, Section III, 1971 Edition with Sumer 1973 Addenda.
4. ASME B&PV Code, Section III, 2010 Edition Subsection NB-3000 – used for primary stress indices
5. Drawing 1MS-22-0018, Rev 4
6. Drawing 1MS-22-0385, Rev 4
7. Drawing 302-222 Sheet 3, Rev 4
8. Drawing 314-251 Sheet 2, Rev 5
9. Calculation SW002 Rev 5.5
10. Calculation SW002/02 Rev 1
11. Calculation SW002 Rev 1
12. EPRI TR-103198-T1, "A Method to Predict Cavitation and the Extent of Damage in Power Plant Piping"
13. NRC Reg. Guide 1.147, Rev 18

ATTACHMENTS

1. MATHCAD Tmin Calculation for Node 26 for SW002 – 4 pages
2. MATHCAD N-513-4 Evaluation – 3 pages
3. UT inspection results of Flaw (WO #1813150-001) – 3 pages
4. PIPESTRESS ANALYSIS Thermal Evaluation – 1 page

COMPUTER PROGRAMS

MATHCAD 14

PIPESTRESS 3.9.0

ASSUMPTIONS

None.

EVALUATION

The piping was reviewed for minimum pipe wall thickness using hoop stress and longitudinal stress. This is documented in Attachment 1. The results of the minimum wall thickness calculation determined that the thermal stress is bounding for the wall thickness. The thermal expansion stresses were originally calculated in Revision 1 of SW002 (Reference 11). Since Revision 1 was issued, subsequent piping analyses have been evaluated and the current revision is SW002 Revision 5.5 (Reference 9). The thermal evaluation was considered bounding in Revision 1 and therefore it was not analyzed in the later revisions. The thermal anchor movements actually increased from the Revision 1 to the Revision 5.5. However, this relaxed the thermal stresses as the pipe was expanding due to its operating temperature of 130F. Attachment 4 includes the stress results from the current revision, including an updated thermal analysis to utilize the current configuration for the purposes of the flaw evaluation.

The flaw will be evaluated utilizing the ASME Code Case N-513-4 (Reference 2) and must fall within the scope of the requirements listed in Section 1 of N-513-4. The flaw meets the requirement of the Section

1.0(d) Scope of N-513-4, as this flaw is located on a tee (Node 26) on drawing 314-251 Sheet 2 (Reference 8).

Continuing forward with Section 2, "Procedure", of N-513-4 (Reference 2):

(a) The flaw geometry has been characterized and is included in Attachment 3.
(b) The flaw is classified as Non-Planar Through Wall. Attachment 3 does not suggest there is a "crack" type indication. The flaw is identified as a "pinhole" flaw.
(c) There is only a single flaw identified, and the remaining pipe wall and weld are nominal.
(d) Flaw Evaluation shall be performed – See Attachment 2
(e) Frequent periodic inspections of no more than 30 day intervals shall be used to determine if flaws are growing and determine a timeframe as which the flaw may be no longer acceptable. This method is recommended over using a flaw growth evaluation due to the nature of the erosion which is difficult to predict (Reference 12).
(f) This calculation does not include an evaluation of the effects of the water spray. That is outside of the scope of this evaluation.
(g) The results provided are the limit of the flaw size. Any further growth would have to be reanalyzed.
(h) Per the NRC stipulations for the use of N-513-4, a repair must be made at the next outage.
(i) This evaluation and the UT examination are documented in accordance with IWA-6300. Licensing is requesting an emergency relief request in order to apply the N-513-4 code case.

Outside of the scope of this calculation, augmented volumetric examination or physical measurement to assess degradation of the affected system shall be performed to identify and detect other susceptible flaw locations per N-513-4.

Additionally, during the inspection of the through wall flaw in the 20 inch Service Water Tee, an external "gouged area" was discovered approximately 80 degrees from the through wall flaw. The external flaw described on page 3 of Attachment 3, has a 2.5" linear portion that is below the calculated minimum required wall thickness of 0.162 inch in Attachment 1. There is no approved ASME Code Case or ASME Section XI/III to evaluate the external gouge. Therefore, the most conservative evaluation would be to analyze the gouge as a separate through wall flaw, in which it would be bounded by the results of this calculation.

