FPL.

August 5, 2013

L-2013-240
10 CFR 50.4
10 CFR 50.55a

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

Re: St. Lucie Unit 1
Docket No. 50-335
Inservice Inspection Plan
Fourth Ten-Year Interval Unit 1 Relief Request No. 7, Revision 0

Pursuant to 10 CFR50.55a(a)(3)(ii), Florida Power & Light, is requesting relief from the requirements of ASME Code, Section XI, Subsection IWA-4000 for defect removal prior to repair, since compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. The details and justification for this request are provided in Attachments 1 and 2 to this letter.

FPL requests approval of this relief request to support the upcoming SL1-25 Fall 2013 refueling outage.

This relief request is applicable to the St. Lucie Unit 1 Fourth Inservice Inspection Interval which began February 11, 2008 and ends February 10, 2018.

Please contact Lyle Berry at (772) 467-7680 if there are any questions about this submittal.

Sincerely,

Eric S. Katzman
Licensing Manager
St. Lucie Plant

Attachments
ESK/LRB

A047
NRR

Florida Power & Light Company
6501 S. Ocean Drive, Jensen Beach, FL 34957

St. Lucie Unit 1
FOURTH INSPECTION INTERVAL
RELIEF REQUEST NUMBER 7, Revision 0

PSL Relief Request

In Accordance with 10CFR50.55a(a)(3)(ii)

—Hardship or Unusual Difficulty without Compensating Increase in Level of Quality or Safety—

1. **ASME Code Component(s) Affected**

Class 3 Intake Cooling Water (ICW) System 30" diameter piping in Unit 1 as follows:

System 21, I-30"-CW-29 and I-30"-CW-30 (Discharge piping downstream of Component Cooling Water (CCW) Heat Exchangers only)

2. **Applicable Code Edition and Addenda**

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Rules for Inservice Inspection of Nuclear Power Plant Components, Section XI, 2001 Edition with Addenda through 2003[1] as amended by 10CFR50.55a, is the Code of Record for the St. Lucie Unit 1 4th 10-year interval.

USAS B31.7 Class 3, 1969 Edition [2] is the Construction Code for St. Lucie Unit 1. The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Rules for Construction of Nuclear Power Plant Components, Section III, Class 3, 1971 Edition with Addenda through Summer 1973[3], is the Code of Record for St. Lucie Unit 1 based on reconciliation with the Construction Code.

3. **Applicable Code Requirement**

ASME Code, Section XI, Paragraph IWA-4421 of the 2001 Edition with Addenda through 2003[1] states that "Defects shall be removed or mitigated in accordance with the following requirements: ..." Subparagraph IWA-4422.1 states that "A defect is considered removed when it has been reduced to an acceptable size."

4. **Reason for Request**

The nuclear safety related ICW System for St. Lucie Unit 1 is comprised of two redundant trains (i.e., 'A' and 'B'). I-30"-CW-29 and I-30"-CW-30 are open ended discharge pipes to the ocean discharge canals. Due to the seawater content, the ICW piping constructed from Standard Wall 30" (0.375 inch wall), A-155 KC-65 (equivalent to SA 106 Grade B) Carbon Steel, has an internal liner to preclude the loss of internal pipe wall due to corrosion. The piping being addressed in this relief request is cement or epoxy lined 30 inch nominal diameter buried piping with a nominal liner thickness of 1/8-inch. The outer surface of the piping is coated with Coal-Tar Epoxy. The ICW piping is classified as a Class 3 component, qualified in accordance with ASME Code, Section III, Subsection ND criteria. Burial depths range from 4 feet-3 inch to 16 feet below grade.

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St. Lucie station performs single train internal pipe inspections each outage, resulting in 100% inspection every other outage. The inspections are performed in accordance with St. Lucie's commitment to the NRC Generic Letter GL 89-13[4]. The objective of this commitment is to perform routine inspection to ensure that corrosion, erosion, protective coating failure, silting, and biofouling does not degrade the performance of the ICW safety-related system. ICW pipe inspections at St. Lucie are performed by a qualified pipe inspector. The inspection methodology consists of draining the pipe and removing a section to allow internal access, cleaning the pipe surface, and performing a visual examination of the cement or epoxy liner. The inspector observes for signs of corrosion deposits, staining, cracks, missing lining, area blisters, peeling/delamination, surface irregularities, or discoloration. UT inspection of degraded pipe metal is performed where there is degradation.

The above described pipe inspections have from time to time identified localized areas of liner loss resulting from corrosion cells in the underlying piping. Should measurements detect a pipe wall loss resulting in a remaining pipe wall thickness less than the prescribed ASME Code required minimum pipe wall thickness or a through-wall leak is identified, a repair in compliance with ASME Code Section XI, Article IWA-4000 "Repair and Replacement" would be required. Full defect removal of discovered localized thinning per IWA-4000 may result in a through-wall defect. This case and in those instances where a through-wall defect is discovered, would result in the potential for leakage due to damage to the external coating. If the external coating was not damaged during the defect removal, a traditional repair of cutting a hole and installing a welded rolled plate to return the piping to its original design condition is not possible as the pipe is buried and the outside of the pipe is not easily accessible. Welding would destroy the surrounding exterior coating and the location would prevent NDE of the exterior of the pipe. Consequently, Florida Power & Light, pursuant to 10 CFR 50.55a(a)(3)(ii), is requesting relief from the requirements of ASME Code, Section XI, Subsection IWA-4000 for defect removal prior to repair since compliance would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Florida Power and Light has installed several repairs without removing the defects, and is requesting relief to leave the existing repairs in place and to allow installation of additional repairs in the future to repair similarly damaged areas. The earliest existing repairs that are still in service were installed in 2005. The ASME Code, Section XI requirements before the current 10-year inspection interval regarding removal of defects are equivalent to those listed in Section 2 and Section 3 above.

The existing repairs include six installed plates in I-30"-CW-29 (Train B) consisting of sizes of 3.5"x3.5", 7.5"x11.5", and 10"x11". The plates in I-30"-CW-29 were all installed in 2012. An additional nineteen plates consisting of sizes of 3.5"x3.5", 11"x11", 8"x8", and 10"x11" are installed in I-30"-CW-30 (Train A). One of the plates was installed in 2005, one in 2008 and the remainder in 2012. The total length of pipe in both trains that contains the bolted patch plates is approximately 200 feet. Isometric views showing the relative location of the bolted patch plate repairs in the ICW piping are provided in Figure 3 through Figure 7.

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5. Proposed Alternative and Basis for Use

Proposed Alternative

Install internal bolted patch plate repairs typical of that illustrated in Figure 1 and Figure 2 to cover the damaged areas of the inside surface of the pipe. The internal bolted patch plates are designed to meet the criteria of the applicable Code of Record[3], as required by ASME Code, Section XI[1], Paragraph IWA-4221.

Basis

A description of the process used to qualify the design, a description of the installation process, and the inspection program to monitor the condition of the repairs is included in this section.

Design Qualification Process:

The design qualification process determines the minimum pipe wall thickness using design formulas of ASME Code, Section III and the criteria presented within FSAR Table 3.9-3 for reviewing interactions of pressure stress and longitudinal bending stresses. The calculations evaluate the required reinforcement versus the actual reinforcement available around the corrosion holes and reviews bolting requirements for the patch plate which is analyzed as a blind flange. Reinforcement interaction is reviewed for the multiple holes to ensure additional reinforcement is not required.

