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10 CFR 50.55a

W3F1-2019-0052

July 18, 2019

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

Subject: 10 CFR 50.55a Relief Number WF3-RR-19-2, Proposed Alternative to Code Case N-666-1, "Weld Overlay of Class 1, 2, and 3 Socket Welded Connections, Section XI, Division 1" in Accordance with 10 CFR 50.55a(z)(2)

Waterford Steam Electric Station, Unit 3
NRC Docket No. 50-382
Renewed Facility Operating License No. NPF-38

In accordance with 10 CFR 50.55a, "Codes and Standards," paragraph (z)(2), Entergy Operations, Inc. (Entergy) hereby requests U.S. Nuclear Regulatory Commission (NRC) approval of the attached alternative to Code Case N-666-1, "Weld Overlay of Class 1, 2, and 3 Socket Welded Connections, Section XI, Division 1." For Waterford Steam Electric Station, Unit 3 (Waterford 3), this request proposes an alternative to specific requirements of Code Case N-666-1 for a repair to American Society of Mechanical Engineers (ASME) Code, Section III, Class 2 austenitic stainless steel piping.

A through-wall flaw was discovered between two socket welded connections on a 1-inch Chemical and Volume Control (CVC) system drain line upstream of the charging pumps suction header. The short distance between the two socket welds (i.e., < 1/8") prevents meeting certain design requirements of Code Case N-666-1. Entergy proposes to install the weld overlay across both socket welded joints, the piping base metal, and on the outer surfaces of the socket weld fittings. This alternative is applicable to the through wall flaw on CVC system line 2CH1-30 until repair is performed during Refueling Outage 23.

Pursuant to 10 CFR 50.55a(z)(2), Entergy requests to use this alternative on the basis that complying with the specified requirement would result in hardship or unusual difficulty, without a compensating increase in the level of quality and safety. The proposed alternative, as described in the Enclosure and associated Attachment, complies with 10 CFR 50.55a(z)(2) and provides an acceptable level of quality and safety. Entergy requests approval of the proposed alternative no later than July 23, 2019.

Enclosure Attachment 2 summarizes the new regulatory commitments made in this submittal.

If you have any questions or require additional information, please contact the Regulatory Assurance Manager, Paul Wood, at (504) 464-3786.

Respectfully,

Ron Gaston

RWG/rd

Enclosure: 10 CFR 50.55a Request Number WF3-RR-19-2
Attachment 1: Structural Integrity Calculation Package 1900769.302, Revision 0, "Evaluation of Weld Overlay Repair of Socket Weld Region," July 18, 2019
Attachment 2: List of Regulatory Commitments

cc: NRC Region IV Regional Administrator
NRC Senior Resident Inspector – Waterford Steam Electric Station, Unit 3
NRC Project Manager

ENCLOSURE
W3F1-2019-0052

10 CFR 50.55a Request Number WF3-RR-19-2

Attachment 1: Structural Integrity Calculation Package 1900769.302, Revision 0, "Evaluation of Weld Overlay Repair of Socket Weld Region," July 18, 2019

Attachment 2: List of Regulatory Commitments.

Entergy Operations, Inc.
10 CFR 50.55a Request Number WF3-RR-19-2
Proposed Alternative to Code Case N-666-1, "Weld Overlay of Class 1, 2, and 3 Socket Welded Connections, Section XI, Division 1"

1. ASME Code Component(s) Affected:

Component: Chemical and Volume Control (CVC) System line 2CH1-30, Volume Control Tank Outlet Header Drain to Equipment Drain Tank Sump

Code Class: 2

Unit: Waterford Steam Electric Station, Unit 3 (Waterford 3)

Interval: Fourth (4^{th}) Interval beginning December 1, 2017 and ending November 30, 2027

2. Applicable Code Edition and Addenda:

ASME Section XI, 2007 Edition through 2008 Addenda

ASME Section III, Subsection NC, 1971 Edition/1972 Winter Addenda (Original Construction Code)

ASME Section III, Subsection NC, 1992 Edition/No Addenda

ASME Section XI Code Case N-666-1 (approved for use by the NRC in Regulatory Guide 1.147)

3. Applicable Code Requirement:

American Society of Mechanical Engineers (ASME) Section XI Code includes the following applicable requirements:

- IWA-4411 states: "Welding, brazing, fabrication, and installation shall be performed in accordance with the Owner's Requirements and, except as modified below, in accordance with the Construction Code of the item."
- IWA-4411(a) states in part: "Later editions and addenda of the Construction Code, or a later different Construction Code, either in its entirety or portions thereof, and Code Cases may be used, provided the substitution is as listed in IWA-4221(c)."