RESULTS

The through wall flaw as recorded in Attachment 3 (page 2 of 3) is acceptable. Further degradation is acceptable as long as the average thickness of the remaining material is greater than 0.051 in, within a diameter of 2.5 inches. Note that the average thickness is 0.177 inches as determined from the UT measurements recorded in Attachment 3.

The external flaw that was discovered during the inspection of the through wall flaw, is bounded by the results of the through wall flaw. This is conservative, as the gouged area, is not a through wall flaw, and does not need to be considered for future growth. The minimum thickness of the gouged area exceeds the 0.051in thickness in Attachment 2.

Daily walkdowns of the area are recommended to ensure any spray evaluations are still valid. This calculation is only applicable for the duration up until the next refueling outage (RF24, Fall 2018), where the flaw must be repaired.

ASME Code Section III design basis evaluation for Tmin for Safety Related Pipe
Note: Previously ran PIPESTRESS analysis data required (moments)
Highlighted fields for input ONLY!

20x20 Tee
Analysis: SW002, Rev. 5.5 & 1 Node: 26

Design Basis Hoop (Circumferential) Stress Equation

Input

$P := 50 \cdot psi$ Pressure (Used 50 psi from 302-222 to be conservative, Normal Design is 16 psi)

$Do := 20 \cdot in$ Pipe Outer Diameter (Actual)

$R_{bend} := 30 in$ Bend Radius (long, 1.5x Nominal OD)

$S_H := 15000 \cdot psi$ Hot Allowable Bending Stress

$S_A := 1.5 \cdot S_H = 2.25 \times 10^4 \cdot psi$

$t_b := 0.375 \cdot in$ Nominal Wall Thickness

$y := .4$ Constant

$$tminHOOP := \frac{P \cdot Do}{2 \cdot [S_H + (y \cdot P)]}$$

$tminHOOP = 0.033 \cdot in$

Input

Using Test Mc

$M_A := 2307 \cdot ft \cdot lbf$ Deadweight Moment

$M_B := 13097 \cdot ft \cdot lbf$ 9U OBE Moment

$M_C := 27114 \cdot ft \cdot lbf$ Thermal Moment*

$M_{BSSE} := 16178 \cdot ft \cdot lbf$ 9E SSE Moment

Note:
The moments are assumed to remain constant with varying wall thickness

Rev. 1 Mc
$M_C := 54251 \cdot ft \cdot lbf$

* - Mc was determined in Rev 1 to be bounding at 54251 ft-lbf. The subsequent revisions did not rerun the thermal analysis stress as the Rev 1 remained bounding. Mc was recalculated by running the Rev 5.5 stress analysis and including the thermal evaluation. See Attachment 4 for the updated thermal stress evaluation.

Equation 8: Longitudinal Pressure + Dwt.

$$i_{teedwt}(t_{minDWT}) := \frac{0.9}{\left(\frac{t_{minDWT} \cdot 4.4}{\frac{Do}{2} - \frac{t_{minDWT}}{2}}\right)^{\frac{2}{3}}}$$

itee is a function of Tmin therefore must be iterated as well.

guess

$t_{minDWT} := 0.3 \cdot in$

Given

$$\left[\frac{P \cdot Do}{4 \cdot t_{minDWT}} + \frac{0.75 \cdot i_{teedwt}(t_{minDWT}) M_A}{\pi \cdot \left(\frac{Do}{2} - \frac{t_{minDWT}}{2}\right)^2 \cdot t_{minDWT}}\right] = S_H$$

$DWT := Find(t_{minDWT}) = 0.061 \cdot in$

Equation 10: Thermal Stress (combination case)

$$i_{teethr}(t_{minTHR}) := \frac{0.9}{\left(\frac{t_{minTHR} \cdot 4.4}{\frac{Do}{2} - \frac{t_{minTHR}}{2}}\right)^{\frac{2}{3}}}$$

itee is a function of Tmin therefore must be iterated as well.

guess

$t_{minTHR} := 0.3 \cdot in$

Given

$$\left[\frac{M_C \cdot i_{teethr}(t_{minTHR})}{\pi \cdot \left(\frac{Do}{2} - \frac{t_{minTHR}}{2}\right)^2 \cdot t_{minTHR}}\right] = S_A$$