The design qualification process includes the following steps:

1. Develop a minimum pipe wall thickness based on hoop stress and longitudinal bending stress per ASME Code, Section III, ND-3641.1 as required by Subsection ND.
2. Determine required and actual reinforcement areas and zones per ASME Code, Section III, Subsection ND.
3. Determine patch plate thickness requirements per ASME Code, Section III, Subsection ND. The installed plate nominal thickness is at least equal to the nominal thickness of the undamaged pipe.
4. Determine the gasket loading and bolt requirements per ASME Code, Section III, Appendix E.
5. Review thread engagement using machinery principles.
6. Address interaction or reinforcement zones per ASME Code, Section III, Subsection ND.
7. Perform stress intensification factor review.

Installation Process Summary:

1. Avoiding damage to any external coatings on the pipe outside surface (OD), prepare the surface of corrosion holes by blast cleaning and fill with epoxy material to the profile of the pipe ID.
2. Remove a section of the pipe lining centered on the affected area.

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3. Clean and smooth interior of pipe to support closure plate fit-up.
4. Layout bolt hole locations on pipe and ultrasonically inspect for thickness. The degraded areas are ultrasonically inspected to determine surrounding wall thickness. All readings outside of the areas of degradation are within the manufacturer's tolerance of nominal wall thickness.
5. Drill and tap ¼" deep bolt holes. Do not allow holes to exceed ¼" depth to maintain minimum wall thickness.
6. Install the studs wrench tight without lubrication.
7. Apply epoxy to pipe beneath closure plate area including corrosion holes previously filled and the gasket area.
8. Before epoxy hardens, install gasket, closure plate, washers and nuts (lightly lubricated).
9. Trim studs flush with the tops of the nuts, degrease and surface prep the exposed area, and cover the entire repair area with epoxy coating. Ensure that the coating is blended to provide smooth transitions to minimize ICW flow turbulence.

Post-installation Inspections:

The piping inspections described in Section 4 are continued after the internal bolted plate repairs are performed. In addition to the visual inspection, a hammer test is generally performed for all patches installed in the pipe. Partial disbondment of a patch will produce a hollow sound when tapped with a chipping hammer. A solid, non-hollow sound indicates that the patch remains in good condition. If a patch is suspect based on visual examination or hammer test results, the patch is removed from the pipe surface for further examination.

Since the bolted patch plate is installed on the inside surface of the piping and it completely covers the damaged area with a gasketed closure, the damaged area is isolated from the corrosive environment. Also, the damaged area is covered with an epoxy coating prior to the repair, including filling the damaged areas for a smooth repair surface, and after the repair, further isolating the damaged area from the corrosion surface. There is therefore minimal potential for the damaged area to expand over time during service such that the repair would no longer be effective. Based on a typical corrosion rate of carbon steel exposed to seawater of 30 mils per year (mpy)[5], the maximum extent of corrosion should the epoxy coating and gasket be breached to allow access to the original defect area would be 0.09-inch, assuming a 3-year inspection interval. The extent of the bolted plate beyond the defect area is always much greater than 0.09 inch so any additional corrosion of the defected area would be identified and corrected during the next inspection. Note that the minimum nominal thickness of the bolted plate is at least as thick as the undamaged piping so the potential corrosion of the plate is no greater than that of the undamaged piping.

Periodic inspections completed to date have not identified any degradation of the existing internal bolted plate repairs.

In early 2012 during the SL1-24 outage, the Unit 1 discharge headers were internally refurbished with Plascite coatings from the CCW Building to 45-degree elevation drop near the discharge canal. This is the area that includes the existing bolted patch plates. The remainder of the two headers and overflow pipes were replaced with new carbon steel piping internally and externally coated with Plascite. This section is normally below the level of the discharge canal and requires divers for inspection.

As discussed above, the bolted patch plate repair is installed on the inside surface of the piping which isolates the damaged area from the corrosive environment. Also, the damaged area is covered with an epoxy coating prior to the repair, including filling the damaged areas for a smooth repair surface, and subsequent to the repair, further isolating the damaged area from the corrosion surface. There is therefore minimal potential for the damaged area to expand over time during service such that the repair would no longer be effective. Limitation on the life of the repair based on the potential degradation to grow to an unacceptable size for the repair or additional subsequent inspections is not required.

The design qualification process, installation process, and the post-installation inspections for the bolted patch plate repairs provide reasonable assurance of the structural integrity of the repair. The location of the defects and the potential additional damage that could occur if the defects were removed prior to the repair as required by the ASME Code, Section XI support the request for an alternative to the ASME Code, Section XI requirement because complying with the requirement would represent a hardship or unusual difficulty without a compensating increase in the level of quality or safety.

6. Duration of Request

This relief request is applicable to the St. Lucie Unit 1 Fourth Inservice Inspection Interval which began February 11, 2008 and ends February 10, 2018.

7. Precedents

There are several precedents for installation of a repair without removal of the initiating defect. These precedents limit the life of the repair because the repair leaves the damaged area exposed to the degradation environment and/or requires subsequent inspection of the damaged area to ensure that it does not grow to an unacceptable size for the repair. Examples of these precedents are listed below:

"Seabrook Station, Unit 1 – Request for Relief to Use an Alternative to the Requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI (TAC No. ME9187)," SER Dated January 14, 2013, Accession Number ML12185A069.

"Indian Point Nuclear Generating Unit No. 3 – Relief Request (RR) No. RR-3-43 for Temporary Non-Code Repair of Service Water Pipe (TAC No. MD6831)," SER Dated February 22, 2008, Accession No. ML080280073.

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8. References

1. ASME Code, Section XI, "Rules For Inservice Inspection of Nuclear Power Plant Components,"2001 Edition with Addenda through 2003.

2. USA Standard Code for Pressure Piping, USAS B31.7-1969, "Nuclear Power Piping."

3. ASME Code, Section III, "Rules for Construction of Nuclear Power Plant Components," 1971 Edition with Addenda through Summer 1973.

4. St. Lucie Letter No. L-2013-005 10 CFR 50.4, dated January 10, 2013 to the USNRC Re: St. Lucie Units 1 and 2, Docket Nos. 50-335 and 50-389, "Clarification of NRC Commitment Regarding Generic Letter 89-13," Accession No. ML13025A208.

5. "Seabrook Station, Unit 1 – Request for Relief to Use an Alternative to the Requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI (TAC No. ME9187)," SER Dated January 14, 2013, Accession Number ML12185A069.

