Calculation Title Page

Total number of sheets 33
(including attachments)

Code Case N-513-3 Pipe Wall Flaw Evaluation for: SW-1802-004-153-24"

TITLE

C-S-1-45893	0	NA	SW
CALCULATION #	**REV. #**	**Vendor Calc#**	**System**

Executive Summary

The through-wall pipe flaw identified and documented in AR# 01895334 has been evaluated in accordance with NRC CC N-513-3 and found to be stable. Calculated Stress Intensity Factors for all Service conditions are within the Code Case specified allowable with the applicable structural factors applied.

The ASME Code required minimum pipe wall thickness for both Design Pressure as well as mechanical loading is t_m = 0.105 inch.

The N-513-3 derived minimum wall for the adjacent non-planar flaw region is 0.120 inch.

Does this calculation:		
1.	Support a MJR [DCR], MNR [MMOD], an independent review method for a DCP, or confirm test results for an installed DCP? If yes, indicate the MJR [DCR], MNR [MMOD] number and/or Test Procedure number.	Yes ☐ No ☒
2.	Support independent analysis? If yes, indicate the procedure, work control or other reference it supports. **Supports the response to AR# 01895334**	Yes ☒ No ☐
3.	Revise, supersede, or void existing calculations? If yes, indicate the calculation number and revisions.	Yes ☐ No ☒
4.	Involve OQAT related systems, components or structures?	Yes ☒ No ☐
5.	Impact the licensing basis, including technical specifications, NUHOMS® HD System Technical Specifications, technical requirements, UFSAR, NUHOMS® HD System Final Safety Analysis Report, procedures or licensing commitments? If yes, identify appropriate change documents.	Yes ☐ No ☒

Approvals (Signature)	
Preparer *H. W. Mentel* [signature]	Date: 8/8/2013
Independent Verifier *S. Das* [signature]	Date: 8/8/2013
Supervisor/Manager *B. E. Brown* [signature]	Date: 8/8/2013

Calculation Revision Control Sheet

CALCULATION NUMBER: **C – S – 1- 4 5 8 9 3**		PAGE **2**
CALC. REV. NO.	TOTAL NO. OF PAGES	(LIST AFFECTED PAGES)
0	**33** Shts. 1 through 26 Plus attachment A Shts. 1 through 7	PURPOSE: Code Case N-513-3 Pipe Wall Flaw Evaluation for: SW-1802-004-153-24" ADDED: n/a REPLACED: n/a DELETED: n/a
		PURPOSE: ADDED: REPLACED: DELETED:
		PURPOSE: ADDED: REPLACED: DELETED:
		PURPOSE: ADDED: REPLACED: DELETED:
		PURPOSE: ADDED: REPLACED: DELETED:

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Revision Level	Preparer/Date	Verifier/Date
0	*HWMe 8/8/13*	*S. Das 8/8/13*

TITLE: Code Case N-513-3 Pipe Wall Flaw Evaluation

CALCULATION FORMAT

Total Number of ATTACHMENT Sheets 7 sheets

Total Number of Calculation Sheets 33 sheets
(including attachment sheets)

1.0 PURPOSE

A through-wall flaw has been identified in pipe line SW-1802-004-153-24". The identification of this flaw has been entered into the Seabrook Station Corrective Action Program via Action Request (AR) 01895334.

The purpose of this calculation is to perform a wall thickness flaw evaluation in accordance with the ASME Boiler and Pressure Vessel Code Case N-513-3. This evaluation will determine whether or not the identified flaw is stable and provide input into the associated system operability determination. Furthermore this evaluation will identify recommended actions with regards to repair/replacement activities of the subject component.

The subject piping is classified as ANS Safety Class 3; Seismic Category I.

2.0 SUMMARY OF RESULTS

EXECUTIVE SUMMARY:

The through-wall pipe flaw identified and documented in AR# 01895334 has been evaluated in accordance with NRC CC N-513-3 and found to be stable. Calculated Stress Intensity Factors for all Service conditions are within the Code Case specified allowable with the applicable structural factors applied.
The ASME Code required minimum pipe wall thickness for both Design Pressure as well as mechanical loading is t_m = 0.105 inch.
The N-513-3 derived minimum wall for the adjacent non-planar flaw region is 0.120 inch.

3.0 REFERENCES / DESIGN INPUTS

1) Action Request # 01895334
2) Code Case N-513-3 "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Section XI, Division 1", Cases of ASME Boiler and Pressure Vessel Code, January 26, 2009.
3) ASME Boiler and Pressure Vessel Code, Section III 1983 Edition. (2007 Edition used for material properties).
4) ASME Boiler and Pressure Vessel Code, Section XI, Appendix C, 2004 Edition
5) Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1", Revision 16, Nuclear Regulatory Commission, October 2010.
6) Y. Takahashi, "Evaluation of Leak-Before-Break Assessment of Pipes with a Circumferential Through-Wall Crack. Part 1: Stress Intensity Factor and Limit Load Solutions," International Journal of Pressure Vessels and Piping, 79, 2002.
7) Pipe Fracture Encyclopedia, US Nuclear Regulatory Commission, Volume 1, 1997.
8) Guidelines for Selection of Marine Materials, 2nd Edition, May, 1971 Copyright © 1966, The international Nickel Company, Inc.
9) FPL Energy Seabrook Structural Engineering Standard Technical Procedure DS36460, Rev. 3, Chg. 00 "Structural Evaluation of Flow Accelerated Corrosion (FAC) in Carbon Steel Piping and Piping Wall Flaws".
10) Code Case N-597-2 ""Requirements for Analytical Evaluation of Pipe Wall Thinning, Section XI, Division 1".
11) Nuclear Fleet Procedure EN-AA-203-1001 Rev. 9, "Operability Determinations / Functionality Assessments".
12) Design Control Manual, NADC Rev. 59
13) Piping Isometric: SW-1802-09 Rev. 7
14) Design Change Isometric SK-EC156603-2001 Rev. 2
15) "Piping Design and Engineering" Fourth Edition, Revised 1973 from ITT Grinnell Corporation.
16) Piping Stress Analysis of Record C-S-1-45718-CALC Rev. 7
17) Calculation 4.4.17.04F-CALC Rev. 6

4.0 ASSUMPTIONS

None

5.0 METHOD OF ANALYSIS

☒ Hand Calculation

Background:

The subject piping is SW-1802-004-153-24", and depicted on isometric SW-1802-09. the latest design change isometric is SK-EC156603-2001.

The current analysis of record for the piping is calculation C-S-1-45718-CALC Rev. 7.
Results from ADLPIPE Output SWONER4.000 dated 07/02/2013 are used.

The ADLPIPE software model node at or adjacent to the through wall leak location is 475.
The following forces and moment loading has been extracted for use in this calculation.
NOTE: Axial Force = Fz ; Torsional moment = Mz Resultant moments M_R conservatively used

Load	Forces, (lbs.) Forces, (kips)				Moments, (ft-lbs.) Moments, (in-kips)			
	Fx	Fy	Fz		Mx	My	Mz	M_R
Deadweight File 11	772	-374	-135		492	362	1218	1363
			-0.135					16.356
OBE Inertia ± File 31	16061	5082	10799		15993	20730	11987	28796
			10.799					345.552
SSE Inertia ± File 41	20610	7510	16605		22570	29614	18457	41558
			16.605					498.696
Hydraulic Transient ± File 200	1382	1074	324		3623	3667	1602	5398
			0.324					64.776

Due to the nature of the hydraulic transients (pump starts/re-starts) Hydraulic Transient loads need not be combined with seismic loading Ref: C-S-1-45718-CALC Rev. 7)
Applicable stress intensification factor, i = 1.0 (Straight pipe).

Method:

Utilizing the mechanical loading shown above, the fracture toughness of the remaining pipe wall will be evaluated per the criteria presented in Code Case N-513-3, to determine the likelihood of further flaw propagation due to the subjective loading. Verification of flaw stability does not negate the requirement of addressing the potential for further degradation due to salt water intrusion.

6.0 BODY OF CALCULATION

1.0 Scope - Applicability:

(a) The Code Case requirements apply to ASME Section III, ANSI B31.1 and ANSI B31.7 piping classified as Class 2 or 3.

The subject piping is classified as: ASME Section III, Subsection ND
The subject piping component is : straight pipe downstream to tee
Piping Material is: SA 106 Grade B

CAUTION

NOTE: Code Case is not applicable to the following:

(1) pumps, valves, expansion joints and heat exchangers;
(2) socket welds;
(3) leakage through a flange joint;
(4) threaded connections employing nonstructural seal welds for leakage protection.

(b) The Code Case applies to Class 2 or 3 piping whose maximum operating temperature does not exceed 200°F and whose maximum operating pressure does not exceed 275 psig.