As an alternative to the IWA-4000 requirements specified above, ASME Section XI Code Case N-666-1 specifies requirements for restoring the structural integrity of socket welded connections with root or toe cracks by deposition of a weld overlay on the outside surface of the pipe, socket weld, and fitting. The Code Case N-666-1 requirements specified below are those for which relief is being requested.

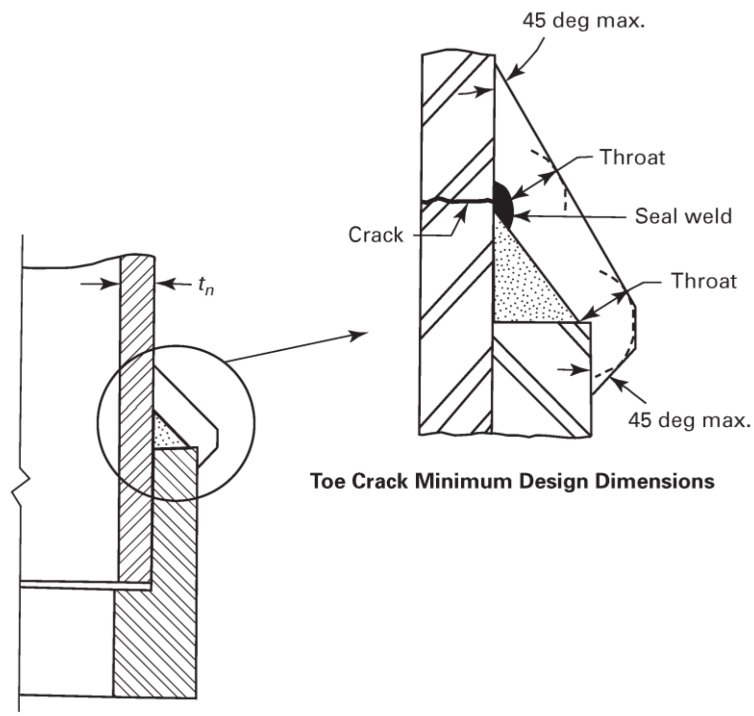
- Paragraph 1(d) of the Code Case states in part: "…the Owner shall verify that the pipe base material adjacent to the socket weld requiring overlay meets the required minimum wall thickness."

- Paragraph 3(a) of Code Case N-666-1 states in part:

  "The completed weld overlay shall meet the dimensional requirements of Figure 1."

  "When the fatigue crack is located in the base metal adjacent to the toe of the socket weld, the minimum throat dimensions shall be measured from the location of the crack farthest from the weld toe."

- Figure 1 of Code Case N-666-1 provides weld overlay design details for toe cracks. According to Figure 1, the included angle of the weld overlay along the axis of the pipe shall not exceed 45°.



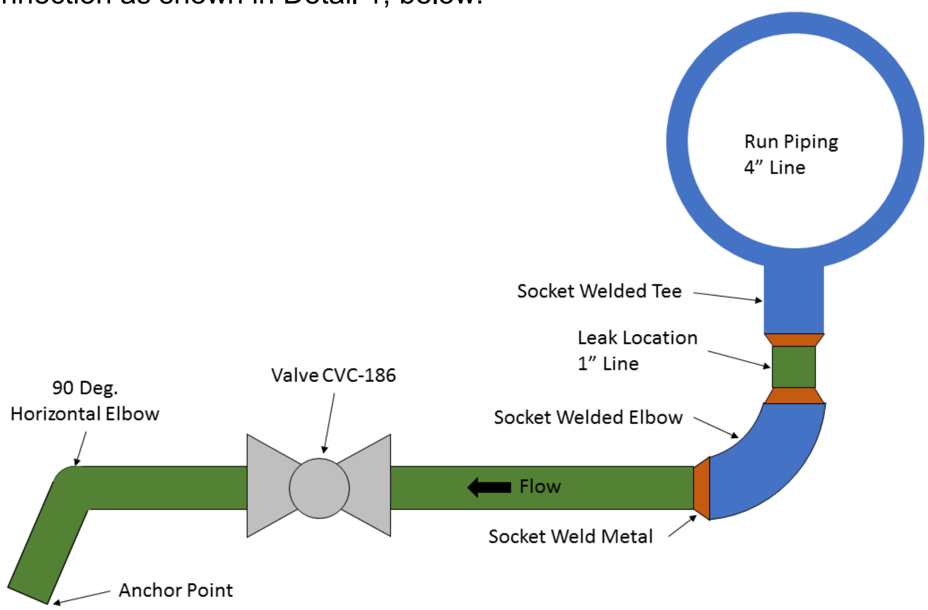
Toe Crack Minimum Design Dimensions

- Paragraph 4(d) of the Code Case states in part: "The weld sequence shall be from the fitting to the pipe for the overlay of toe cracks… The completed weld overlay shall meet the dimensional requirements of Figure 1."