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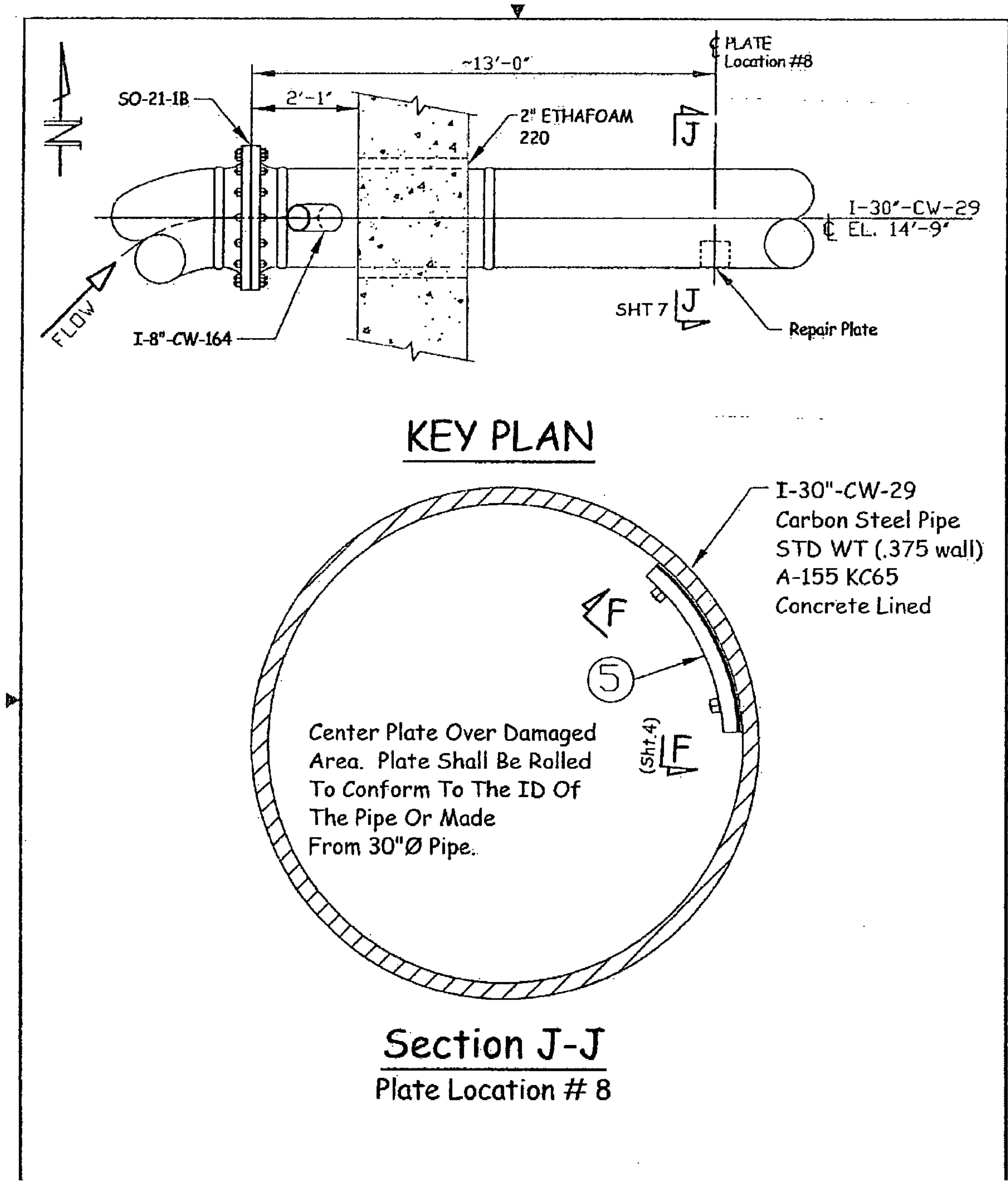

Figure 1: Typical Bolted Patch Plate Drawing Key Plan and Section J-J View

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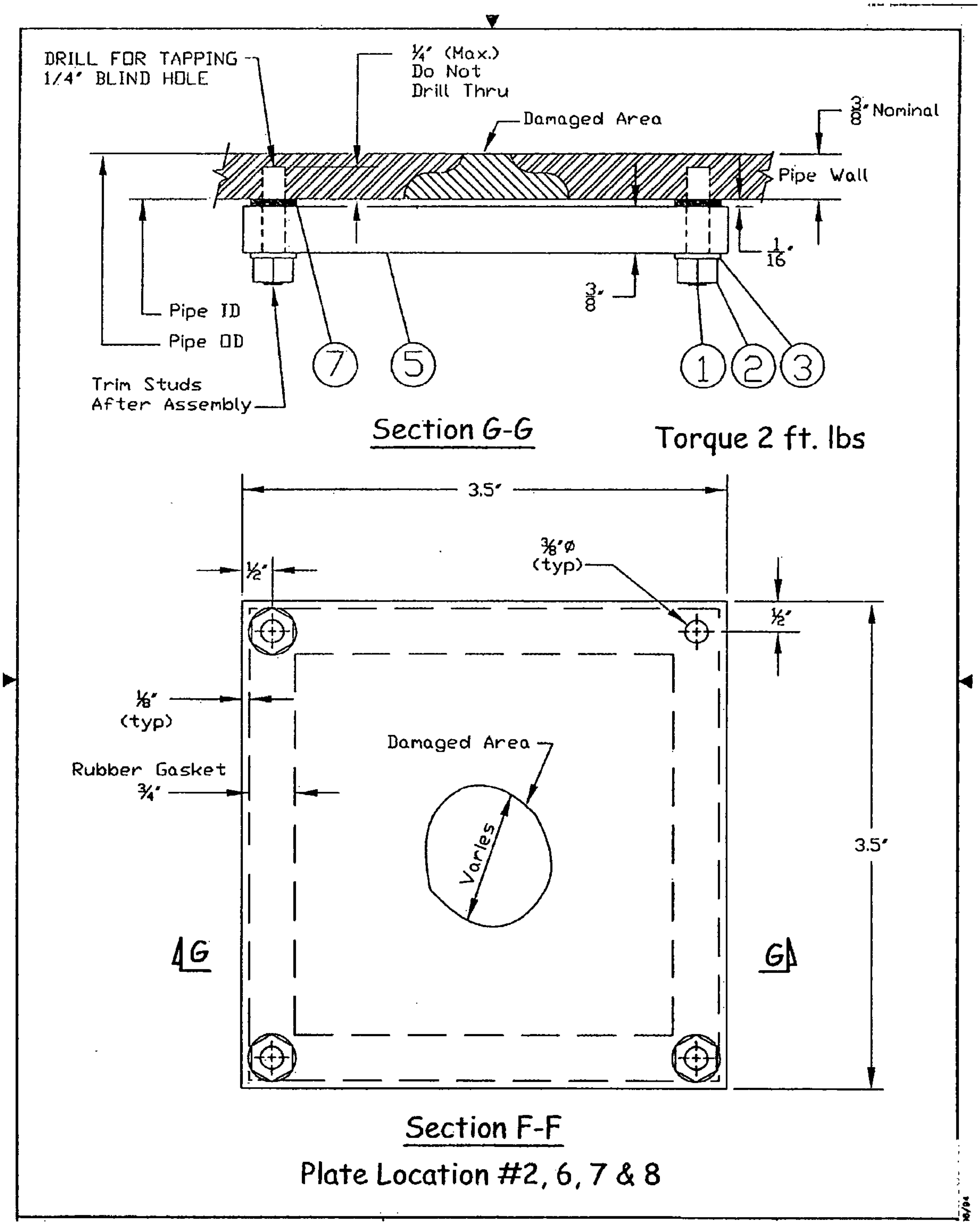