SOLUTION

$THR := Find(t_{minTHR}) = 0.207 \cdot in$

Equation 11: Longtudinal Pressure + Dwt. + Thermal Stresses

$$i_{teeeq11}(t_{minEQ11}) := \frac{0.9}{\left(\frac{t_{minEQ11}\cdot 4.4}{\frac{Do}{2} - \frac{t_{minEQ11}}{2}}\right)^{\frac{2}{3}}}$$

itee is a function of Tmin therefore must be iterated as well.

guess

$t_{minEQ11} := 0.3\cdot in$

Given

$$\frac{P\cdot Do}{4\cdot t_{minEQ11}} + \left[\frac{0.75\cdot i_{teeeq11}(t_{minEQ11})M_A}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{minEQ11}}{2}\right)^2\cdot t_{minEQ11}}\right] + \left[\frac{M_C\cdot i_{teeeq11}(t_{minEQ11})}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{minEQ11}}{2}\right)^2\cdot t_{minEQ11}}\right] = S_H + S_A$$

Eq. 8 + 10

SOLUTION

$EQ11 := Find(t_{minEQ11}) = 0.162\cdot in$

Equation 9U: Longitudinal Pressure + Dwt. (Ma) + OBE Stresses (Mb)

$$i_{teeeq9U}(t_{min9U}) := \frac{0.9}{\left(\frac{t_{min9U}\cdot 4.4}{\frac{Do}{2} - \frac{t_{min9U}}{2}}\right)^{\frac{2}{3}}}$$

itee is a function of Tmin therefore must be iterated as well.

guess

$t_{min9U} := 0.3\cdot in$

Given

$$\frac{P\cdot Do}{4\cdot t_{min9U}} + \left[\frac{0.75\cdot i_{teeeq9U}(t_{min9U})M_A}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{min9U}}{2}\right)^2\cdot t_{min9U}}\right] + \left[\frac{0.75\cdot i_{teeeq9U}(t_{min9U})M_B}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{min9U}}{2}\right)^2\cdot t_{min9U}}\right] = 1.2\cdot S_H$$

SOLUTION

$T9U := Find(t_{min9U}) = 0.15\cdot in$

Equation 9E: Longitudinal Pressure + Dwt. (Ma) + SSE Stresses (Mb redefined for SSE)

$$i_{teeeq9E}(t_{min9E}) := \frac{0.9}{\left(\frac{t_{min9E}\cdot 4.4}{\frac{Do}{2} - \frac{t_{min9E}}{2}}\right)^{\frac{2}{3}}}$$

itee is a function of Tmin therefore must be iterated as well.

guess

$t_{min9E} := 0.3\cdot in$

Given

$$\frac{P\cdot Do}{4\cdot t_{min9E}} + \left[\frac{0.75\cdot i_{teeeq9E}(t_{min9E})M_A}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{min9E}}{2}\right)^2\cdot t_{min9E}}\right] + \left[\frac{0.75\cdot i_{teeeq9E}(t_{min9E})M_{BSSE}}{\pi\cdot\left(\frac{Do}{2} - \frac{t_{min9E}}{2}\right)^2\cdot t_{min9E}}\right] = 1.8\cdot S_H$$

$0.75\, i_{teedwt}(DWT) = 7.51$

SOLUTION

$T9E := Find(t_{min9E}) = 0.13\cdot in$

$i_{teethr}(THR) = 4.411$

$0.75(i_{teethr}(EQ11)) = 3.904$

$0.75\, i_{teeeq9U}(T9U) = 4.108$

$0.75(i_{teeeq9E}(T9E)) = 4.539$

Tmin := max(tminHOOP, THR, T9U, EQ11, T9E, DWT)

$Tmin = 0.207\cdot in$ for Equation 10

Tmin := max(tminHOOP, T9U, EQ11, T9E, DWT)

$\boxed{Tmin = 0.162\cdot in}$ for Equation 11

Since the ASME Code allows the use of Equation 10 or 11, the tmin for Equation 11 was utilized to be the limiting minimum wall thickness required by the code.

ASME Code Case N-513-4
Non-Planar Flaw Evaluation of 20" Tee

$OD_{pipe} := 20in$ $t_{nom} := 0.375in$ $p := 50psi$ $S_a := 15ksi$ $R_m := \frac{OD_{pipe} - t_{nom}}{2}$

A leak was discovered near a previous pinhole leak in the Service Water Piping System. Due the local proximity, the Separation Requirements have to be confirmed to analyze the flaw's either as one flaw, or two separate flaws. The new leak is located 3.75" down from the previous leak in the weld that was analyzed using ASME Code Case N-513-3.