Code Case N-666-1 has been approved for use in Regulatory Guide 1.147 with the following condition: "A surface examination (magnetic particle or liquid penetrant) must be performed after installation of the weld overlay on Class 1 and 2 piping socket welds. Fabrication defects, if detected, must be dispositioned using the surface examination acceptance criteria of the Construction Code identified in the Repair/Replacement Plan."

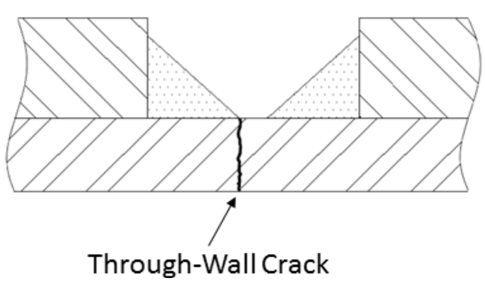
4. Reason for Request:

On July 2, 2019, a leaking flaw was discovered at Waterford 3 in the CVC system. The leakage was initially identified while performing surveillances for TS 3.4.5.2 for UNIDENTIFIED Reactor Coolant System (RCS) leakage. Subsequent investigations identified the actual source of leakage as being from CVC system in line 2CH1-30. The Class 2 leaking pipe is upstream of valve CVC-186. More specifically, the leak is located in a short section of straight pipe in between a socket welded tee and a socket welded elbow in a 1-inch Nominal Pipe Size (NPS) drain line connection as shown in Detail 1, below.



Detail 1: Pipe Configuration Around Line 2CH1-30

The leak is due to a vibration-induced flaw through the straight section of pipe at the toe of a socket welded tee branch. Detail 2 provides an example cross section of the piping configuration with the through-wall leak. Due to the proximity of a socket welded elbow, there is not a sufficient length of straight pipe to overlay the socket weld toe crack following the dimensional requirements of Figure 1 in the Code Case N-666-1. The distance between the toes of the socket welds is 1/8" or less.



Detail 2: Low Cycle/High Stress Flaw Configuration

Entergy has determined that the degradation mechanism which contributed to flaw inititation growth is low cycle/high stress (vibration) fatigue. This is consistent with information provided by the Electric Power Research Institute (EPRI) in EPRI Report 3002010753, "Welding and Repair Technology Center: Practical Guideline to Socket Welding," (Reference 2) which provides information of fatigue mechanisms and their contributions to failures of socket welded connections. Section 3.4 of this report states in part:

> "The results of socket weld tests performed… indicate that, in general, failures at a lower cycle/higher stress (i.e., LCF) tended to originate at the toe, while the higher cycle/lower stress (i.e., HCF) failures tended to occur at the root. The majority of test failures occurred due to cracks that initiated at weld roots (i.e., HCF). Toe related (i.e., LCF) failures occurred in tests at higher stress levels that were premature with identical tests in which root failures prevailed."

The location and appearance of the flaw (circumferential orientation, at the toe of the fillet weld) is indicative of a fatigue failure. Since September 2014, Entergy has typically operated the Waterford 3 CVC system in an alignment where two (2) of the three (3) charging pumps are running simultaneously (hereinafter, the “nominal” configuration), with an exception of primarily running one charging pump from February 2016 to March 2017. Prior to September 2014, the CVC system alignment generally only included one (1) operating pump (resulting in several permutations of “alternate” configurations).

On July 8, 2019, following identification of the failure, Entergy obtained vibration data in the nominal configuration from several locations on the 1-inch drain line as well as the 4-inch CVC header to which it attaches. The resulting data demonstrated relatively low baseline levels coupled with regular "pulses" wherein significantly increased amplitudes are observed for short periods (2-5 seconds). The pulses appear to be driven by acoustic imbalance between the two positive-displacement charging pumps operating in parallel. The pulses are of sufficient amplitude to have imparted fatigue damage; however, given their occasional nature and low frequency, result in slower accumulation of cycles than is typical for branch lines. This evidence supports the conclusion that the failure originated due to vibration.

<u>Structural Evaluation</u>

An evaluation of the structural stability of the circumferentially oriented through-wall flaw was performed following the criteria prescribed in ASME Code Case N-513-3. This evaluation calculates the allowable through-wall flaw in the circumferential direction for the affected piping to be 1.7 inches (41% of pipe circumference), which is bounding for the actual through-wall flaw which was determined to be 1.162" in length when characterized by a volumetric examination method (radiography). Based on the Code Case N-513-3 structural evaluation, it was determined that the leaking pipe is structurally stable.