Figure 2: Typical Bolted Patch Plate Drawing Sections F-F and G-G Views

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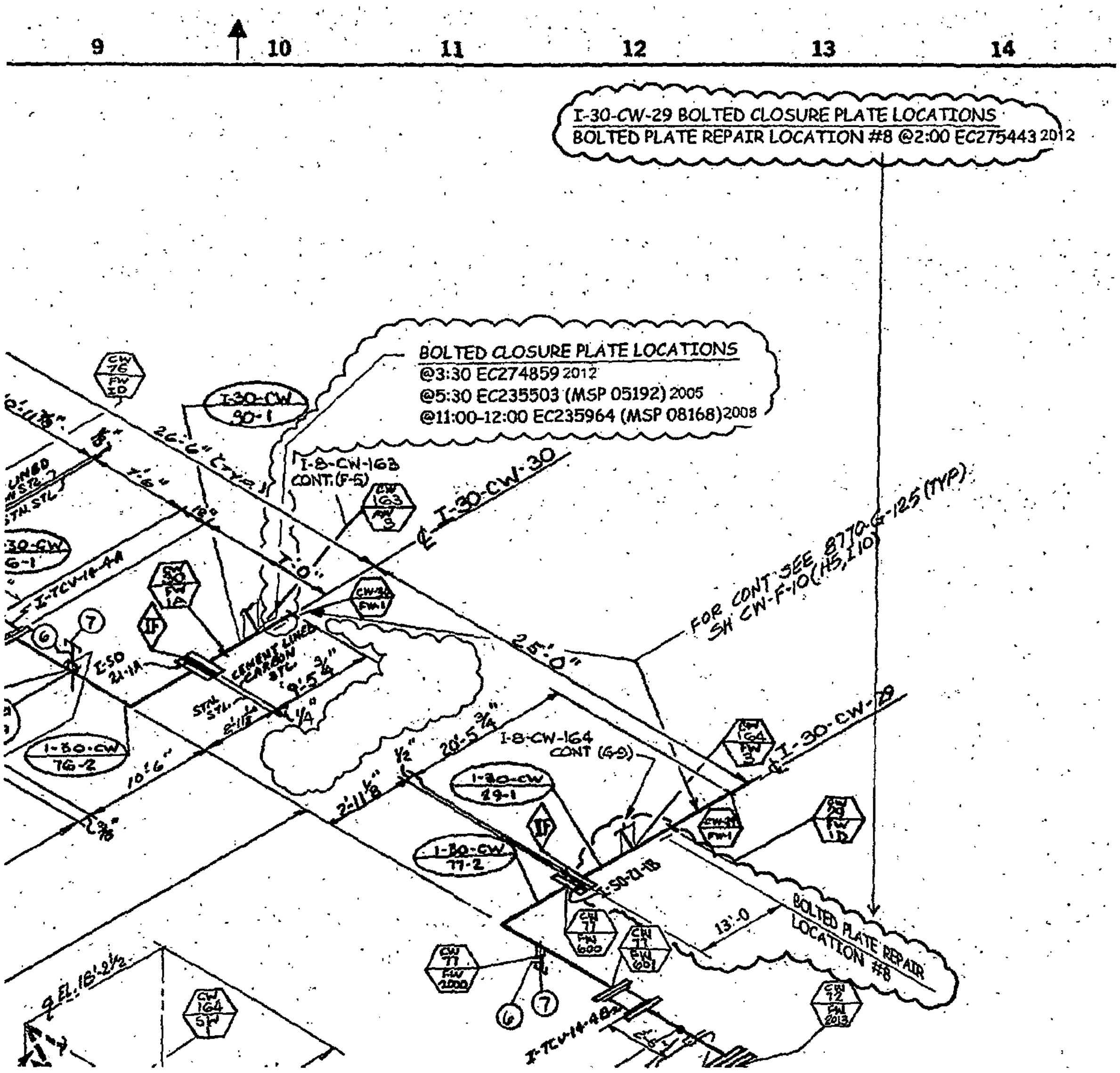

Figure 3: Bolted Patch Plate Repair Locations
I-30"-CW-30 (Train A) (Three Locations)

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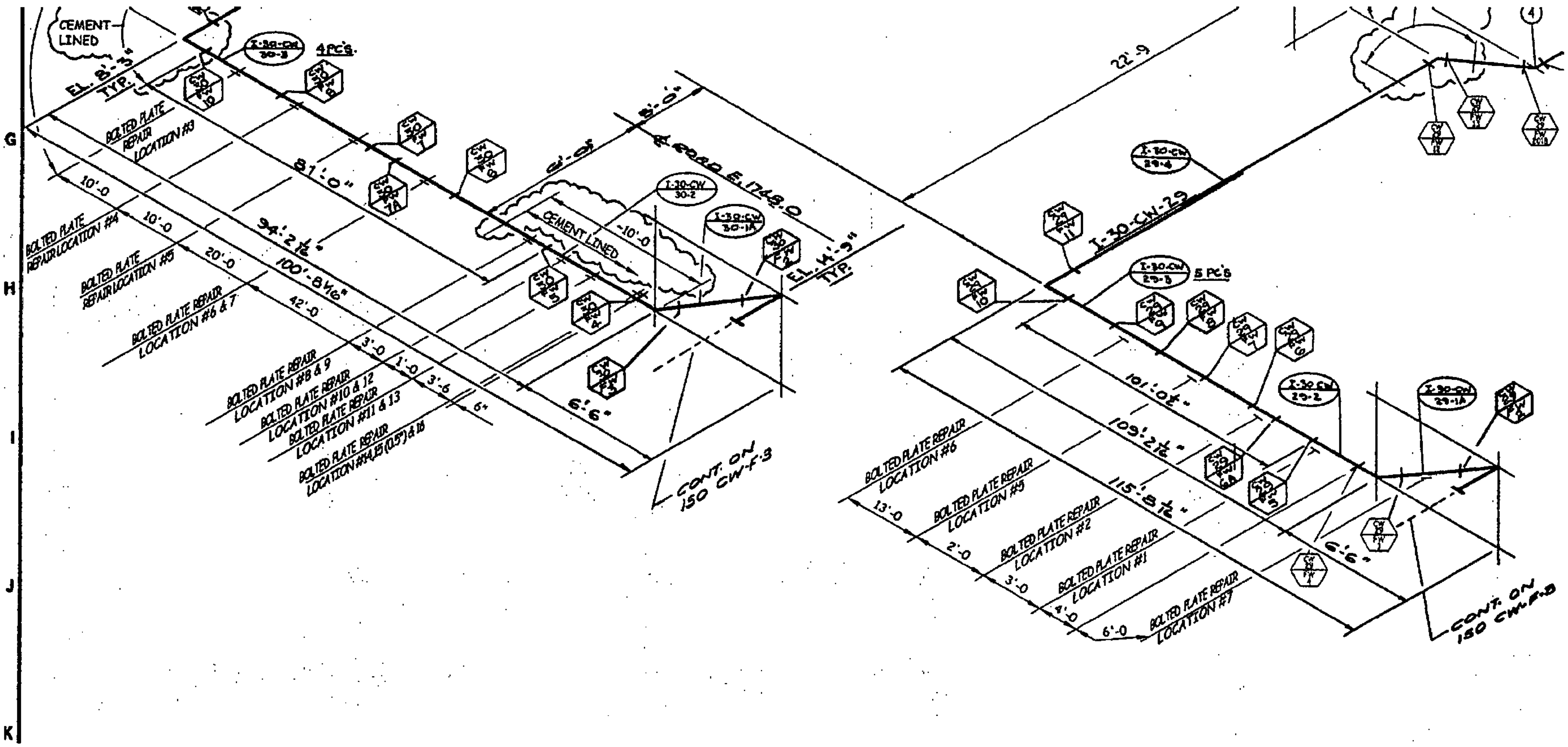