$L_{pinhole} := 0.1875in$ $L_{teeleak} := 2in$

$L_{m\_avg} := \frac{L_{pinhole} + L_{teeleak}}{2} = 1.094 \cdot in$ From Section 3.2(a) of N-513-4

$2 \cdot L_{m\_avg} = 2.188 \cdot in$ This confirms that the flaw being 3.75" away is acceptable to be analyzed as an individual flaw.

ASME Code Case N-513-4 Equation 4

$t_{min} := \frac{p \cdot OD_{pipe}}{2 \cdot (S_a + 0.4 \cdot p)} = 0.033 \cdot in$ As Attachment 1 stated, Thermal Stress is Bounding for determining minimum wall thickness for the tee.

$t_{minv} := 0.162in$ Using 0.162 in for tmin for conservatism.

For through-wall leakage along portion of the thinned wall:

ASME Code Case N-513-4 Equation 7

$t_{adj} := 0.32in$ The value was selected to be greater than t_min and less than nominal.

$d_a := \frac{1.5 \cdot \sqrt{R_m \cdot t_{adj}} \cdot (t_{adj} - t_{min})}{t_{min}}$ $d_a = 2.592 \cdot in$

d_a must be greater than or equal to d_adj

$d_a = 2.592 \cdot in$ vs $d_{adj} := 2.5in$

Equation 8 was iterative until d_a yielded a result of 2.592", which is the first diameter of the data points taken around the through wall flaw. The flaw continues diagonal and is contained within at 2.5" diameter non-planer thinned area. At the 2.5" diagonal dimension, the wall begins to satisfy the minimum pipe wall thickness required.

ASME Code Case N-513-4 Equation 8

$$t_c := 0.353 \cdot d_{adj} \cdot \sqrt{\frac{p}{S_a}} \qquad t_c = 0.051 \cdot in$$

This means that t_c_avg (the average wall thickness measurements within a measurement diameter around the flaw of 2.5in) must be greater than or equal to 0.051in.

Taking the average of data points thru wall flaw yields an average of 0.177in. See Attachment 3 for UT data points.

$t_1 := 0.348in \quad t_2 := 0.089in \quad t_3 := 0.224in \quad t_4 := 0.114in \quad t_5 := 0.099in \quad t_6 := 0.143in$

$t_7 := 0.162in \quad t_8 := 0.215in \quad t_9 := 0.375in \quad t_{hole} := 0in$

$$t_{cavg} := \frac{t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7 + t_8 + t_9 + t_{hole}}{10}$$

$t_{cavg} = 0.177 \cdot in$

t_cavg is greater than t_c, therefore Equation 8 is satisfied.

This confirms that the flaw meets the requirement of Section 3.2 Non-Planar flaws in Straight Pipes. Since this flaw is located outside of the reinforcement region of an ASME B16.9 standard tee fitting, the additional Sections 3.5 must be satisfied.

$t_{adj} = 0.32 \cdot in$ From Equation 7

ASME Code Case N-513-4 Equation 13

$$\sigma_h := \frac{p \cdot OD_{pipe}}{2 \cdot t_{adj}} = 1563 \cdot psi$$ Allowable 15,000 psi, OK

B1 indices from Table NB-3681(a)-1

$B_1 := 0.5$

ASME Code Case N-513-4 Equation 14

$$\sigma_m := B_1 \cdot \left(\frac{p \cdot OD_{pipe}}{2 \cdot t_{adj}} \right) = 781.25 \cdot psi$$ Allowable 15,000 psi, OK

$ID_{pipe} := OD_{pipe} - 2 \cdot t_{nom} = 19.25 \cdot in$

B2 indices from NB-3683.9

$R_m := \frac{(OD_{pipe} + ID_{pipe})}{4} = 9.8125 \cdot in$

$B_{2B} := 0.4 \cdot \left(\frac{R_m}{t_{nom}} \right)^{\frac{2}{3}} = 3.526$

$B_{2R} := 0.5 \cdot \left(\frac{R_m}{t_{nom}} \right)^{\frac{2}{3}} = 4.407$

$M_b := \left[(2307 ft \cdot lbf)^2 + (13097 ft \cdot lbf)^2 \right]^{\frac{1}{2}} = 13298.6 \cdot ft \cdot lbf$ SRSS of Ma and Mb OBE shown on Attachment I