<u>Risk Impact</u>

The risk impact of the identified flaw has been evaluated. An evaluation of the CVC drain line determined that structural integrity of the pipe would be maintained with a flaw larger than currently identified, which demonstrates that the nuclear safety risk is minimal. The leakage does not impact any specified safety functions and remains within the Technical Specification operational leakage limits. Plant operations personnel have conservative decision-making triggers to ensure actions are taken in advance of reaching the Technical Specification limits. Radiological and Industrial Safety risk is minimal because the leakage is in the low pressure suction side of the charging system. The CVC drain line is not specifically modeled in the station Probabilistic Risk Analysis (PRA) model but the impact would be to the boric acid inventory through the charging system. The loss of the boric acid makeup tank capacity would result in a change in the core damage frequency (ΔCDF) of 1.7E-7/year. This change in core damage frequency falls within the Regulatory Guide 1.174 acceptance guidelines (Reference 1) for very small changes to CDF.

Hardship to Repair

The location of this leak on 2CH1-30 is a common CVC line which is downstream of both the Boric Acid Makeup pump discharge and Boric Acid Gravity Feed Valves and upstream of the suction of all three CVC charging pumps.

The CVC system is designed to maintain the chemistry and purity of the reactor coolant during normal operation and shutdowns, maintain the required volume of water in the RCS compensating for reactor coolant contraction or expansion resulting from changes in reactor coolant temperature and for other coolant losses or additions, and control the boron concentration in the RCS to compensate for reactivity changes.

Two independent charging pumps are required to be operable per Technical Specification LCO 3.1.2.4 in Modes 1-4. There is no action statement if more than one of the independent pumps are inoperable. Two boron injection paths to the RCS via the charging pumps are required to be Operable per Technical Specification LCO 3.1.2.2. With no action statement for more than one flow path inoperable, LCO 3.0.3 requires shutdown within 1 hour.

An ASME Section XI, IWA-4000 repair of the leak in drain line 2CH1-30 cannot be performed without shutting down the plant should such a repair become necessary. As an alternative to IWA-4000, Entergy proposes to perform a weld overlay repair of the subject through-wall flaw based on ASME Section XI Code Case N-666-1. Code Case N-666 was originally approved by the ASME in April 2006. Since that time, the weld overlay methodology of this code case has been used across the industry to restore structural integrity of degraded socket weld connections.

Entergy intends to use Code Case N-666-1 to perform a weld overlay repair of the leaking through-wall flaw on drain line 2CH1-30. To do this, Entergy has initiated this relief request to propose alternatives to certain requirements in Code Case N-666-1.

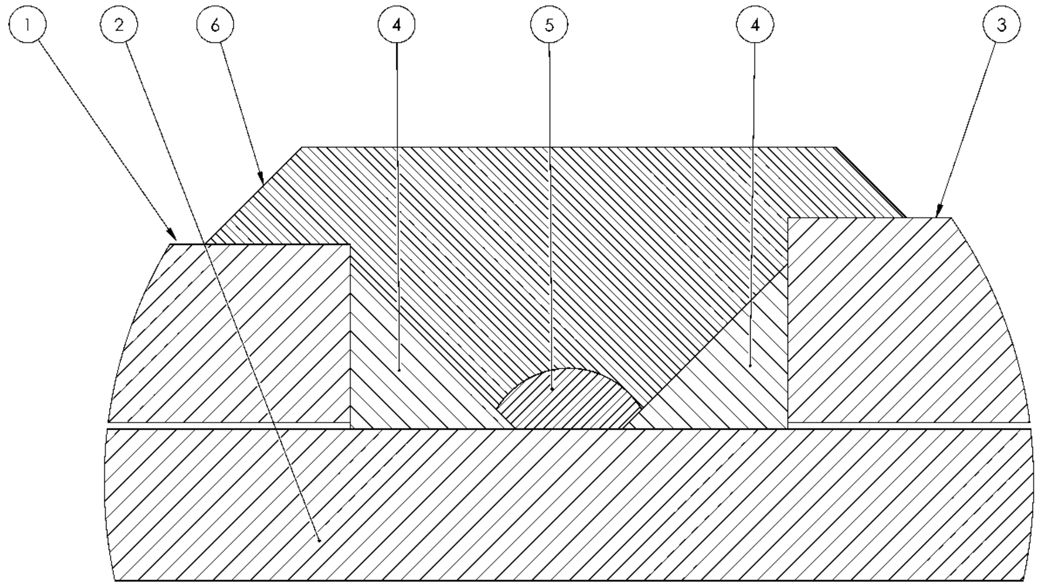
5. Proposed Alternative and Basis for Use:

Pursuant to 10 CFR 50.55a(z)(2), Entergy is proposing an alternative to specific ASME Section XI Code requirements in Code Case N-666-1 as conditionally approved for use by the NRC in Regulatory Guide 1.147. Entergy's proposed alternative and bases is provided below:

A. Code Case N-666-1, paragraph 1(d) requires that the pipe base material adjacent to the socket weld requiring overlay be verified to meet the required minimum wall thickness. However, the close proximity of the adjacent socket weld does not permit access to the pipe base material for verification that the pipe meets the minimum wall thickness. Therefore, as an alternative, Entergy proposes to install the weld overlay across both socket welded joints, the pipe, and on the outer surfaces of the socket weld fittings. The weld overlay thickness will be designed to meet the minimum required wall thickness.