Figure 4: Bolted Patch Plate Repair Locations
I-30"-CW-30 (Train A)
(Sixteen Locations)
See Figure 5 for Location Listing

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I-30-CW-29 BOLTED CLOSURE PLATE LOCATIONS
BOLTED PLATE REPAIR LOCATION # 1 @7:00-10:00 EC275443 2012
BOLTED PLATE REPAIR LOCATION #2 @5:00 EC275443 2012
BOLTED PLATE REPAIR LOCATION #5 @3:00-6:00 EC275443 2012
BOLTED PLATE REPAIR LOCATION #6 @5:00 EC275443 2012
BOLTED PLATE LOCATIONS 3 & 4 DO NOT EXIST
BOLTED PLATE REPAIR LOCATION #7 @3:00 EC275443 2012

I-30-CW-30 BOLTED CLOSURE PLATE LOCATIONS
BOLTED PLATE REPAIR LOCATION #1 @6:30 EC275645 2012
BOLTED PLATE REPAIR LOCATION #2 @7:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #3 @5:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #4 @6:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #5 @5:30 EC275645 2012
BOLTED PLATE REPAIR LOCATION #6 @12:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #7 @9:30 EC275645 2012
BOLTED PLATE REPAIR LOCATION #8 @2:30 EC275645 2012
BOLTED PLATE REPAIR LOCATION #9 @10:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #10 @5:30 EC275645 2012
BOLTED PLATE REPAIR LOCATION #11 @2:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #12 @2:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #13 @7:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #14 @4:00 EC275645 2012
BOLTED PLATE REPAIR LOCATION #15 @8:15 EC275645 2012
BOLTED PLATE REPAIR LOCATION #16 @8:00 EC275645 2012

Figure 5: Bolted Patch Plate Repair Location Listing for Figure 4

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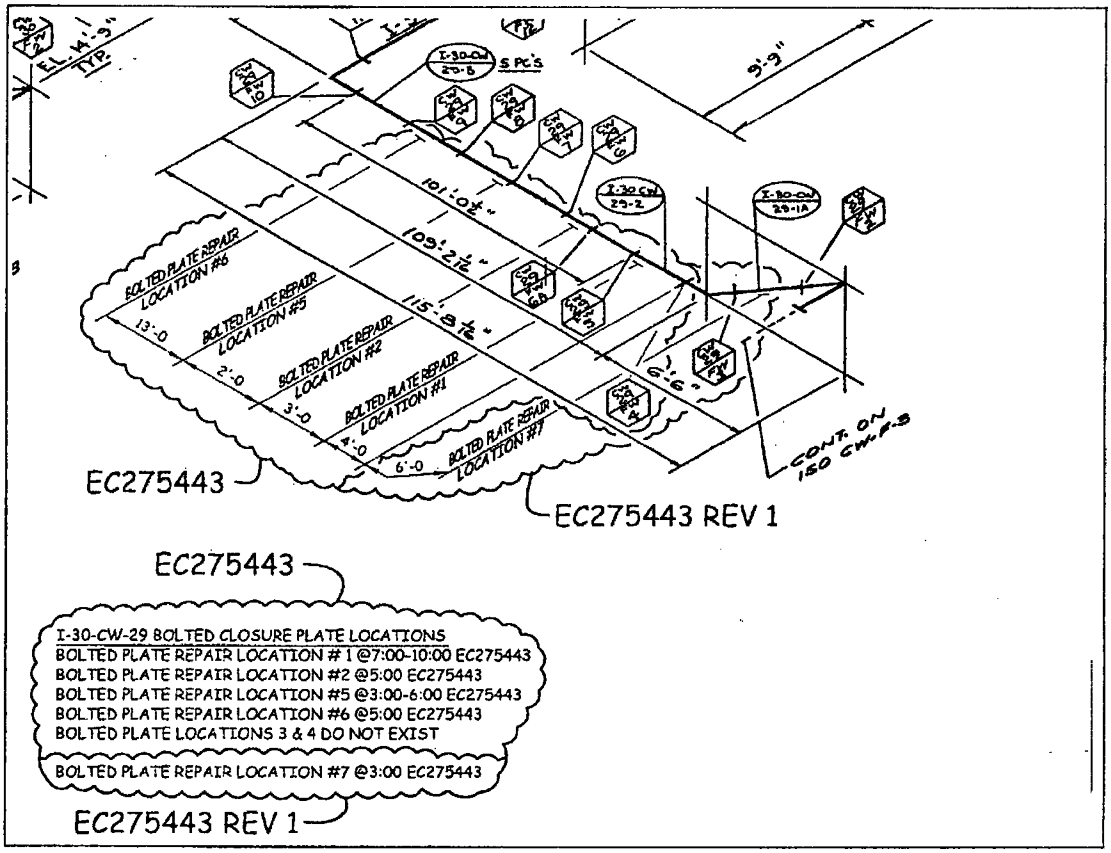

Figure 6: I-30"-CW-29 (Train B)
(Five Locations)

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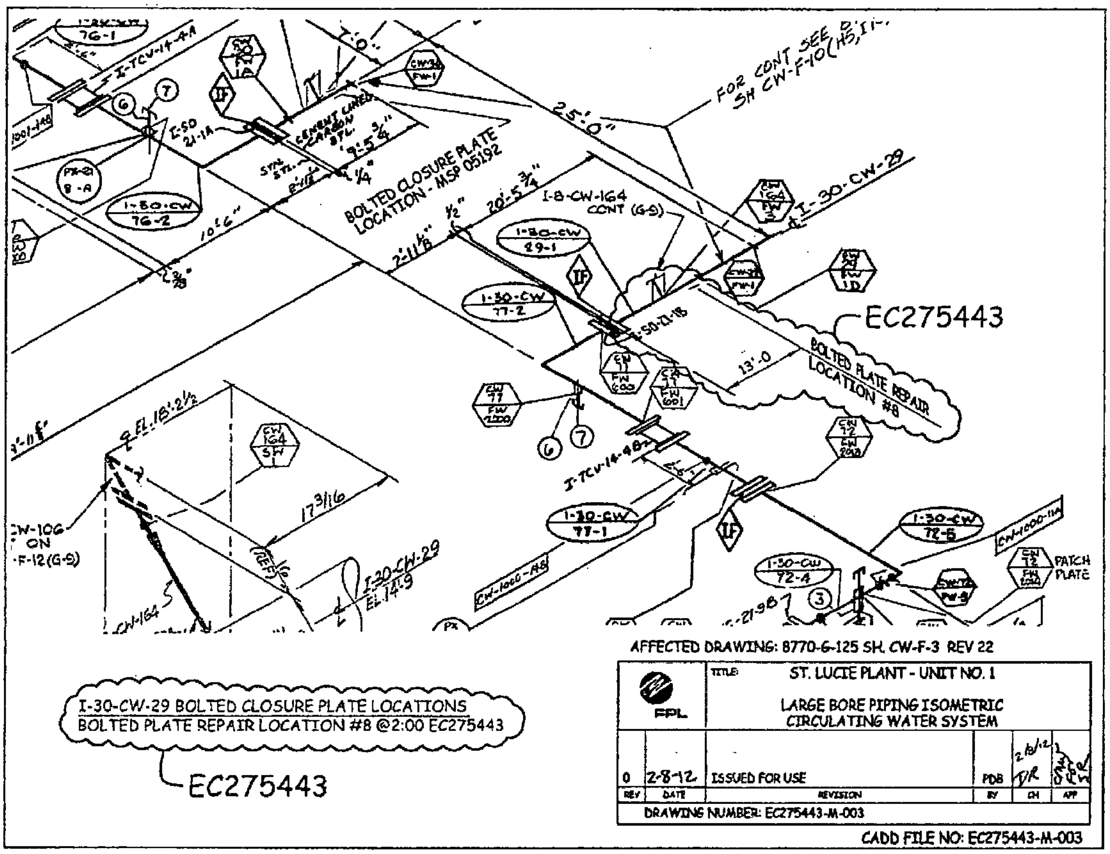