The subject piping maximum operating temperature = 90 $\leq$ 200°F
The subject piping maximum operating pressure = 171 $\leq$ 275 psig
Reference Source for temperature / pressure conditions: Calculation 4.4.17.04F-CALC Rev. 6, Sht. U-3

(c) Flaw Evaluation criteria are permitted for pipe and tube. It cannot be used for adjoining fittings and flanges as calculations are based upon round pipe. However the criteria is applicable to that portion of the fitting where it transitions from pipe up to a distance of $(R_o t)^{1/2}$ from the weld centerline.

Is the flaw location adjacent to a fitting / flange weld ?
Yes, but located on the straight pipe; $(R_o t)^{1/2}$ criteria is not applicable.

2.0 Scope - Procedure:

(a) The flaw geometry shall be characterized by volumetric inspection methods or by physical measurement. The full pipe circumference at the flaw location shall be inspected to characterize the length and depth of all flaws in the pipe section.

The subject flaw has been characterized by: UT exam
ES1807.012 Form A: Ultrasonic Thickness Examination Report attached. See Attachment A

(b) Flaw Classification: Planar or Nonplanar
Ref: a) See N-513-3 Fig. 1 – Through wall flaw geometry – all through wall flaws are planar
b) See N-513-3 Fig. 3 – Nonplanar Flaw due to Wall Thinning
Based upon the description in AR# 1895334, AR photographs and the examination data documented in Attachment A , the flaw is classified is classified as non-planar.

(c) Are multiple flaws present? (circle, as applicable) No
If the answer is yes, the interaction and combined area of loss of flaws in a given pipe section shall be accounted for in the flaw evaluation. In accordance with Section IWA-3300 of Section XI, the adjacent flaws shall be bounded by a single rectangular or circumferential planar area.

(d) A flaw evaluation shall be performed to determine the conditions for flaw acceptance.
Section 3.0 provides the accepted methods for conducting the required analysis.

3.0 Flaw Evaluation:

Background

Typically flaw evaluations are prepared for identified through wall flaws in ferritic piping.
Code Case N-513-3 provides criteria for the evaluation of nonplanar flaws (Section 3.2) and planar flaws in austenitic piping (Section 3.1(b)).

What follows is a review of the Code Case N-513-3 sections.

3.1(a) For planar flaws, the flaw shall be bounded by a rectangular or circumferential planar area in accordance with the methods described in ASME Section XI, Appendix C. Note that the flaw to be addressed should in most cases be a surface flaw on the interior diameter of the piping. Based upon Article C-2400 the flaw has to be characterized as axial, circumferential or a combination of both. The minimum wall thickness should first be determined as follows: (CC N-513-3 Eq. 4)

$$t_{min} = \frac{pD_o}{2(S + 0.4p)}$$

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P = maximum operating pressure at flaw location = 171 psi
Ref. Source = 4.4.17.04F-CALC Rev. 6 Sht. U-3
D_o = Piping outside diameter = 24 inches
S = pipe material allowable stress at operating temperature

$$t_{\min} = \frac{(171)(24)}{2(17100 + 0.4(171))} = 0.1195 = 0.120 \text{ inch}$$

Utilizing the derived value of t_m envelope those area(s) mapped on the ES1807.012 Form A: Ultrasonic Thickness Examination Report (Attachment A). Determine the applicable general flaw length dimension, L, in both the axial and circumferential directions.

As discussed in the UT report the flaw size is conservatively bounded by 2.327 inches circumferentially by 1.50 inches axially due to the absence of normal intermittent responses. The area is bounded by good wall with thickness ranges of 0.592 to 0.896 inch for the tee and 0.388 to 0.420 inch for the pipe. Within the bounded area the remaining wall cannot be measured and is assumed to be 0.00 inch thick. The fact that wall does physically exists the flaw is considered to be non-planar

NOTE: It is very rare that identified flaws in SW system piping are purely axial or circumferential in nature.

The identified flaw is characterized as: (check off as appropriate)
☒ AXIAL L_{axial} = 1.50 inches
☒ CIRCUMFERENTIAL L_{circ} = 2.327 inches

If multiple planar flaws have been identified, discontinuous indications shall be considered as singular flaws if the distance between adjacent flaws is equal to or less than the dimension S, where S is determined in accordance with Section XI Fig. IWA-3330-1.

3.1(b) For planar flaws in austenitic piping. . . . . Not applicable to this evaluation.

3.1(c) For planar flaws in ferritic piping . . . . . .this section is addressed below.

3.2 For nonplanar flaws. . . . . . . .Not applicable to this evaluation, except as may be noted above.

3.2(c) When there is through-wall penetration along a portion of the thinned wall, as illustrated in N-513-3 Fig. 5, the flaw may be evaluated by the branch reinforcement method. This approach is practical when highly localized pinhole leaks are identified, but not utilized here.

3.2(d) The identified flaw may be evaluated as two independent planar through –wall flaws – one oriented in the axial direction and the other oriented in the circumferential direction. The through-wall lengths for each flaw are the lengths L_{axial} and L_{circ} where the local wall thickness is equal to t_m as projected along the axial and circumferential planes. Conservatively in considering a flaw as both axial and circumferential, the larger determined length can be utilized. Hence the flaw is considered as circular with a diameter equal to *L*. Note that the flow area of the flaw, or the total of the flow areas of multiple flaws that are combined into a single flaw for the purpose of evaluation, shall not exceed the lesser of the flow area of the pipe or 20 in.^{2}.

L_{circ} = 2.327 inches will be used for the circumferential direction
L_{axial} = 1.5 inches will be used for the axial direction

Check the flow area of the mathematical representation of the flaw:

$$Area = L_{\text{axial}} L_{\text{circ}} = (1.5)(2.327) = 3.491 \le \textit{lesser of } 20\,in^2 \quad or \quad \textit{Pipe flow area}$$

3.3 In performing a flaw growth analysis, the procedures in C-3000 may be used as guidance. Relevant growth rate mechanisms shall be considered. Article C-3000 addresses flaw growth attributed to fatigue due to cyclic loading and SCC growth. For the SW system piping, the primary growth mechanism is the rate of wall loss due to exposure to seawater. Per Reference 8, the typical corrosion rate of carbon steel immersed in quiet seawater is 15 mils per year.

3.4 For non-ferrous materials, flaws may be evaluated. . . . . Not applicable to this evaluation.

3.1(c) For planar flaws in ferritic piping, the evaluation procedure of Appendix C shall be used. Per Article C-1000, Section C-1200(f) the screening procedure described in C-4000 should be used to determine the failure mechanism for the material and temperature for the identified flaw. However per Article C-4000, Section C-4222 the criteria for Classes 2 and 3 ferritic piping are in the course of preparation. The analyst shall establish the failure mode relevant for the flawed pipe under evaluation. Considering the larger SC ($\geq$ 1.8) criteria (see Fig. C-4220-1) and the fact that NRC Generic Letter 90-05 recommended a LEFM approach for evaluating through-wall flaws in Class 3 piping, the Article C-7000 LEFM criteria is used. When through-wall flaws are evaluated in accordance with C-7300 or C-7400, the formulas for evaluation given in C-4300 may be used, but with values for F_m , F_b , and F applicable to through-wall flaws. Relations for F_m , F_b , and F that take into account flaw shape and pipe geometry (*R/t* ratio) shall be used. Appendix I to CC N-513-3 provides equations for F_m , F_b , and F for a selected range of *R/t*. The F_m and F_b equations provided in CC N-513-3 are accurate in the range of R/t of 5 to 20. It is noted that alternative solutions for F_m and F_b may be used when the R/t ratio is greater than 20. The Takahashi relations presented in Reference 6 are applicable in the R/t range of 1.5 to 80.5 and will be used in this calculation.

Evaluation

1) Determination of Flaw acceptance criteria. The stability of an identified through-wall flaw is considered acceptable provided the derived stress intensity factor, K_I, is less than the critical fracture toughness for the material, which is based upon the measure of toughness of the material.

$$K_I \leq \left(J_{Ic}\, E'/1000\right)^{0.5}$$

For through-wall flaws, meeting the above criteria ensures the acceptability of the pipe for temporary service. Margin is provided by the use of the structural factors dictated by CC N-513-3.

Article C-8000, Section C-8321 addresses toughness properties for ferritic steel base metals subject to circumferentially and axial oriented flaws, with a minimum upper shelf temperature value given in the absence of specific data.
For this calculation a minimum J_{Ic} value for SA-106 Grade B carbon steel base metal is obtained from Reference 7. Table B1 in Reference 7 provides a summary of all low temperature fracture testing conducted with SA-106 Grade B material in the database. The lowest value J_{Ic} = 293 lbs. / in. has been conservatively selected for use in this CC N-513-3 evaluation.