B. Code Case N-666-1, paragraph 3(a) requires that the completed weld overlay comply with the dimensional requirements of Figure 1 and that the minimum throat dimension of the weld overlay be measured from the location of the crack farthest from the weld toe. However, the weld overlay cannot be designed to meet the dimensional requirements of paragraph 3(a) or Figure 1 as the installed piping configuration and the location of the leak is on a section of straight pipe in between a socket welded tee and a socket welded elbow. Furthermore, the distance between the two socket welds does not permit the weld overlay to be terminated on the pipe while meeting the 45° (maximum) requirement between the pipe and weld overlay contour.

Entergy's weld overlay design proposes an alternative design to the dimensional requirements of Figure 1 of Code Case N-666-1. The proposed repair design maintains the required wall thickness and throat dimensions as defined in paragraph 3(a) of Code Case N-666-1, and also maintains the wall thickness requirements per the Code of Construction requirements (ASME Section III, 1971 Edition with Addenda through Winter 1972). Detail 3, below, provides a schematic of the proposed repair design. The weld overlay design applies weld metal across both socket welded joints, the pipe, and on the outer surface of the socket weld fittings. The throat dimension of this design, measured from the leak seal weld surface, is greater than 0.138-inch (77 percent of the nominal wall thickness of the pipe or 0.179-inch) and meets the Code Case's design throat dimension.



Item	Description	Material
1	SOCKET WELD BRANCH CONNECTION	SA-182 F304
2	1-inch SCH 80S PIPE	SA-376 TP304
3	ELBOW	SA-182 F304
4	SOCKET WELD	E308 / ER308
5	SEAL WELD	E308L / ER308L
6	WELD OVERLAY	E308L / ER308L

Detail 3: Weld Overlay Design

A structural evaluation of the repair design is provided in Enclosure 1. This evaluation uses the hoop and axial stress limits of the 1971 Edition/Winter 1972 Addenda of ASME Section III to determine the minimum required wall thickness of the repaired pipe configuration. This evaluation is based on operating loads and conservatively does not include the thickness provided by the 1-inch NPS, Schedule 80 socket welded pipe that contains the through-wall crack. The results of this evaluation show that the minimum required wall thickness for the weld overlay repair is 0.021-inch. Compared to the required throat dimension of the repair weld at the location of the toe crack, an additional 0.117-inch of thickness margin is available. The actual configuration results in additional material being applied over the seal weld.

C. Code Case N-666-1, paragraph 4(d) requires that the weld sequence shall be from the fitting to the pipe for overlay of toe cracks and that the completed weld overlay comply with Figure 1. However, the close proximity of the adjacent socket welds does not facilitate deposition of weld metal using this weld sequence. Therefore, as an alternative, Entergy proposes to implement the proposed weld overlay design as follows:

- The crack will be seal welded in accordance with Code Case N-666-1, paragraph 4(b). Afterwards, the seal weld, remaining socket welds, and adjacent base materials to be overlaid shall be visually examined using VT-1 criteria in accordance with Code Case N-666-1, paragraph 4(c).

- Due to the configuration of the repair design, weld beads will be deposited in individual layers until the V-groove cavity and weld overlay build-up is completed as shown schematically in Detail 3. Weld sequence shall be from fitting to fitting.

- As required by Code Case N-666-1, paragraph 4(d), the weld overlay design will consist of at least two structural overlay layers deposited around the entire circumference of the socket welds, adjoining pipe, fittings. The throat dimensions of this design do not include the seal weld layers.

- The completed weld overlay will be examined and tested in accordance with Code Case N-666-1, Section 5. However, final dimensions of the completed weld overlay will comply with Entergy's proposed weld overlay design described in Section 5.B of this relief request.

All other requirements of Code Case N-666-1, including the conditional acceptance requirement in Regulatory Guide 1.147 will be met.

6. Duration of Proposed Alternative:

Entergy's intention is to perform an ASME Section XI, IWA-4000 repair on CVC system line 2CH1-30 during the next refueling outage. The proposed alternative is applicable until repair is performed during Refueling Outage 23.

7. Precedents:

None

8. References:

1. NRC Regulatory Guide 1.174, Revision 3, "An Approach for Using Probabilistic Risk Assessment in Risk-informed Decisions on Plant-Specific Changes to the Licensing Basis," January 2018, ADAMS Accession No. ML17317A256.