Figure 7: I-30"-CW-29 (Train B)
(One Location)

CALCULATION COVER SHEET

Calculation No: **PSL-1FSM-12-007** Revision No: **2**

Title: **Min Wall Thickness and Bolted Plate Repairs- Line I-30"-CW-29 and CW-30 - ICW Discharge to Canal**

This calculation determines the pipe minimum wall thickness for Internal Corrosion per ASME Section III and the criteria presented within UFSAR Table 3.9-3 for reviewing interactions of pressure stress and longitudinal bending stresses.
Revision 1 addresses application of bolted plate repairs on line I-30"-CW-29, which could also be applicable to I-30"-CW-30.
Revision 2 adds information about the weight of the plates, the shear of the bolting, the seismic properties of the plates and pipe and the Stress Intensity Factor of the bolting

LIST OF EFFECTIVE PAGES

TABLE OF CONTENTS

No.	Attachment Title	Pages	Rev
1	Pipe Stress Input	1	0
2	Stress Intensification Review	1	1
3	PCA Engineering, Inc. UT readings, taken 2-4-12	7	1
4	Patch Plate Addition	1	2

No.	Description		Printed Name	Signature	Date
2	Added info about seismic and bolt hole reinforcement	By	D. Russer	[signature]	8/1/13
		Check	W. B. Neff	W. B. Neff	8/1/13
		Apr	S. Ramani	S. Ramani	8/1/13
1	Added Repair Plate Design	By	Carol M. Wallace	Signature on File	2/7/2012
		Check	Steve Marshall	Signature on File	2/7/2012
		Apr	C. Wallace for S. Ramani	Signature on File	2/7/2012
0	Issued For Use	By	Carol M. Wallace	Signature on File	2/2/2012
		Check	W.B. Neff	Signature on File	2/2/2012
		Apr	Steve Marshall	Signature on File	2/2/2012
REVISIONS					

Form 82A (4/11), 82B (6/94), 82C (6/94) Equivalent

St. Lucie Unit 1
Min Wall Thickness and Bolted Plate Repairs-
Line I-30"-CW-29 and CW-30 - ICW Discharge to Canal

1.0 Purpose / Scope

This calculation determines the pipe minimum wall thickness for Internal Corrosion per design formulas of ASME Section III and the criteria presented within UFSAR Table 3.9-3 for reviewing interactions of pressure stress and longitudinal bending stresses.

Revision 1 addresses application of bolted plate repairs on line I-30"-CW-29, which could also be applicable to line I-30"-CW-30. The subject lines have no isolation valves to the discharge canal and operate at near atmospheric pressure. The calculation reviews a repair methodology that blanks off the corrosion holes or deep pitting with bolted plates on the ID of the pipe. Calculation Parts 2-6 are added in Revision 1.

Revision 2 addresses the weight of the plates on the pipe, the shear of the bolting, the seismic properties of the plates and pipe and the Stress Intensity Factor of the bolting.

Calculation evaluates the required reinforcement versus the actual reinforcement available around the corrosion holes and reviews bolting requirements for the bolted plate which is analyzed as a blind flange. Reinforcement interaction is reviewed for the multiple holes to ensure additional reinforcement is not required.

Calculation developed in support of AR 1730604.

2.0 Methodology

Part

1 The methodology used in the analysis is to:

1. Develop a minimum pipe wall thickness based on hoop stress.
2. Develop a minimum pipe wall thickness based on longitudinal stress calculated using the maximum allowed stress for each code equation.
3. The larger calculated minimum wall is used as the minimum wall criteria.

This analysis extrapolates the original pipe stress analysis to determine new longitudinal stress interaction ratios. A new pressure stress is calculated for the assumed wall thickness and the bending stresses within the interaction equations are extrapolated by the ratio of the nominal wall section modulus to the reduced wall section modulus.

Analysis assumes uniform wall reduction from the ID within the area of interest of the pipe run. Additional local wall thinning may be acceptable with further analysis and information on actual wall thickness of surrounding areas.

2 Determine required and actual reinforcement areas and zones per ASME Section III, Subsection NC.

3 Determine repair plate thickness requirements per ASME Section III, Subsection NC.

4 Determine gasket loading and bolt requirements per ASME Section III Appendix E.

5 Review thread engagement using machinery principles.

6 Address interaction of reinforcement zones per ASME Section III, Subsection NC.

3.0 References

1. St. Lucie Unit 1 FSAR Amendment 24
2. St. Lucie NAMS DataBase
3. Navco Piping Catalog, Edition 11, 1984
4. Section III, 1971 Edition, Summer 1973 Addenda, NC-3641.1
5. Section III, 1971 Edition, Summer 1973 Addenda, Appendix I
6. Section III, 1971 Edition, Summer 1973 Addenda, NC-3611.1
7. Section III, 1971 Edition, Summer 1973 Addenda, NB-3652
8. EBASCO Backfit Stress Analysis Design Criteria, Rev 2, 12/7/87
9. Roark's Formulas for Stress & Strain, 6 Edition, pages 67, 518
10. Not Used
11. Stress Calc 1000, Rev 5 & 1001, Rev 5 (Orig Code of Record ANSI B31.7 Class 3)
12. Stress Iso R-SK-172-11, Rev 5 and R-SK-172-12, Rev 5
13. Piping Isometric 8770-G-125 Sh CW-F-10, Rev 3
14. EPRI Good Bolting Practices Volume 1, NP-5067
15. Machinery's Handbook, 26 Edition, Industrial Press, Inc., Pages 1490, 1491
16. Fastener Standards, 6th Edition, Industrial Fasteners Institute
17. EC 275443
18. ASME Section III, 1971 Edition, Summer 1973 Addenda
19. Specification FLO-8770.099, rev. 4, General Power Piping

4.0 Assumptions/Data Input

1. Plate material will be a low carbon steel, such as SA/A-106 Grade B (Allowable 15,000 psi, lowest allowable of materials allowed by Ref. 19 for Pipe Code CS-1). Equivalent materials are acceptable. For specific materials used, see EC.

2. Fastener material will be SA-193 Grade B7 and SA-194-2H. Equivalent materials are acceptable. For specific materials used, see EC.

3. Plate is on ID of Pipe. An arbitrary external pressure of 15 psig will be used to calculate gasket loading assuming zero pressure within the piping.