Per C-1300, $E' = E/\left(1 - \nu^2\right)$

E = Young's Modulus at maximum operating temperature = 29,392 ksi @ 90°F

ν = Poisson's ratio = 0.3

$$\therefore \quad E' = 29392/\left(1 - 0.3^2\right) = 32299\ ksi$$

$$\therefore \quad K_I = \left(293\left(32299/1000\right)\right)^{0.5} = 97.281\ ksi\sqrt{in.}$$

2) Determination of Load Relations F_m, F_b, and F for through-wall flaws. For through-wall flaws, the crack depth (a) will be replaced with the half crack length (c) in the stress intensity factor equations used (per CC N-513-3 Appendix I, section I-1).

Circumferential Flaw Load Relations – From Reference 6 (NOTE: $F_t = F_m$)

Geometrical factor for axial load:

$$F_t = \left[A_t + B_t\left(\frac{\theta}{\pi}\right) + C_t\left(\frac{\theta}{\pi}\right)^2 + D_t\left(\frac{\theta}{\pi}\right)^3 + E_t\left(\frac{\theta}{\pi}\right)^4\right]$$

$$A_t = 1$$
$$B_t = -1.040 - 3.1831(\xi) - 4.83(\xi)^2 - 2.369(\xi)^3$$
$$C_t = 16.71 + 23.10(\xi) + 50.82(\xi)^2 + 18.02(\xi)^3$$
$$D_t = -25.85 - 12.05(\xi) - 87.24(\xi)^2 - 30.39(\xi)^3$$
$$E_t = 24.70 - 54.18(\xi) + 18.09(\xi)^2 + 6.745(\xi)^3$$
$$\xi = \log\left(\frac{t}{R}\right)$$

Geometrical factor for bending moment:

$$F_b = \left(1 + \frac{t}{2R}\right)\left[A_b + B_b\left(\frac{\theta}{\pi}\right) + C_b\left(\frac{\theta}{\pi}\right)^2 + D_b\left(\frac{\theta}{\pi}\right)^3 + E_b\left(\frac{\theta}{\pi}\right)^4\right]$$

$$A_b = 0.65133 - 0.5774(\xi) - 0.3427(\xi)^2 - 0.0681(\xi)^3$$
$$B_b = 1.879 + 4.795(\xi) + 2.343(\xi)^2 - 0.6197(\xi)^3$$
$$C_b = -9.779 - 38.14(\xi) - 6.611(\xi)^2 + 3.972(\xi)^3$$
$$D_b = 34.56 + 129.9(\xi) + 50.55(\xi)^2 + 3.374(\xi)^3$$
$$E_b = -30.82 - 147.6(\xi) - 78.38(\xi)^2 - 15.54(\xi)^3$$
$$\xi = \log\left(\frac{t}{R}\right)$$

L_{circ} = 2.327 inches

$c = L_{circ}/2$ = 1.1635 inches

OD = 24 inches

t = 0.375inches (Note: surrounding "good" wall – not nominal) Per the UT report, outside the bounding area the thickness abruptly changes to above nominal wall; therefore nominal wall thickness is used.

$R = (\text{OD} - t) / 2 =$ 11.8125 inches

R/t = 31.5 NOTE: for R/T ratio > 20, the Equations for F_t and F_b become increasing conservative.

$\Theta = c/R =$ 1.1635 / 11.8125 = 0.0985

Θ / π = 0.0313

$$\xi = \log\left(\frac{t}{R}\right) = \log\left(\frac{0.375}{11.8125}\right) = -1.498$$

$$A_t = 1$$

$$B_t = -1.040 - 3.1831(-1.498) - 4.83(-1.498)^2 - 2.369(-1.498)^3 = 0.853$$

$$C_t = 16.71 + 23.10(-1.498) + 50.82(-1.498)^2 + 18.02(-1.498)^3 = 35.572$$

$$D_t = -25.85 - 12.05(-1.498) - 87.24(-1.498)^2 - 30.39(-1.498)^3 = -101.41$$

$$E_t = 24.70 - 54.18(-1.498) + 18.09(-1.498)^2 + 6.745(-1.498)^3 = 123.78$$

$$F_t = \left[1 + 0.853(0.0313) + 35.572(0.0313)^2 - 101.41(0.0313)^3 + 123.78(0.0313)^4\right] = 1.059$$

$$A_b = 0.65133 - 0.5774(-1.498) - 0.3427(-1.498)^2 - 0.0681(-1.498)^3 = 0.976$$

$$B_b = 1.879 + 4.795(-1.498) + 2.343(-1.498)^2 - 0.6197(-1.498)^3 = 2.037$$

$$C_b = -9.779 - 38.14(-1.498) - 6.611(-1.498)^2 + 3.972(-1.498)^3 = 19.168$$

$$D_b = 34.56 + 129.9(-1.498) + 50.55(-1.498)^2 + 3.374(-1.498)^3 = -57.938$$

$$E_b = -30.82 - 147.6(-1.498) - 78.38(-1.498)^2 - 15.54(-1.498)^3 = 66.638$$

$$F_b = \left(1 + \frac{0.375}{2(11.8125)}\right)\left[0.976 + 2.037(0.0313) + 19.168(0.0313)^2 - 57.938(0.0313)^3 + 66.638(0.0313)^4\right] = 1.074$$

<u>Axial Flaw Load Relation</u>

$$F = 1 + 0.072449\lambda + 0.64856\lambda^2 - 0.2327\lambda^3 + 0.038154\lambda^4 - 0.0023487\lambda^5$$

where

c = half crack length

$\lambda = c/(R\,t)^{1/2}$

L_{axial} = 1.5 inches
$c = L_{axial}/2$ = 0.750 inches
OD = 24 inches
t = 0.375inches (Note: surrounding "good" wall – not nominal) Per the UT report, outside the bounding area the thickness abruptly changes to above nominal wall; therefore nominal wall thickness is used.
$R = (OD - t) / 2$ = 11.8125 inches
$\lambda = c/(Rt)^{1/2}$ = 0.750 / (11.8125 x 0.375)$^{1/2}$ = 0.356

$$F = 1 + 0.072449(0.356) + 0.64856(0.356)^2 - 0.2327(0.356)^3 + 0.038154(0.356)^4 - 0.0023487(0.356)^5$$
$$= 1.098$$

3) Determination of actual flaw stress intensity factor K_I for Circumferential Flaws (Ref. C-7300 / C-4311)

$$K_I = K_{Im} + K_{Ib} + K_{Ir}$$

where

$$K_{Im} = (SF_m)\left(P/(2\pi R_m t)\right)(\pi a)^{0.5}(F_m)$$

$$K_{Ib} = \left[(SF_b)\left(M/\pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$

$$K_{Ir} = K_I \text{ from residual stresses at the flaw location}$$

where

SF_m and SF_b are structural factors from C - 2621 - see below

a is flaw depth which for through - wall flaws is equal to c the half crack length

P is the total axial load on pipe including pressure, kips

R_m, t, F_m, F_b previously defined/derived

M is applied moment on the pipe, in - kips

σ_e secondary bending stress (unintensified), thermal expansion

The Structural Factors for Circumferential Flaws per C-2621 are as follows:

Service Level	Membrane Stress, SF_m	Bending Stress, SF_b
A	2.7	2.3
B	2.4	2.0
C	1.8	1.6
D	1.3	1.4

General Notes:

1) Unless there is evidence of a base metal repair or other wall repair history and in consideration of low operating temperature, K_{Ir} is assumed to be 0.00.
2) K_{Im} and K_{Ib} will be calculated for Service Levels A (Normal), B (Upset), C (Emergency) and D (Faulted).