$ID_{pipe\_flaw} := OD_{pipe} - 2 \cdot t_{min} = 19.676 \cdot in$ I based on moment of inertia based on degraded section

$I_t := 0.0491 \left(OD_{pipe}^{\ 4} - ID_{pipe\_flaw}^{\ 4} \right)$

ASME Code Case N-513-4 Equation 15

$\sigma_b := B_{2R} \cdot \left(\frac{M_b \cdot OD_{pipe}}{2 \cdot I_t} \right) = 14155.159 \cdot psi$ Allowable 15,000 psi, OK

ASME Code Case N-513-4 Equation 16

$i := 2.95 \qquad M_e := 27114 ft \cdot lbf$ M.c shown on Attachment I

$\sigma_e := i \cdot \left(\frac{M_e \cdot OD_{pipe}}{2 \cdot I_t} \right) = 19319.138 \cdot psi$ Allowable 22,500 psi, OK

Flaw has be successfully qualified using ASME Code Case N-513-4.

QSP-516
ATTACHMENT I
PAGE 1 OF 1
REVISION 8

ULTRASONIC THICKNESS DETERMINATION REPORT

SITE: VCS Unit 1 WORK REQUEST #: 1813150-001 DATE: 7/2/18

SYSTEM: SW DRAWING/ISO #: IMS-22-018 LOCATION: IB412

CODE/CLASS: ASME CL3 SURFACE CONDITION: As forged. AREA OF INTEREST: Ⓐ

PIPE SIZE: 20" NOMINAL THICKNESS: .375 JOINT DESIGN: Fitting

BASE METAL SPECS: Carbon Steel MINIMUM ALLOWABLE THICKNESS: N/A

INSTRUMENT MODEL #: 38DL Plus SERIAL #: 120492708 COUPLANT BATCH #: 15D018

CALIBRATION STANDARD #: UT-101 TRANSDUCER: S/N 803005

LOCATION NUMBER	ACTUAL THICKNESS	SKETCH
		*See attached.

Per the provided acceptance criteria, this test is: SAT ☐ UNSAT ☐ INFO ONLY ☑

REMARKS: *See attached

Ⓐ Around pinhole leak below field weld (FW-1)