4. The addition of the stud holes and the required reinforcement area does not have a negative effect on the required reinforcement area of the branch connections as defined in the ASME Code Section NC-3643.3(c). Furthermore, the stud holes were not drilled beyond the minimum wall thickness.

5. The Stress Intensity Factor (SIF) was reviewed for the studs of each plate and was found to have a negligable effect on the result of Attachment 2. No additional evaluation was required however the conditions of Attachment 2 still apply.

Piping System Inputs:		**30" 0.375 (STD) A-155 KC-65**			
t-nominal: tnom	0.375 in	Outside Diameter : Do	30	in	(3)
		Inside Diameter : Di	29.25	in	(3)
Corrosion Allowance : A	*(generally 0 for this analysis)*		0	in	(4)
Design P:	90 psig	Design T:	125	deg F*	(2)

Stress Analysis Inputs:	**PSL 1 Section III**			REF
Prepared: **See Att. 1**	Verified: **See Att. 1**			
Code of Record: ASME B&PV Code Section III, 1971 Edition through Summer 1973 Addenda				(11)
Stress Calc 1000, Rev 5 & 1001, Rev 5 (Orig Code of Record ANSI B31.7 Class 3)				(11)
Stress Iso R-SK-172-11, Rev 5 and R-SK-172-12, Rev 5				(12)
Piping Isometric 8770-G-125 Sh CW-F-10, Rev 3				(13)
		Max Stress		
Long Press. Stress (tnom) (Do NOT include in below Eq's)		2633	psi	(11)
Eq 8 (P)+(Dead Weight)**		502	psi**	(11)
Eq 9 Upset (P)+(DWt+OBE Inertia)**		1134	psi**	(11)
Eq 9 Emergency (P)+(DWt+DBE Inertia)**		1765	psi**	(11)
Eq 10 Thermal**		4553	psi**	(11)
Stress Allowable Hot: Sh		15000	psi	(11)
Allowable Stress Range for Expansion Stresses: Sa		22500	psi	(11)
y coefficient	*(0.4 if less than 900F)*	0.4	-	(4)

* For information only. Data not used by the analysis. **Equations Show General Form with P Included
The 4 Boxed Max Stress Values Provide the Moment Stress Only (Pressure Stress subtracted out)

5.0 <u>Calculation</u>

Part 1 - Minimum Wall Calculation

Develop tmin based on Hoop Stress:

					REF
tmin based on Hoop Stress	(P Do)/(2 (Sh + P y)) + A		**0.090**	in	(4)
Original Section Modulus:	$Z = 3.14/32\ (Do^4 - Di^4)/Do$		255.167	cu in	(9)
Mill Tolerance (tnom +/- 12.5%):	0.328 to 0.422 in	tnom	0.375	in	(3)

Develop tmin Based on Longitudinal Stresses:

tmin based on Longitudinal Stress (Guess & Iterate)			**0.074**	in	-
Diameter Inside Di'	Di'=Do-2tmin		29.853	in	-
New Section Modulus	$Z' = (3.14/32)\ (Do^4 - Di'^4)/Do$		51.630	cu in	(8)
Section Modulus Ratio	SM Ratio = Z / Z'		4.942	-	-
Longitudinal Pressure Stress	(P Do)/(4 tmin)		9169	psi	(9)
Code Equations & Acceptance Criteria:	*May Not Exceed*		L Stress	IR≤1.0	
Eq 8 = P + SM Ratio (DWt)	Sh	15000	11650	0.78	(11)
Eq 9 = P + SM Ratio (Dwt + OBE Inertia)	1.2 Sh	18000	14773	0.82	(11)
Eq 9 = P + SM Ratio (Dwt + DBE Inertia)	1.8 Sh	27000	17892	0.66	(11)
Eq 10 = SM Ratio (Th)	Sa	22500	22502	1.00	(11)

Calculation assumes general wall reduction due to Internal Corrosion
The Minimum Wall Criteria is 0.090 inches.

Calculation assumes general wall reduction due to Internal Corrosion
Additional local wall thinning may be acceptable with further analysis, provided the wall thickness of the surrounding area is greater than the above minimum wall criteria.

Part 2 (Case 1) - Reinforcement for Minimum Assumed Hole Size (0.25")

Branch Connection Reinforcement Calculation per ASME Section III, NC-3643.3
Pipe Code CS-1

Symbol	Units	Description
Dob	in	outside diameter of branch connection
Doh	in	outside diameter of header
d1	in	inside diameter of branch connection
d2	in	half width of reinforcing zone, greater of d1 or (Tb+Th+(d1/2)) but not > Dob
L	in	height of reinforcement zone outside of run or reinforcement = 2.5Tb
te	in	thickness of attached reinforcing pad
Tb	in	thickness of the branch, use minimum
Th	in	thickness of the run, use minimum
tmb	in	required minimum wall thickness branch
tmh	in	required minimum wall thickness header / run
P	psi	internal Design Pressure
T	deg F	internal Design Temperature
S	psi	maximum allowable stress for the material at design temperature
y		coefficient
A	in	additional thickness
a	deg	angle between axes of branch and run
tc	in	weld throat, smaller of 1/4" or 0.7Tb(ave) Fig NB-3352.4-2
w	in	weld leg, =1.41 tc

						Ref
Dob	0.25				Assumed, Bounding	-
Doh	30				Design	2
d1	0.25				Assumed, Bounding	-
		d1	Tb+Th+(d1/2)	Dob	NC-3643.3	18
d2	0.25	0.25	0.45	0.25	NC-3643.3	18
L	0.000				NC-3643.3	18
te	0				Assume no reinforcing pad	-
Tb (ave)	0				Assume no wall thickness	-
Tb (min)	0.000				87.50%	3
Th (ave)	0.375				NAMS	2
Th (min)	0.328				87.50%	3
tmb	N/A	tmb=(P*Dob)/ 2 (S+Py) + A			NC-3641.1(a)	18
tmh	0.090				See Part 1	-
P	90				NAMS	2
T	125				NAMS	2
S	15,000				See Part 1	11
y	0.4				See Part 1	18
A	0				See Part 1	18
a	90				Design	17
a radians	1.571				360 degrees = 2 p radians	-
		1/4"	0.7Tb	Lesser of	Fig NB-3352.4-2	18
tc	0	0	0		Not Used	-
w	0				Not Used	-

Calculate area required:

Area required = 1.07(tmh)(d1)
0.024 sq. in.

Calculate area available (see ASME Section III, NC-3643.3 for clarification):

Area A1 = (2*d2-d1)*(Th min-tmh)
0.060 sq. in.

Area A2 = 2L*(Tb min-tmb)/sina
0 sq. in.

Area A3= area provided by deposited weld metal beyond OD of run & branch
2 (0.5 * w*w)
0 sq. in.

Area A4= area provided by a reinforcing ring, pad or integral reinforcement
0 sq. in.

Area A5= area provided by a saddle on right angle connections
0 sq. in.

Aavail= A1 + A2 + A3 + A4 + A5
0.060 sq. in.

Compare area available to required area:

Avail		Required area
0.060 sq. in.	>	0.024 sq. in.

No additional reinforcement of the assumed hole is required.