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P and *M* determination for Service Levels A, B, C & D

$$P_{pressure} = \left(p_{\max.operating\ pressure}\right) A_{FLOW} / 1000 \quad where \quad A_{FLOW} = \pi\left(\frac{OD-2(t)}{2}\right)^2 = \pi\left(\frac{24-2(0.375)}{2}\right)^2 = 424.6$$

$$P_{normal} = P_{DW} + P_{pressure}$$

$$P_{upset} = P_{DW} + P_{pressure} + \sqrt{P_{OBEI}^2 + P_{OBESAD}^2} + P_{TR}$$

$$P_{emergency} = P_{DW} + P_{pressure} + P_{TR}$$

$$P_{faulted} = P_{DW} + P_{pressure} + \sqrt{P_{SSEI}^2 + P_{SSESAD}^2} + P_{TR}$$

$$M_{normal} = M_{DW}$$

$$M_{upset} = M_{DW} + \sqrt{M_{OBEI}^2 + M_{OBESAD}^2} + M_{TR}$$

$$M_{emergency} = M_{DW} + M_{TR}$$

$$M_{faulted} = M_{DW} + \sqrt{M_{SSEI}^2 + M_{SSESAD}^2} + M_{TR}$$

Normal Loads:

$$P_{pressure} = \left(p_{\max.operating\ pressure}\right) A_{FLOW} / 1000 = (171)(424.6)/1000 = 72.607\, kips$$

$$P_{normal} = P_{DW} + P_{pressure} = (0.135) + (72.607) = 72.742\ kips$$

$$M_{normal} = M_{DW} = 16.356\ in-kips$$

Upset Loads:

$$P_{upset} = P_{DW} + P_{pressure} + \sqrt{P_{OBEI}^2 + P_{OBESAD}^2} + P_{TR}$$

$$= (0.135) + (72.607) + \sqrt{(10.799)^2 + (0)^2} + (0) = 83.541\ kips$$

$$M_{upset} = M_{DW} + \sqrt{M_{OBEI}^2 + M_{OBESAD}^2} + M_{TR}$$

$$= (16.356) + \sqrt{(345.552)^2 + (0)^2} + (0) = 361.908\ in-kips$$

Emergency Loads:

$$P_{emergency} = P_{DW} + P_{pressure} + P_{TR}$$
$$= (0.135) + (72.607) + (0.324) = \quad 73.066\ kips$$
$$M_{emergency} = M_{DW} + M_{TR}$$
$$= (16.356) + (64.776) = 81.132\ in-kips$$

Faulted Loads:

$$P_{faulted} = P_{DW} + P_{pressure} + \sqrt{P_{SSEI}^2 + P_{SSESAD}^2} + P_{TR}$$
$$= (0.135) + (72.607) + \sqrt{(16.605)^2 + (0)^2} + (0) = 89.347\ kips$$
$$M_{faulted} = M_{DW} + \sqrt{M_{SSEI}^2 + M_{SSESAD}^2} + M_{TR}$$
$$= (16.356) + \sqrt{(498.696)^2 + (0)^2} + (0) = 515.052\ in-kips$$

Determination of actual flaw stress intensity factor K_I for Circumferential Flaws

$$K_I = K_{Im} + K_{Ib} + K_{Ir}$$

where

$$K_{Im} = (S\,F_m)\left(P / (2\pi R_m t)\right)(\pi a)^{0.5}(F_m)$$
$$K_{Ib} = \left[(S\,F_b)\left(M / \pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$
$$K_{Ir} = 0.0$$

The stress intensity attributed to residual stresses (K_{Ir}) is 0.0 based upon the fact that the piping at the leak location was replaced in April 2011 under EC# 156603. At the time of the replacement there was no evidence of a base metal repair nor was one applied. Furthermore this piping is subject to low operating temperature.

CALCULATION NUMBER	Sht. No.
C–S–1–45893	18

Revision Level	Preparer/Date	Verifier/Date
0	*HWMe 8/8/13*	*S. Das 8/8/13*

TITLE: Code Case N-513-3 Pipe Wall Flaw Evaluation

<u>Normal K_I Determination</u> (All equation terms previously derived)

$$K_I = K_{Im} + K_{Ib}$$

$$K_I = (S\,F_m)\left(P_{normal} / (2\pi R_m t)\right)(\pi a)^{0.5}(F_m) + \left[(S\,F_b)\left(M_{normal} / \pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$

$$K_I = (2.7)\left((72.742) / (2\pi(11.8125)(0.375))\right)(\pi(1.1635))^{0.5}(1.059) + \left[(2.3)\left((16.356) / \pi(11.8125)^2(0.375)\right) + (0.0)\right](\pi(1.1635))^{0.5}(1.074) =$$

$$K_I = 14.287 + 0.470 = 14.757\ ksi\sqrt{in.}$$

<u>Upset K_I Determination</u> (All equation terms previously derived)

$$K_I = K_{Im} + K_{Ib}$$

$$K_I = (S\,F_m)\left(P_{upset} / (2\pi R_m t)\right)(\pi a)^{0.5}(F_m) + \left[(S\,F_b)\left(M_{upset} / \pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$

$$K_I = (2.4)\left((83.541) / (2\pi(11.8125)(0.375))\right)(\pi(1.1635))^{0.5}(1.059) + \left[(2.0)\left((361.908) / \pi(11.8125)^2(0.375)\right) + (0.0)\right](\pi(1.1635))^{0.5}(1.074) =$$

$$K_I = 14.585 + 9.041 = 23.626\ ksi\sqrt{in.}$$

Emergency K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} + K_{Ib}$$

$$K_I = (S F_m)\left(P_{emergency} / (2\pi R_m t)\right)(\pi a)^{0.5}(F_m) + \left[(S F_b)\left(M_{emergency} / \pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$

$$K_I = (1.8)\left((73.066) / (2\pi(11.8125)(0.375))\right)(\pi(1.1635))^{0.5}(1.059) + \left[(1.6)\left((81.132) / \pi(11.8125)^2(0.375)\right) + (0.0)\right](\pi(1.1635))^{0.5}(1.074) =$$

$$K_I = 9.567 + 1.621 = 11.188\ ksi\sqrt{in.}$$

Faulted K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} + K_{Ib}$$

$$K_I = (S F_m)\left(P_{faulted} / (2\pi R_m t)\right)(\pi a)^{0.5}(F_m) + \left[(S F_b)\left(M_{faulted} / \pi R_m^2 t\right) + \sigma_e\right](\pi a)^{0.5}(F_b)$$

$$K_I = (1.3)\left((89.347) / (2\pi(11.8125)(0.375))\right)(\pi(1.1635))^{0.5}(1.059) + \left[(1.4)\left((515.052) / \pi(11.8125)^2(0.375)\right) + (0.0)\right](\pi(1.1635))^{0.5}(1.074) =$$

$$K_I = 8.449 + 9.007 = 17.456\ ksi\sqrt{in.}$$

Summary of calculated K_I values for the identified Circumferential through-wall flaw

	Normal	Upset	Emergency	Faulted
K_I $ksi\sqrt{in.}$	14.757	23.626	11.188	17.456

4) Determination of actual flaw stress intensity factor K_I for Axial Flaws (Ref. C-7400 / C-4312)

$$K_I = K_{Im} + K_{Ir}$$

where

$$K_{Im} = (S\,F_m)(p\,R_m/t)(\pi\,a/Q)^{0.5}\,(F)$$

$$K_{Ir} = K_I \text{ from residual stresses at the flaw location}$$

where

F is the structural factor from C-2622 - see below

a is flaw depth which for through-wall flaws is equal to c the half crack length

p is the maximum operating pressure, ksi

$S\,F_m, R_m, t$ previously defined/derived

$Q = 1 + 4.593(a/l)^{1.65}$ = 1.0 (set to unity per CC N-513-3 Appendix I for through-wall flaws)

The Structural Factor for Axial Flaws per C-2622 are as follows:

Service Level	Membrane Stress, SF_m
A	2.7
B	2.4
C	1.8
D	1.3

General Notes:

3) Unless there is evidence of a base metal repair or other wall repair history and in consideration of low operating temperature, K_{Ir} is assumed to be 0.00.
4) K_{Im} will be calculated for Service Levels A (Normal), B (Upset), C (Emergency) and D (Faulted).

Determination of actual flaw stress intensity factor K_I for Axial Flaws

Determination of actual flaw stress intensity factor K_I for Axial Flaws

$$K_I = K_{Im} + K_{Ir}$$

where

$$K_{Im} = (S F_m)(p R_m/t)(\pi a/1.0)^{0.5}(F)$$

$$K_{Ir} = 0.0$$

The stress intensity attributed to residual stresses (K_{Ir}) is 0.0 based upon the fact that the piping at the leak location was replaced in April 2011 under EC# 156603. At the time of the replacement there was no evidence of a base metal repair nor was one applied. Furthermore this piping is subject to low operating temperature