Inspector: [signature] Level: II Date: 7/3/18

Inspector: _____ Level: _____ Date: _____

PLANNER WORK SHEET

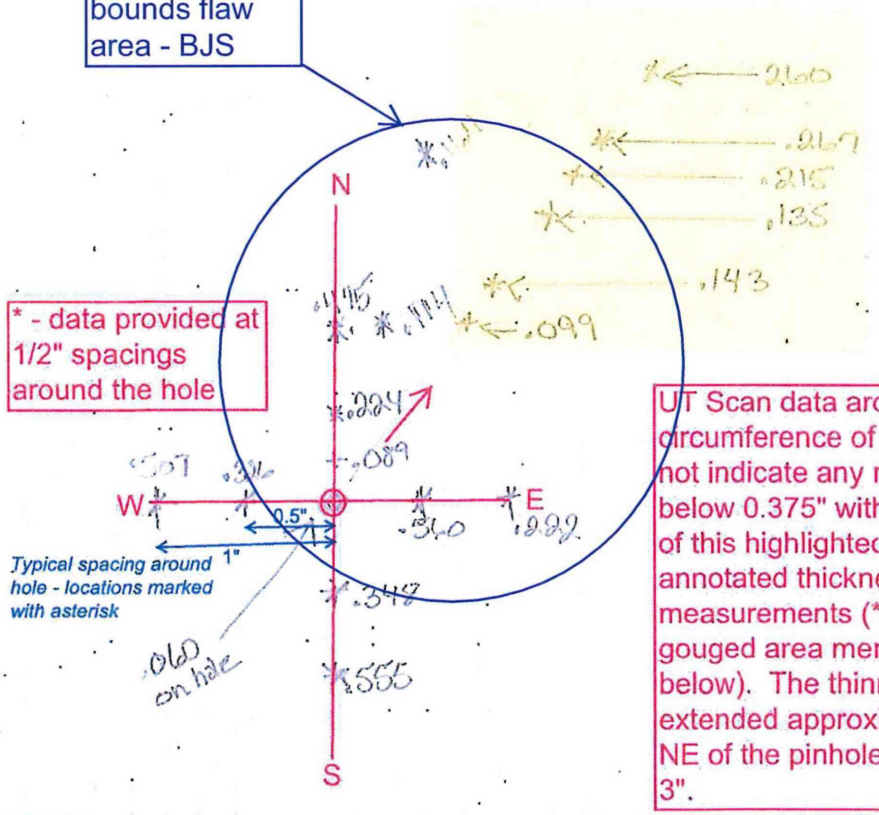
PLANNER _____
DOCUMENT _____
DATE _____

Jan

PROJECT TITLE WO #1813150 - UT Results for SW Pin Hole Leak

PAGE ____ OF ____

2.5" flaw size bounds flaw area - BJS



* - data provided at 1/2" spacings around the hole

UT Scan data around the circumference of the tee did not indicate any reading below 0.375" with exception of this highlighted area and annotated thickness measurements (*and the gouged area mentioned below). The thinned region extended approximately 45° NE of the pinhole out about 3".

Readings were taken all around the area of the hole and the tee. If the thickness reading fell below 0.375", that data point was recorded.

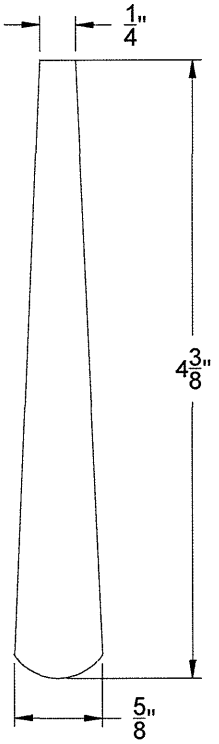
*There was a "gouged area" on the OD of the pipe. Engineering took pictures and measured the area with the indentation--approximately 1" wide and 3.5" long. Lowest thickness reading in this area was 0.097".

PLANNER SIGNATURE/DATE	PLANNING SUPERVISOR APPROVAL SIGNATURE/DATE

Center-line of Weld to flaw: 3.75"

Size of flaw: 0.9 mm

Groove Geometry:



UT Results for Groove (in 1/2" increments starting at the top):

Left Side of Groove	Center of Groove	Right Side of Groove
0.458"	0.466"	0.490"
0.472"	0.469"	0.468"
0.483"	0.473"	0.458"
0.495"	0.449"	0.466"
0.510"	0.109"	0.486"
0.539"	0.131"	0.554"
0.682"	0.090"	0.665"
0.667"	0.103"	0.695"
0.655"	0.102"	0.650"
	0.176"	
	0.695"	

Measurements were taken until the end of the groove (left and right). The center was measured until a return to t_nom was detected (thus the extra two measurements). The missing measurements to either side of these two extra center measurements should be considered to be at or around the ones preceding them. The extra measurements in the center are due mainly to the groove itself and the curvature of the tee branch.

CALCULATION NUMBER 1234 CODE SECTION III CLASS 3 ASME-1971 REV S73 J. Hatcher 2018/07/02 15:30:22 [102]
Addition of slip on flanges to base of inlet for SW inlet

LOADING CASE NO. 201 THERMAL ANALYSIS - Thermal 130F

NUMBER OF CYCLES NOT ENTERED SA BASED ON F=1.