2. EPRI Report 3002010753, Welding and Repair Technology Center: Practical Guideline to Socket Welding, EPRI, Palo Alto, CA: 2017.

9. Attachments:

1. Structural Integrity Calculation Package 1900769.302, Revision 0, "Evaluation of Weld Overlay Repair of Socket Weld Region," July 18, 2019

2. List of Regulatory Commitments

ENCLOSURE, ATTACHMENT 1
W3F1-2019-0052

Structural Integrity Calculation Package 1900769.302, Revision 0, "Evaluation of Weld Overlay Repair of Socket Weld Region," July 18, 2019

Structural Integrity Associates, Inc.

File No.: 1900769.302

Project No.: 1900769

Quality Program Type: ☒ Nuclear ☐ Commercial

CALCULATION PACKAGE

PROJECT NAME:

Waterford Code Case N-513 Evaluation of Leaking Class 2 Line

CONTRACT NO.:

10585075

CLIENT:

Entergy Nuclear

PLANT:

Waterford Steam Electric Station, Unit 3

CALCULATION TITLE:

Evaluation of Weld Overlay Repair of Socket Weld Region

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
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1.0 OBJECTIVE

A leaking flaw was recently discovered at the Waterford Steam Electric Station, Unit 3 (Waterford) in the Chemical and Volume Control (CVC) system. The Class 2 leaking pipe is upstream of valve CVCMVAAA186 (CVC-186). The objective of this calculation is to determine the minimum required wall thickness for the repaired section of piping with a weld overlay repair.

2.0 METHODOLOGY

The structural suitability of a weld overlay repair is accomplished by verifying that the thickness of the weld buildup meets the required minimum thickness for the operational condition. The methodology of this calculation uses the equations for hoop stress and axial stress along with allowable stresses from Section III, 1971 Edition with Addenda through Winter 1972 Code of Construction [1].

The hoop stress limit is defined by the Code of Construction [1, NC-3641.1 Equation 3] and calculates the minimum required wall thickness due to internal pressure, t_m. The axial stress limits are defined as a series of stress limits based on pressure and piping loads:

- Equation 8, Longitudinal Stresses due to Sustained Loads [1, NC-3652.1]
- Equation 9, Longitudinal Stresses due to Occasional Loads [1, NC-3652.2]
- Equation 10, Longitudinal Thermal Expansion Stresses [1, NC-3652.3(a)]
- Equation 11, Longitudinal Thermal Expansion and Sustained Loads Stress [1, NC-3652.3(b)]

The smallest wall thickness that satisfies both the hoop and axial stress limits is defined as the minimum wall thickness, t_{min}. Note that only Equation 10 or Equation 11 is required to be met, not both [1, NC-3652.3]. Therefore, only Equation 10 is evaluated herein. For this evaluation, the t_{min} value will be conservatively calculated using the dimensions of the weld buildup over the socket welded connections and ignoring the structural benefit of the unflawed existing base pipe material.

2.1 Criteria for Hoop Stress

The minimum thickness required based on hoop stress, Equation 3 [1, NC-3641.1], assures against gross structural failure due to primary membrane pressure loading. Equation 3 is written as a design thickness calculation based on the maximum allowable stress. The minimum thickness required for design pressure, t_m, is defined by Equation 3 as:

$$t_m = \frac{PD_o}{2(SE + Py)} + A$$

P	=	Internal design pressure, psi
D_o	=	Outside pipe diameter, in
S	=	Maximum allowable stress at design temperature, psi
E	=	Longitudinal weld joint efficiency factor (1.0 for seamless pipe)
y	=	Pressure coefficient
	=	0.4 [1, NB-3641.1]
A	=	Additional thickness, in

The additional thickness value, A, is taken as zero.

2.2 Criteria for Axial Stress

Equations 8, 9, and 10 [1, NC-3652] are intended to show that the calculated axial stresses in the piping component, due to pressure and piping loads, meet the Code of Construction stress limits. An iterated uniform wall thickness is used to calculate the piping stresses in these equations, which are compared to an allowable stress for design purposes. The thickness that results in a stress equal to the allowable stress is taken as the minimum thickness for that condition.