Normal K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} = (S F_m)(p R_m/t)(\pi a/1.0)^{0.5}(F)$$

$$= (2.7)((0.171)(11.8125)/(0.375))(\pi(0.750))^{0.5}(1.098)$$

$$K_I = 24.512\ ksi\sqrt{in.}$$

Upset K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} = (S F_m)(p R_m/t)(\pi a/1.0)^{0.5}(F)$$

$$= (2.4)((0.171)(11.8125)/(0.375))(\pi(0.750))^{0.5}(1.098)$$

$$K_I = 21.788\ ksi\sqrt{in.}$$

Emergency K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} = (S F_m)(p R_m/t)(\pi a/1.0)^{0.5}(F)$$

$$= (1.8)((0.171)(11.8125)/(0.375))(\pi(0.750))^{0.5}(1.098)$$

$$K_I = 16.341\ ksi\sqrt{in.}$$

Faulted K_I Determination (All equation terms previously derived)

$$K_I = K_{Im} = (S\,F_m)(p\,R_m/t)(\pi\,a/1.0)^{0.5}\,(F)$$

$$= (1.3)((0.171)(11.8125)/(0.375))(\pi\,(0.750))^{0.5}\,(1.098)$$

$$K_I = 11.802\,ksi\sqrt{in.}$$

Summary of calculated K_I values for the identified Axial through-wall flaw

	Normal	Upset	Emergency	Faulted
K_I $ksi\sqrt{in.}$	24.512	21.788	16.341	11.802

5) CONCLUSION - Prepared input for use in the Operability Determination

FLAW STABILITY CHECK				
Flaw Type	Service Load	Stress Intensity Factor $K_I\left(ksi\sqrt{in}\right)$		Allowable / Calculated
		Calculated	Allowable	
Circumferential	Normal	14.757	97.281	6.59
	Upset	23.626	97.281	4.12
	Emergency	11.188	97.281	8.70
	Faulted	17.456	97.281	5.57
Axial	Normal	24.512	97.281	3.97
	Upset	21.788	97.281	4.46
	Emergency	16.341	97.281	5.95
	Faulted	11.802	97.281	8.24

The calculated Stress Intensity Factors include the required structural factors prescribed by Code Case N-513-3 and ASME Section XI, Division 1 Article C-2620. The acceptable calculated stress intensity factors ensures the acceptability of the pipe for temporary service.

The Structural Factors for Circumferential Flaws per C-2621 are as follows:

Service Level	Membrane Stress, SF_m	Bending Stress, SF_b
A	2.7	2.3
B	2.4	2.0
C	1.8	1.6
D	1.3	1.4

The Structural Factor for Axial Flaws per C-2622 are as follows:

Service Level	Membrane Stress, SF_m
A	2.7
B	2.4
C	1.8
D	1.3

A review of the Flaw UT data identified an adjacent minimum remaining pipe wall (t_p) of 0.388 inch. This is a non-planar flaw and per CC N-513-3 must be greater than the N-513-3 derived minimum wall.

$$t_p \quad = \quad (0.388) \geq t_{\min} \quad = \quad (0.120)(\text{calculated on sht. 9})$$

CALCULATION NUMBER	Sht. No.
C-S-1-45893	24

Revision Level	Preparer/Date	Verifier/Date
0	HWMe 8/8/13	S. Das 8/8/13

TITLE: Code Case N-513-3 Pipe Wall Flaw Evaluation

4.0 ASME Code Required Minimum Wall Thickness per CC-597

Determine minimum wall required for Design Pressure

$$t_{min} = \frac{P D_o}{2(S + \gamma P)}$$

P = Design operating pressure at flaw location = 150 psi
Ref. Source = Calculation 4.4.17.04F-CALC Rev. 6, Sht. U-3
D_o = Piping outside diameter = 24 inches
S = pipe material allowable stress at Design Temperature = 17100 psi @200°F
γ = 0.4, except where $D_o < 6\,(t_m)$ (Note: use 0.4 then verify that this value is acceptable)

$$t_{min} = \frac{(150)(24)}{2(17100 + 0.4(150))} = 0.105 \text{ inch}$$

$$D_o = 24 < 6(0.105) = 0.630 \text{ use of 0.4 is acceptable}$$

Determine minimum wall required for mechanical loading

Piping Stress Evaluation (Simplified Analysis Approach)

The effect on piping stresses at the reduced wall location must be evaluated with consideration given to changes in the pipe metal area, pipe inside area, section modulus and stress intensification factor.

EQ. 8 = $P D_o / 4 t_{pred} + 0.75 i [(M_b + P A_o \delta) / Z_{min})] \leq 1.143 S$

with M_b based upon deadweight loads only.

EQ. 9 = $P D_o / 4 t_{pred} + 0.75 i [(M_b + P A_o \delta) / Z_{min})] \leq 1.143 \times 1.2 S = 1.372 S$

with M_b based upon deadweight, OBE seismic and transient loads, as applicable.

For the evaluation the derived minimum wall thickness for pressure is used for t_{pred}.

A_o = total cross-sectional area of pipe based on nominal outside diameter, $\pi D_o^2 / 4 = 452.4 \text{ in.}^2$

δ = nominal distance between the center of the pipe and the neutral axis of the thinned piping section $= t_{nom} - t_{pred} = 0.375 - 0.105 = 0.270$ in.

$Z_{min} = I_{min} / R_{max}$ where $R_{max} = (D_o / 2) + \delta = 12.270$ in.
where $I_{min} = 0.0491 [D_o^4 - (D_o - 2 t_{pred})^4] = 562.72 \text{ in.}^4$

$Z_{min} = 45.861 \text{ in.}^3$

CALCULATION NUMBER	Sht. No.
C–S–1–45893	25

Revision Level	Preparer/Date	Verifier/Date
0	*HWMe 8/8/13*	*S. Das 8/8/13*

TITLE: Code Case N-513-3 Pipe Wall Flaw Evaluation

The moment loading terms were extracted previously and are displayed on Sht. 6 (Note: M_R conservatively used)

For Deadweight M_b = (12) 1363 = 16356 in-lbs.
For Total M_b = Deadweight + SRSS (OBEI & OBEA) + TR = (12) 30159 = 361908 in.-lbs.

Intensification factor = 1.0; Considering the wall thinning, the factor is re-calculated as follows:
Not required due to component being straight pipe.

EQ. 8 = $P D_o / 4 t_{pred} + 0.75 i [(M_b + P A_o \delta) / Z_{min})] \leq 1.143 S$

EQ. 8 = 8571 + 756 = 9327 $\leq$ 1.143 (17100) = 19545 psi

EQ. 9 = $P D_o / 4 t_{pred} + 0.75 i [(M_b + P A_o \delta) / Z_{min})] \leq 1.143 \times 1.2 S = 1.372 S$

EQ. 9 = 8571 + 8291 = 16862 $\leq$ 1.372 (17100) = 23461 psi

☒ Simplified stress evaluation is acceptable with calculated stresses within Code allowable. Check for cyclic operation.

☐ Simplified stress evaluation is not acceptable. Detailed review performed in calculation ________

Evaluation for Cyclic Operation

Is t_{pred} = 0.105 > 0.75 t_{nom} = 0.281 ? ☐ YES ☒ NO

Is N (Equivalent Full Temperature Cycles) at time of next inspection $\leq$ 150 ? ☒ YES ☐ NO

If the response to both questions is YES, piping stress equations that include thermal expansion and anchor movements stresses need not be evaluated. If not, continue below.

The thermal expansion and anchor movement stress at the inspection location from the referenced analysis of record is not applicable (cold system; no anchor movement).

The Stress Range Reduction Factor (f) used in analysis is 1.0

Is N (Equivalent Full Temperature Cycles) $\leq$ 650 ? ☒ YES ☐ NO

If the response is YES - no further cyclic evaluation is required; component is acceptable.

7.0 REVIEWERS COMMENTS AND RESOLUTIONS

Line by line check performed.

Any and all reviewer comments, corrections, and changes have been reviewed by the Cognizant Design Engineer and have, with the mutual consent of the reviewer, been incorporated.

8.0 ATTACHMENTS

Check as applicable; identify Attachment letter and number of sheets:

☐ Pending Engineering Change Review - Attachment ____ Number of sheets ______

☐ ADLPIPE / CARS output.

Input file	Output file	Run date	Attachment	Number of sheets

Input files stored on EMAGDK# ______________

☒ Other: (list along with Attachment letter and number of sheets per attachment).

Identified Flaw UT Report Attachment A Number of Sheets: 7

Total number of Attachment sheets: 7.

Form A: Ultrasonic Thickness Examination Report

COMPONENT ID:	1-SW-1802-004	SYSTEM:	SW	CLASS:	ASME III
DRAWING NO.:	SK-EC156603-2001	REV.:	002	JOINT #:	SEE SKETCH
WORK DOCUMENT:	40260904-02	BLDG.:	PAB	ROOM:	SLOT
				ELEV.:	531

INSTRUMENT DATA

INSTRUMENT: MFG/MODEL: ZETEC / ZIRCON

☒ Flaw Detector ☐ Thickness Gauge

COMP SURFACE TEMP >125° ☒ NO ☐ YES FLS No.: N/A CAL. DUE DATE: N/A

CAL BLOCK	THICKNESS:	0.800	.101	N/A			**TRANSDUCER**
	FLS NO.:	N/A				TIME CHECKED	MFG.: ZETEC
MAT'L CS	CAL. DUE:						SER #: 1112302
CALIBRATION CHECK	INITIAL:	0.801	0.100			2130	SIZE: 7.2mm FREQ: 5.0 MHZ
	INTERIM:	N/A					**COUPLANT**
	INTERIM:						MFG.: SONOTECH
	INTERIM:						TYPE #: ULTRAGEL II
	FINAL:	0.800	0.100			0110	BATCH #: 1225

COMMENTS SKETCH (include obstructions, components, extensions, etc.) ☒ ATTACHED

* - SEE UT REPORT SUMMARY

☒	COATED SURFACE	**Maximum Coating Thickness M_c**		**Minimum Wall Thickness M_t**	
✓	NON-COATED SURFACE	**Maximum Thickness**	*	**Minimum Wall Thickness**	*

☐ ACCEPTABLE ☐ REJECT ☒ EVAL. REQ.