EQUATION 10 THERMAL EXPANSION

	POINT NO.	LOCAL FORCES IN POUNDS SHEAR 1 (X)	SHEAR 2 (Y)	AXIAL (Z)	MOMENTS IN FOOT POUNDS BEND.1 (X)	BEND.2 (Y)	TORSION (Z)	SIF	STRESS PSI	STRESS RATIO
ANCHOR	29									
				* ALLOWABLE STRESS SA = 22500. *						
TANGENT	29	900.	-177524.	-9149.	224572.	1151.	2685.	1.000	24204. *	1.076
	27	-900.	177524.	9149.	-194925.	-1000.	-2685.	1.000	21010.	0.934
TANGENT	27	-177524.	-900.	-9149.	1000.	-194925.	2685.	1.000	21010.	0.934
	26	177524.	900.	9149.	124.	-26980.	-2685.	2.954	8632.	0.384
WELDING TEE	26									
WELDING TEE	26									
TANGENT	26	-10363.	-1312.	-5800.	3774.	-12225.	827.	2.954	4082.	0.181
	25	10363.	1312.	5800.	-2134.	-729.	-827.	1.000	259.	0.012
TANGENT	25	1312.	-10363.	-5800.	-729.	2134.	827.	1.000	259.	0.012
	24	-1312.	10363.	5800.	7144.	-1322.	-827.	1.000	788.	0.035
TANGENT	24	1312.	-10363.	-5800.	-7144.	1322.	827.	1.000	205.	0.009
	23	-1312.	10363.	5800.	9632.	-1007.	-827.	1.000	273.	0.012
JUNCTION	18									
TANGENT	18	1312.	-10363.	-5800.	-21467.	-491.	827.	1.000	2316.	0.103
	17	-1312.	10363.	5800.	34421.	2131.	-827.	2.950+	10967.	0.487
JUNCTION	17									
JUNCTION	17									
TANGENT	17	1234.	-841.	-2475.	-49.	-1351.	2172.	1.000	276.	0.012
	16	-1234.	841.	2475.	1105.	2901.	-2172.	1.000	408.	0.018
LR ELBOW	16	-1234.	841.	-2475.	1105.	2901.	2172.	3.766	1538.	0.068
15B	6500	-877.	-841.	2623.	-733.	-3271.	-2933.	3.766	1808.	0.080
TANGENT	6500	841.	-877.	-2623.	3271.	-733.	2933.	1.000	480.	0.021
	121	-841.	877.	2623.	-1410.	2518.	-2933.	1.000	443.	0.020
TANGENT	121	841.	-877.	-2623.	1410.	-2518.	2933.	1.000	443.	0.020
	12	-841.	877.	2623.	451.	4303.	-2933.	1.000	563.	0.025
LR ELBOW	12	-841.	877.	-2623.	451.	4303.	2933.	3.766	2121.	0.094
11B	6501	-2623.	-877.	841.	740.	152.	-2644.	3.766	1116.	0.050

VERIFICATION RECORD: CALCULATION

Calculation # SW002/04 Revision 0

The following questions, as a minimum should be answered for calculation verification.

Yes	N/A	
☒	☐	Have inputs, including codes, standards, regulations, requirements, procedures, data and engineering methodology been correctly selected and applied?
☒	☐	Has the calculation been developed in accordance with applicable station procedures (e.g., ES-0412).
☒	☐	Is the plant design basis/criteria maintained?
☐	☒	Have assumptions been identified, especially those requiring later confirmation?
☒	☐	Have references been properly identified and complete?
☒	☐	Have the calculation, results, tables and figures been reviewed with regard to numerical accuracy, units and consistency?
☒	☐	Has the calculation been developed/revised in a clear and understandable manner as to not require recourse to the originator?
☒	☐	Is the output reasonable compared to the input?
☒	☐	Do the diagrams or models depicted represent the physical situation correctly and incorporate necessary features for a correct analysis?
☒	☐	Has the calculation cover page been completed in an accurate manner?
☒	☐	Are the sign conventions used in figures and equations consistent?
☒	☐	Is consistent nomenclature used throughout the calculation (e.g., figures, tables)?
☒	☐	Are symbols used on figures and in the text defined?
☐	☒	Are concurrent in-process revisions been addressed and coordinated with this revision?
☒	☐	Has the Calculation Index been updated?
☐	☒	Additional considerations (see attached TWR)?

VERIFICATION RECORD: CALCULATION

Calculation # SW002/04 Revision 0

CALCULATIONS UTILIZING COMPUTER PROGRAMS:

Yes	N/A		
☒	☐	Has the program been appropriately defined, including the version?	
☒	☐	Is the basic methodology used by the program appropriate for the calculation?	
☒	☐	Has the appropriate computer program been used?	
☒	☐	Has the calculation been performed within the known limits of the program?	
☒	☐	Has the computer program been verified and validated in accordance with VCS-SAP-1040?	A
☐	☒	Has the program been defined, controlled, and benchmarked so that the results reported are traceable to a particular version of the program and a particular set of input data?	
☐	☒	Have limits for the program been defined, as appropriate?	
☒	☐	Comments have been included and resolved.	
☐	☒	Is the Validation Data set for the application complete, and provide repeatable results?	

WT Wood	/	7/3/18
Verifier's Printed Name	Verifier's Signature	Date