The Longitudinal Stresses Due to Sustained Loads, S_{SL}, must satisfy the following requirement [1, NC-3652.1, Equation 8]:

$$S_{\mathrm{SL}} = \frac{\mathrm{PD}_o}{4\mathrm{t}_n} + \frac{0.75\mathrm{iM}_A}{Z} \leq 1.0\mathrm{S}_h$$

P	=	Internal design pressure, psi
D_o	=	Outside pipe diameter, in
t_n	=	Nominal wall thickness, in
i	=	Stress intensification factor (Note: 0.75i may not be less than 1.0) (see [1, NC-3673.2(b)])
M_A	=	Resultant moment due to sustained loads, in-lb (see [1, NC-3654])
Z	=	Section modulus, in^3 (see [1, NC-3654])
S_h	=	Allowable stress at design temperature (equivalent to S for this evaluation), psi

The Longitudinal Stresses Due to Occasional Loads, S_{OL}, must satisfy the following requirement 1, NC-3652.2, Equation 9]:

$$S_{\mathrm{OL}} = \frac{P_{max} D_o}{4\mathrm{t}_n} + 0.75\mathrm{i}\frac{(M_A + M_R)}{Z} \leq 1.2S_h$$

P_{max}	=	Peak pressure (taken as operating pressure), psi
D_o	=	Outside pipe diameter, in
t_n	=	Nominal wall thickness, in
i	=	Stress intensification factor (Note: 0.75i may not be less than 1.0) (see [1, NC-3673.2(b)])
M_A	=	Resultant moment due to sustained loads, in-lb (see [1, NC-3654])
M_R	=	Resultant moment due to occasional loads, in-lb (see [1, NC-3652.4])
Z	=	Section modulus, in^3 (see [1, NC-3654])
S_h	=	Allowable stress at design temperature (equivalent to S for this evaluation), psi

The Thermal Expansion Stresses, S_E, must satisfy the following requirement [1, NC-3652.3(a), Equation 10]:

$$\frac{iM_C}{Z} \leq S_A$$

i	=	Stress intensification factor
M_C	=	Range of resultant moment due to thermal expansion, in-lb (see [1, NC-3652.2])
Z	=	Section modulus, in^3 (see [1, NC-3654])
S_A	=	Allowable stress range for expansion stresses, psi

The allowable stress range, S_A, is defined as S_A=f $(1.25S_c+0.25S_h)$ [1, NC-3611.1(b)(3)], where f is defined as the stress range reduction factor for full temperature thermal cycles. S_c is the basic material allowable stress at minimum (cold) temperature. For this evaluation, the reduction factor is assumed to be equal to 1.0 since the number of thermal expansion cycles is expected to be below 7,000 (see Section 4.0, Assumption No. 2). Therefore, S_A is equal to $1.5S_h$ as S_c and S_h are equivalent for this evaluation.

3.0 DESIGN INPUTS

The following design inputs were provided by Entergy personnel to be used in the analysis:

1. Pipe Material = SA-376, TP-304 [2]
2. Pipe Nominal Size = 1-inch Schedule 80 [2]
3. Maximum Operating Temperature = 120°F [3]
4. Design Temperature = 250°F [3]
5. Maximum Operating Pressure = 85 psig [3]
6. System Code of Construction = ASME Section III, 1971 Edition with Addenda through Winter 1972 [3]
7. Code Allowable Stress, interpolated at 120°F, = 18.6 ksi [1, Table I-7.2]
8. Material Yield Strength = 30 ksi [1, Table I-7.2]
9. Material Ultimate Strength = 75 ksi [1, Table I-7.2]

The pipe outside diameter (1.315 inches) and nominal thickness (0.179 inch) are obtained from readily available industry information based on the pipe size and schedule.

The OD of the socket welded elbow and coupling are assumed to be those of 3000 lb fittings from [5], which have a maximum fitting OD of 1.8125 inches.

Piping loads are taken from the design basis stress report [4]. The location of interest is at Node 403, but the bounding loads used in the evaluation are taken from Node 402, which is the branch of the socket welded connection to the 4-inch run piping. The methodology requires moment loads as input, which are obtained from the Reference [4] nodal outputs for each load case. Three load cases are utilized: thermal expansion (TH), sustained (DW), and operating basis earthquake (OBE). OBE is the only seismic loading evaluated in the stress report and is, therefore, the only seismic loading evaluated herein. The component moments at Node 402 are taken from each load case in the Reference [4] output. The square root sum of squares (SRSS) moments are calculated for each load.

Constrained thermal expansion stress in a simple system is roughly linear over small ranges of changes in temperature (ΔT), with slight non-linearities introduced due to temperature depended material properties. Complex systems, such as piping systems, are not strictly linear due to geometric effects and the potential influence of mixed metals. The design basis stress report only evaluates thermal expansion loading for the design temperature of 250°F. If the reference temperature for thermal expansion stress is taken as 70°F (see Assumption 1), the evaluated ΔT is 180°F. The maximum operating temperature is only 120°F, which represents a ΔT of 50°F. Rather than use the thermal expansion loading for the full 180°F ΔT, the thermal expansion loads are scaled by a factor of 0.5. This represents an evaluated ΔT of approximately 90°F, which is still considered conservative when the actual ΔT is nearly half that amount.