EXAMINER: (signature) [signature]

EXAMINER: (print) HAMBY, S.W. LVL III DATE 8/7/13

REVIEWER: (print) LVL DATE

ENGINEERING EVALUATION ☐ N/A ☐ ATTACHED ☐ SEE BELOW

EVALUATION COMMENTS:

☐ ACCEPT RESPONSIBLE ENGINEER DATE:

(To be completed if required above)

AR#: 01895334 ORIGINATOR: D. YATES DATE: 8/7/13

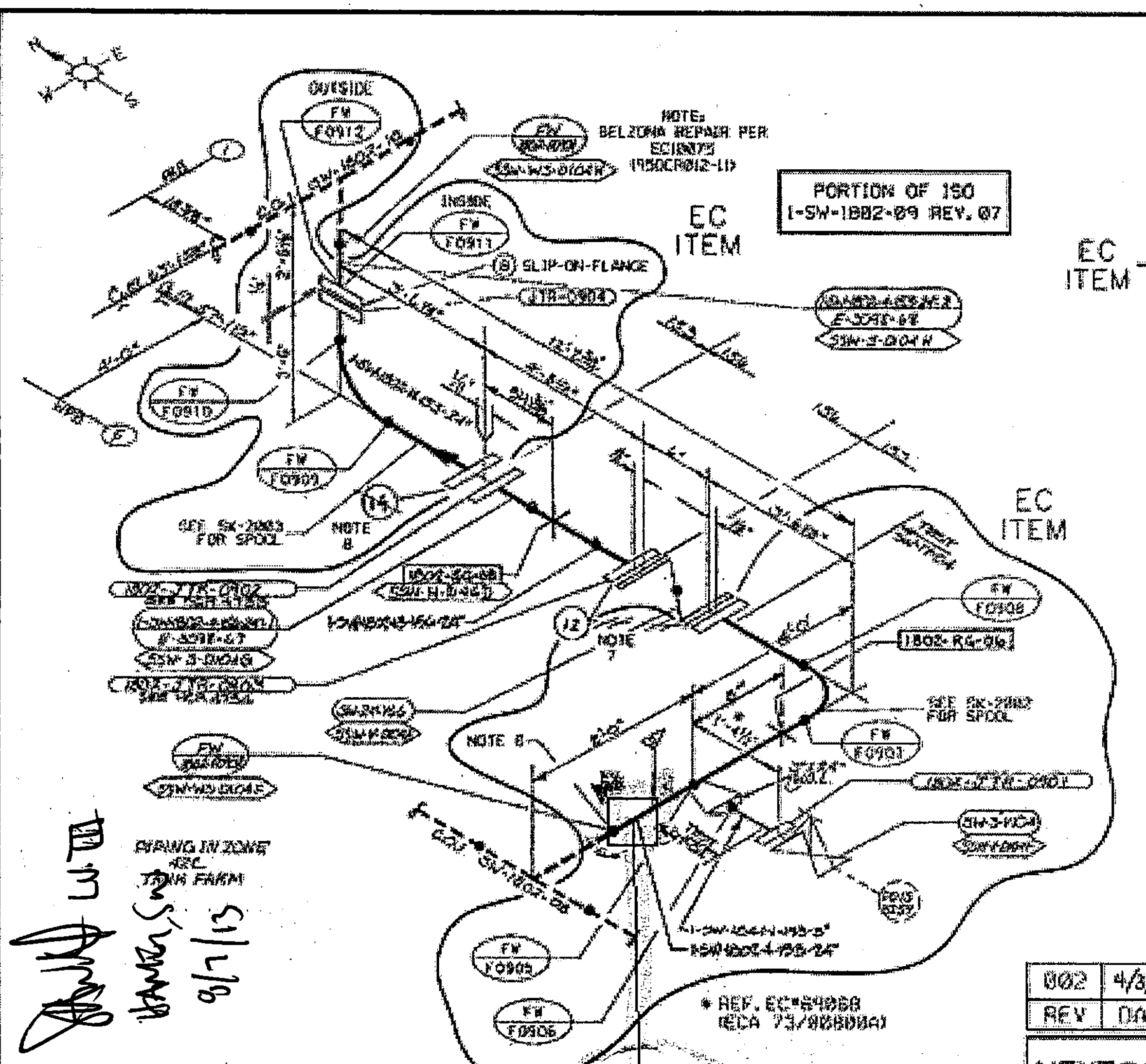
ATTACHMENT A TO C-S-1-45893 REV. 0 SHT. 1 OF 7

UT EXAM LOCATION SKETCH

WO-40260904-02

[signature] LVL III
HAMEL, S.
8/7/13

ME



Location of flaw

DELETED FW'S
F0903 & F0904

LAST FW USED
F0912

LAST JTR USED
JTR-0904

AFFECTED DWG
1-SW-1802-09
805363
805365
801802
FP94316

BILL OF MATERIAL

ITEM NO	SC	CONST CODE	QUANT	SIZE	REV 002 DESCRIPTION	MAT SPEC	[illegible] SP
8	3	[illegible]	4	6/8"	[illegible] STUDS, E/MERCER COATING, OR B7,	[illegible]	[illegible]
					FULL THRD W/ FULL FLANGE INSULATION KIT	REV	
2			8	5/8"	NUTS, HEX, E/MERCER COATING OR 2H, 3, 4, OR 7	[illegible]	[illegible]
3			8	[illegible]	[illegible] STUDS, E/MERCER COATING, OR B7, FULL THRD	[illegible]	[illegible]
4			16	[illegible]	[illegible] STUDS, E/MERCER COATING, OR B7, FULL THRD	[illegible]	[illegible]
5			320	[illegible]	NUTS, HEX, E/MERCER COATING OR 2H, 3, 4, OR 7	[illegible]	[illegible]
6	NNS		3	24"	GASKET, 1/8" THK, RUBBER NEOPRENE OR NEOPRENE,	------	[illegible]
					NO FABRIC INSERTION, FULL FACE, ANSI B16.5 GROUP		
					[illegible]		
7			6	3"	GASKET, 1/8" THK, RUBBER NEOPRENE OR NEOPRENE,	------	[illegible]
					NO FABRIC INSERTION, FULL FACE, ANSI B16.5		
					GROUP 1 [illegible] (NOTE 6)		
8	3		6	24"	FLANGE, SLIP-ON, 150# ANSI -NOTE 3	[illegible]	[illegible]
9	3		48	[illegible]	X 9 [illegible] STUDS, E/MERCER COATING, OR B7, FULL THRD	[illegible]	[illegible]

SEE SKETCH SK-EC156603-2002 & 2003 FOR ADDITIONAL B.O.M. IT[EMS]

EC ITEM

NOTES:

1. ALL PIPE ERECTION TO BE IN ACCORDANCE WITH PIPE SPECS 248-2 AND 248-51.
2. CUT ID'S ARE FOR REFERENCE ONLY.
3. PIPE SUPPORTS ARE SHOWN FOR REFERENCE ONLY REFER TO PIPE SUPPORT DRAWINGS FOR DETAILS.
4. FIELD WELD & JOINT TORQUE RECORD NUMBERS SHALL BE UNIQUE SUCH AS 1802-FW 1802-JTR-09XX UNLESS NOTED OTHERWISE.
5. 1/16" GASKETS OR A COMBINATION OF 1/16" AND 1/8" GASKETS MAY BE USED AS REQ UP TO A MAXIMUM OF 1/4".
6. TRANSITION FROM CEMENT LINING TO BELZONA LINING SHALL BE TAPERED [illegible] BY GRINDING CEMENT OR APPLICATION OF BELZONA R METAL. BELZONA S METAL SHALL OVERLAP THIS TRANSITION ONTO THE CEMENT BY 1" MIN. (REF. DWG [illegible])
7. REMOVE/DELETE (NOT TO BE REINSTALLED) COMPRESSION RING ON SOUTH SIDE OF [illegible] (REF. EC2931, AR200101)
8. REMOVE/DELETE COMPRESSION RING (NOT TO BE REINSTALLED).