To conservatively account for the stress intensification due to the weld overlay repair, a stress intensification factor (SIF) of 1.3 is used in the analysis. This SIF is consistent with Figure NC-3672.9(a)-1 from the Code of Construction for socket welded connections [1]. Application of this SIF to the analysis is conservative as the stress intensification created by the original socket welded joint will be reduced with the addition of the repair weld metal. The geometric configuration of the weld overlay will result in a design that is similar to a butt welded connection, which have an SIF of 1.0 per Figure NC-3672.9(a)-1 from the Code of Construction [1].

The loads for the analysis, derived from Reference [4], are shown in Table 1.

Table 1: Applied Moment Loads

	From Stress Report (ft-lbs)			Resultant	ΔT Scale Factor Applied	Evaluated Loads
	X	Y	Z	(in-lbs)	(in-lbs)	(in-lbs)
DW	19	1	8	248	---	248
OBE	21	13	16	353	---	353
TH	53	170	42	2195	1098	1098

4.0 ASSUMPTIONS

The following assumptions are used in the evaluation.

1. It is assumed that 70°F is used as the reference temperature (i.e., the zero-stress state) in the design basis thermal expansion stress analysis [4]. The stress report then evaluates the change in temperature from 70°F to 250°F. Use of 70°F is typical for such an evaluation. Use of a different reference temperature would result in a change in the resulting stress (higher stress for a lower reference temperature, lower stress for a higher reference temperature). However, use of a significantly different reference temperature does not have a meaningful impact on the results of the analysis, and there is no basis for evaluating from a different reference temperature.
2. It is assumed that the full thermal cycles for the piping system total less than 7,000 cycles. Given the operation of the system, this assumption is appropriate for determining the stress range reduction factor (f) for this analysis.
3. The evaluation assumes no structural benefits from the existing base pipe material. This is reasonable and conservative for analyzing the acceptance of the weld overlay buildup.

5.0 CALCULATIONS

For longitudinal stresses, the thickness, t_n, is iterated for Equations 8, 9, and 10 until the calculated stress is equal to the allowable stress, as defined for each equation. This calculation provides a resulting minimum thickness necessary that meets the Code of Construction requirements based on the dimensions of the added weld overlay material. The section modulus of the weld overlay cross section is also iterated as function of the evaluated thickness. The minimum thickness necessary for hoop stresses is calculated directly from Equation 3.

6.0 RESULTS OF ANALYSIS

The resulting t_{min} for each loading condition is shown in Table 2.

Table 2: Minimum Thickness Results

Loading Condition	Minimum Required Thickness (inch)
Equation 3 - Hoop Stress	0.004
Equation 8 - Sustained Load - Deadweight	0.008
Equation 9 - Occasional Load - OBE	0.013
Equation 10 - Thermal Expansion	**0.021**

The Code of Construction minimum required wall thickness for these conditions is taken as the maximum of the resulting thicknesses tabulated in Table 2. Therefore, the minimum required wall thickness for the weld overlay design is 0.021 inch and is limited by thermal expansion.

7.0 CONCLUSIONS

This evaluation calculates the minimum required thicknesses of the Waterford Steam Electric Station, Unit 3 CVC system Class 2 piping region upstream of valve CVCMVAAA186 (CVC-186) in support of a Code Case N-666-1 weld overlay repair. The Code of Construction minimum required wall thickness for the weld overlay repair is 0.021-inch. This minimum thickness is based on the dimensions of the socket welded fittings and the resulting weld overlay and conservatively ignores the structural benefit of the existing unflawed base pipe material.

8.0 REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section III, 1971 Edition with Addenda through Winter 1972.
2. Waterford Drawing No. 4305-3913, SI File No. 1900769.205.
3. Email from T. House (Entergy) to E. Houston (SI), Subject "RE: SI Contact Information," July 2, 2019, SI File No. 1900769.208.
4. Waterford Stress Report No. SA-2869-2, Revision 2, "Stress Analysis of CH-Piping per SMP-1743 'As-Built'," SI File No. 1900769.201.
5. Ladish General Catalog No. 55, Forged and Seamless Welding Pipe Fittings,1954, SI File No. 1900769.209.

ENCLOSURE, ATTACHMENT 2
W3F1-2019-0052

List of Regulatory Commitments

Attachment 2
List of Regulatory Commitments

This table identifies actions discussed in this letter for which Entergy commits to perform. Any other actions discussed in this submittal are described for the NRC's information and are **not** commitments.

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE (If Required)
	ONE-TIME ACTION	CONTINUING COMPLIANCE	
Perform an ASME Section XI, IWA-4000 repair during the next refueling outage.	X		RF 23