REV	DATE	DRWN	CHKD	REV	DATE	DRWN	CHKD	REV	DATE	DRW
002	4/8/11	JM	[illegible]							

NEXTera ENERGY SEABROOK

EC156603	REV.: 002
BLDG/ELEV	PAB / EL. 53'-0"
SAFETY CLASS 3	TITLE INSTALLATION DETAIL SERVICE WATER PIPING REPAIRS 1-SW-1802-04-153-24" & 1-SW-1802-14-1[illegible]
SEISMIC CAT. I	
PREP/DATE J. MIRANDA 05/05/10	SKETCH NO. SK-EC156603-2001
CHK/DATE B.C. SAUTTER 6/29/10	PAGE NO.

04/03/11

MECH:EC156603.DGN [illegible]

ATTACHMENT A TO C-S-1-45893 REV. 0
SHT. 2 OF 7

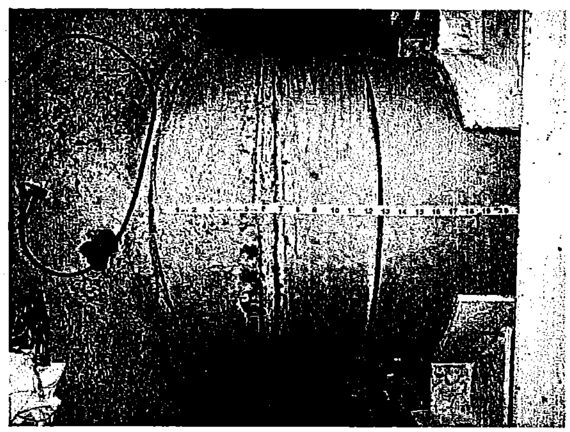
NEXTera ENERGY SEABROOK

UT Thickness Examination at Through Wall Leak Upstream of SW-V-65

(8/7/13, WO-40260904-02, AR-01895334)

Discussion

On August 7, 2013 a through wall leak was detected on line SW-1802-004-153-24" upstream of SW-V-65. The leak is adjacent to the Tee-to-Pipe weld near SW-V-104. In accordance with WO-40260904-02 the area surrounding the through wall leak was UT examined. Additionally, in accordance with AMSE Code Case N-513 the entire circumference at the through wall leak was also examined. Approximately six inches upstream and downstream of the through wall leak area was examined (see below). The exam was performed to determine magnitude and extent of all flaws the pipe section.



Examination Technique

The examination was performed using a 12 element, 5MHz array with a 7.2 mm active aperture. The focal laws generated 61 Longitudinal Wave (L-Wave) examination angles from -30° to 30°.

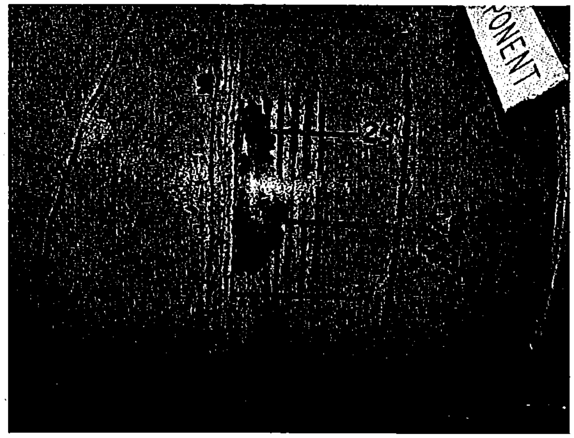
In addition to the L-Wave exam a supplemental Shear Wave (S-Wave) angle beam exam was performed. This exam was performed in order to eliminate the possibility that a non-corrosion type degradation mechanism, specifically planar flaws or cracking, was present. This technique used the same array but generated only 41 angles that ranged from 30° to 70°.

Examination Results

The examination revealed that the through wall leak at this location is the result of a single isolated flaw that appears to be related to corrosion. The thickness ranges of the examination areas away from the flawed area at the through wall leak are within the nominal with no corrosion present. The thickness ranges outside the leak region were **0.592"-0.896"** for the Tee and **0.388"-0.420"** on the piping.

NEXTera ENERGY SEABROOK

Encoded UT data was collected at this location and was used to evaluate the through wall leakage area. The encoded data provides an image that is useful when trying to determine flaw characteristics. A 3-inch by 6-inch area surrounding the flaw was selected for the encoded examination (see below).



The encoded area encompassed the entire flawed area. The review of the encoded data illustrates that the flawed area has an abrupt change in thickness from nominal (Attachment C). Additionally, the area is essentially absent the normal intermittent thickness readings that are seen within flawed areas of SW piping.

Without the normal intermittent responses the area needs to be conservatively bounded by where the inside surface response is initially lost. In doing so this results in a flaw that is 2.327-inches circumferentially by 1.50-inches axially with a remaining wall thickness of 0.00-inches (Attachments A, B and C).

During the angle beam exam the flaw could be seen in all four directions which is not typical for planar flaws. For evaluation purposes the flaw should considered non-planar.

Examiner: [signature] HAMEL, S.W.

Signature

8/7/13

Date

Design Engineering Review:

Signature

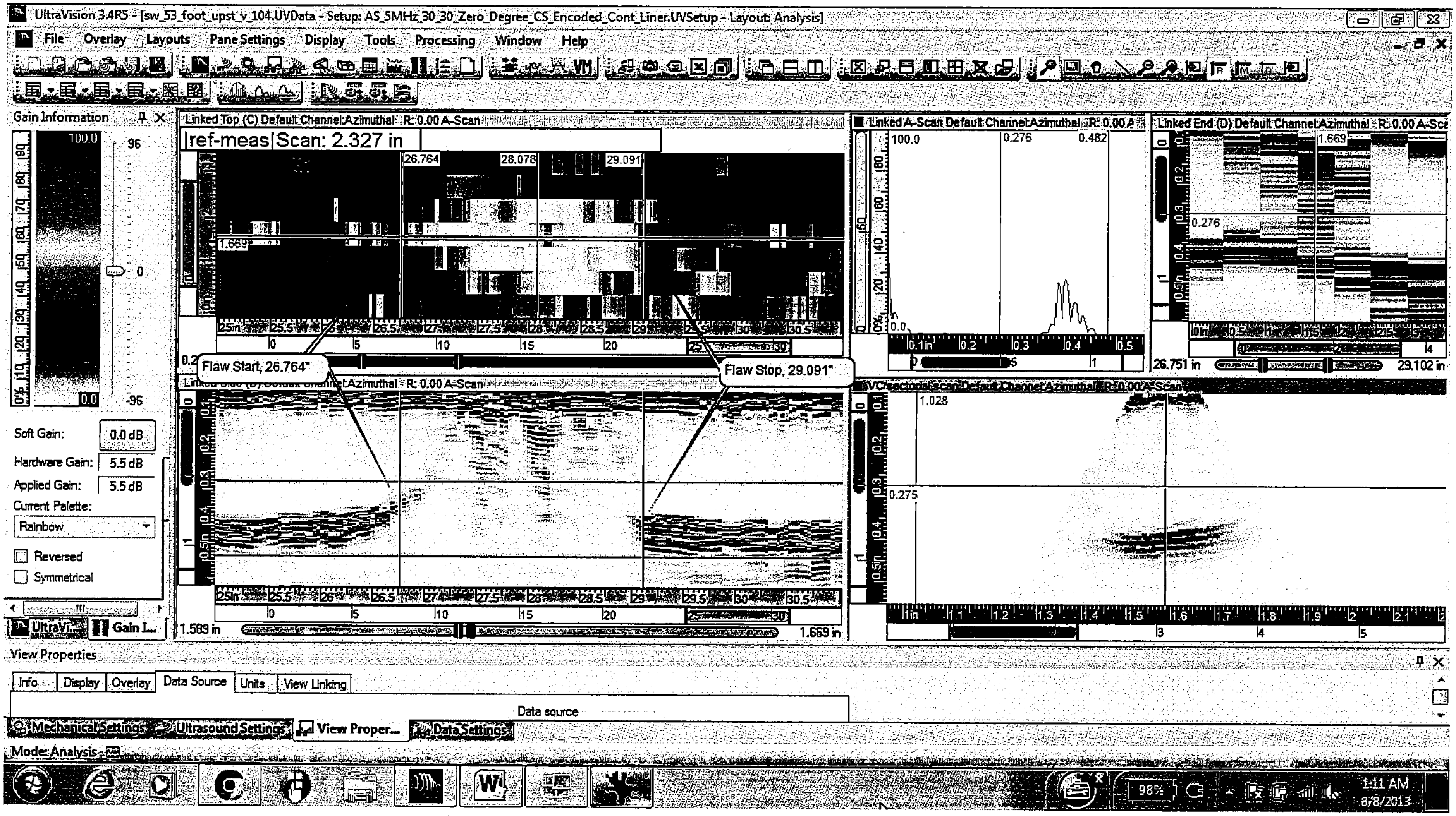
Date

ATTACHMENT A TO C-S-1-45893 REV. 0
SHT. 4 OF 7

ATTACHMENT A TO C-S-1-45893 REV. 0 SHT. 5 OF 7

Attachment A

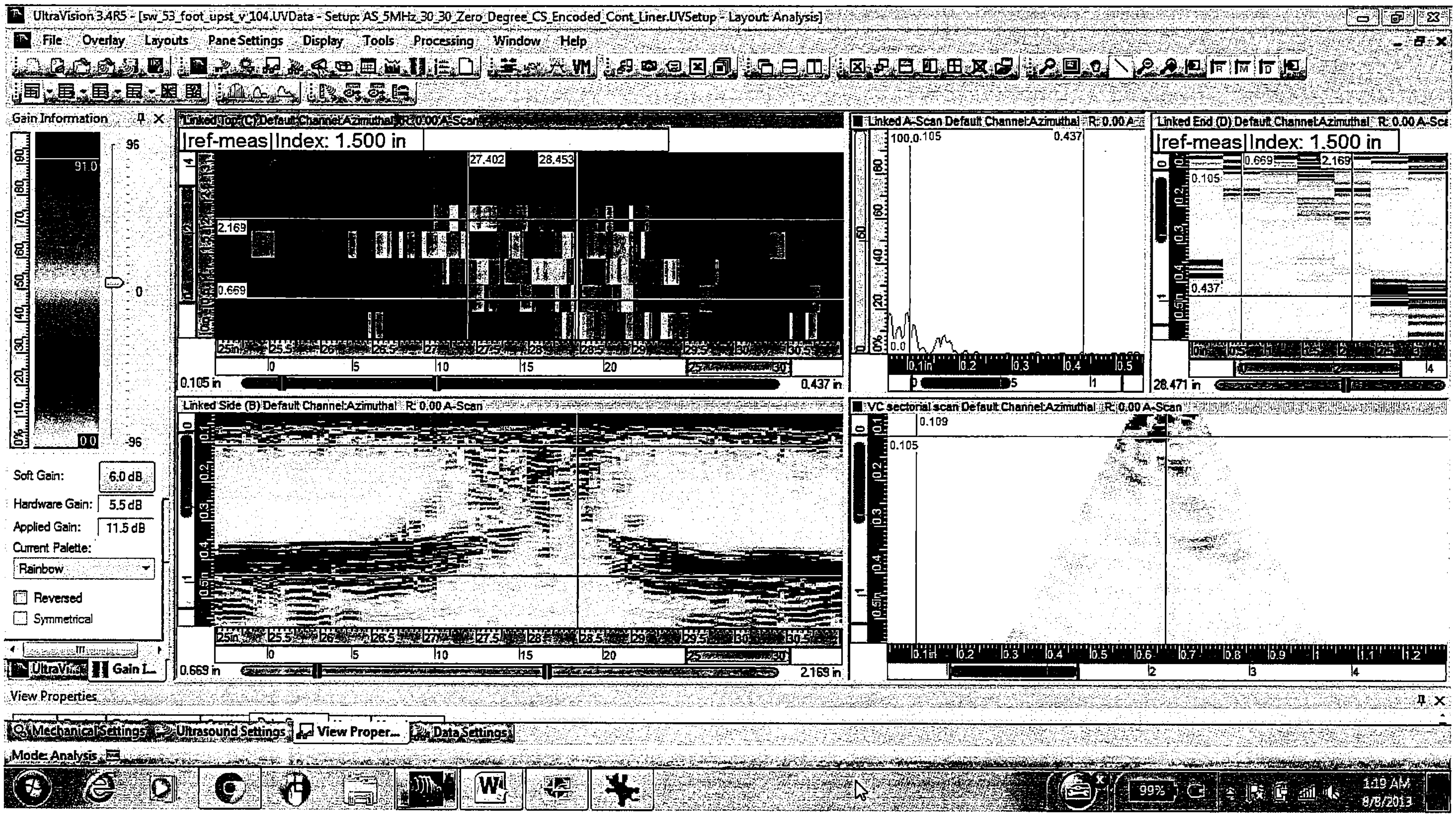
(Encoded Exam Screen Capture)



Total Length of Flaw in the Circumferential Direction, **2.367"**

Attachment B

(Encoded Exam Screen Capture)



Total Length of Flaw in the Axial Direction, **1.50"**

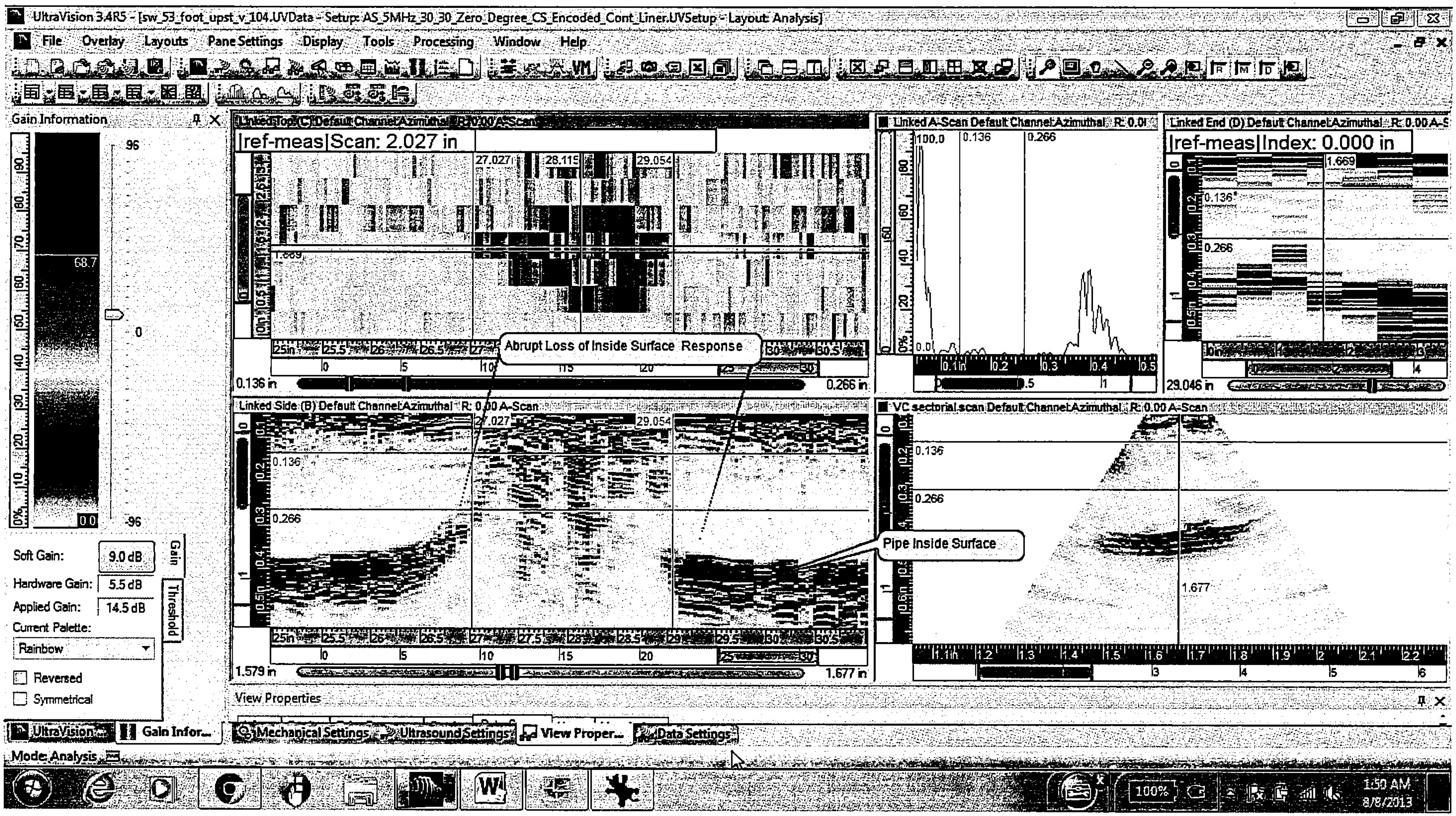
ATTACHMENT A TO C-S-1-45893 REV. 0 SHT. 6 OF 7

NEXTera ENERGY SEABROOK

ATTACHMENT A TO C-S-1-45893 REV. 0
SHT. 7 OF 7

Attachment C

(Encoded Exam Screen Capture)



Typical Abrupt Loss of Inside Surface Response