Part 2 (Case 2) - Reinforcement for Maximum Assumed Hole Size (30")

Branch Connection Reinforcement Calculation per ASME Section III, NC-3643.3
Pipe Code CS-1

Symbol	Units	Description
Dob	in	outside diameter of branch connection
Doh	in	outside diameter of header
d1	in	inside diameter of branch connection
d2	in	half width of reinforcing zone, greater of d1 or (Tb+Th+(d1/2)) but not > Dob
L	in	height of reinforcement zone outside of run or reinforcement = 2.5Tb
te	in	thickness of attached reinforcing pad
Tb	in	thickness of the branch, use minimum
Th	in	thickness of the run, use minimum
tmb	in	required minimum wall thickness branch
tmh	in	required minimum wall thickness header / run
P	psi	internal Design Pressure
T	deg F	internal Design Temperature
S	psi	maximum allowable stress for the material at design temperature
y		coefficient
A	in	additional thickness
a	deg	angle between axes of branch and run
tc	in	weld throat, smaller of 1/4" or 0.7Tb(ave) Fig NB-3352.4-2
w	in	weld leg, =1.41 tc

						Ref
Dob	30				Assumed, Bounding	-
Doh	30				Design	2
d1	30				Assumed, Bounding	-
		d1	Tb+Th+(d1/2)	Dob	NC-3643.3	18
d2	30	30	15.33	30	NC-3643.3	18
L	0.000				NC-3643.3	18
te	0				Assume no reinforcing pad	-
Tb (ave)	0				Assume no wall thickness	-
Tb (min)	0.000				87.50%	3
Th (ave)	0.375				NAMS	2
Th (min)	0.328				87.50%	3
tmb	N/A	tmb=(P*Dob)/ 2 (S+Py) + A			NC-3641.1(a)	18
tmh	0.090				See Part 1	-
P	90				NAMS	2
T	125				NAMS	2
S	15,000				See Part 1	11
y	0.4				See Part 1	18
A	0				See Part 1	18
a	90				Design	17
a radians	1.571				360 degrees = 2 p radians	-
		1/4"	0.7Tb		Fig NB-3352.4-2	18
tc	0	0	0		Not Used	-
w	0				Not Used	-

Calculate area required:

Area required = 1.07(tmh)(d1)
2.882 sq. in.

Calculate area available (see ASME Section III, NC-3643.3 for clarification):

Area A1 = (2*d2-d1)*(Th min-tmh)
7.150 sq. in.

Area A2 = 2L*(Tb min-tmb)/sina
0 sq. in.

Area A3= area provided by deposited weld metal beyond OD of run & branch
2 (0.5 * w*w)
0 sq. in.

Area A4= area provided by a reinforcing ring, pad or integral reinforcement
0 sq. in.

Area A5= area provided by a saddle on right angle connections
0 sq. in.

Aavail= A1 + A2 + A3 + A4 + A5
7.150 sq. in.

Compare area available to required area:

Avail		Required area
7.150 sq. in.	>	2.882 sq. in.

No additional reinforcement of the assumed hole is required.

The above cases show that hole sizes up to 30" diameter do not require additional reinforcement, provided the wall thickness in the surrounding areas is $\geq$0.328".

Part 3A - Plate Thickness for 3.5" x 3.5" Plate

Data used in the 3.5" x 3.5" plate and bolting analysis is summarized in this section.

Patch Plate Inputs:		Value	Units	REF
Design Temperature		125	F	2
Design Pressure		90	psig	2
Base Metal Information				
Pipe Nominal Wall		0.375	in	2
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Patch Information				
Width	Assume Width is the smaller plate dimension.	3.5	in	17
Height	Assume Height is the larger plate dimension.	3.5	in	17
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Opening Dimensions				
Gasket Width		0.75	in	17
Plate overlap		0.125	in	
Width	=Patch Width - 2 (Overlap + Gasket Width)	1.75	in	17
Height	=Patch Height - 2 (Overlap + Gasket Width)	1.75	in	17
Bolting Information				
Diameter		0.25	in	17
Material		SA-193 Gr. B7		17
Allowable Stress	Table I-7.3	25000	psi	5
Yield Stress	Table I-1.3	105000	psi	5
Number of Bolts		4		17
Area of Bolt		0.0318	in^2	16
k for Thread Lubricant N-5000		0.15	-	14

Minimum Required Patch Plate Thickness (ASME Section III, NB-3647.2)

tm	minimum thickness = t + A	
t	calculated thickness = d6*(3*P/16*S)^.5	
d6	Gasket ID	Assume max height/width, increase by 10%, conservative.
P	Design Pressure	Use of design pressure is extremely conservative.
S	Stress Allowable	
A	Mechanical Allowances (NB-3613) = 0	

tm =	(110% *(Height/Width, max)*((3*90)/(16*15000))^0.5+0	0.065	in	
	Meets plate thickness of	**0.375**	**in**	**OK**

Part 4A - Bolt/Gasket Loading for 3.5" x 3.5" Plate

FLANGE JOINT LOADING/GASKET SEATING CALCULATIONS

ASME Section III Appendix E methodology, modified for square patch plate

GASKET AREA			Value	Units	REF
W	Pressure Width	= Gasket Width + Opening Width	2.5	in	17
H	Pressure Height	= Gasket Width + Opening Height	2.5	in	17
Land	Gasket Width		0.75	in	17
b	1/2 Gasket Width	=Land/2	0.375	in	
A	Short Dimension Cover	=Patch Width - 2 (Overlap)	3.25	in	17
B	Long Dimension Cover	=Patch Height - 2 (Overlap)	3.25	in	17
C	Short Dimension Gasket ID	=Patch Width - 2 (Overlap + Gasket Width)	1.75	in	17
D	LongDimension Gasket ID	=Patch Height - 2 (Overlap + Gasket Width)	1.75	in	17
d	Bolt Diameter		0.25	in	17
N	Number of Bolts		4		17
PRESSURE AREA					
P Area		W*H	6.25	in^2	-
REQUIRED SEATING LOAD (Wm2)					
y			200	lb/in^2	18
G Area		=(A*B)-(C*D)-((N*PI*(d+0.125)^2)/4)	7.06	in^2	18
Wm2		=y* G Area	1412	lb	18
OPERATING SEATING LOAD (Wm1)					
P ext		Patch is on ID, Assume 15 psi external	15	psig	Ass. 3
P Area		=W*H	6.25	in^2	
m		Gasket Factor	1		18
Wm1		=(P ext*P Area)+(G Area*m*P ext), modified for rectangle	200	lb	18
REQUIRED BOLT STRESS/TORQUE					
Load		Greater of Wm1 or Wm2	1412	lb	18
Bolt Diameter			0.25	in	17
Load/Bolt		=Load / N	353	lb	-
Bolt Stress		=Load/Bolt/((3.14*Bolt Dia^2)/4)	7189	psi	-
Bolt Torque		=K*d* Load/(N*12)	1.10	ft-lbs	14
			2 ft-lbs specified		

Rounded up to next whole number

Part 5A - Bolting for 3.5" x 3.5" Plate

ICW Pipe -Pipe Code CS-1 (SA-106 Grade B Used, Assumption 1)

Bolts: SA-193 Grade B7, 1/4"-20 UNC-2A

				REF
D	Bolt Basic Major Diameter (nominal diameter)	0.250	in	17
n	Threads per inch	20	-	17
	Thread Class (External)	2A	-	17
Le'	Actual Thread Engagement	0.250	in	17
Esmin	External Thread Minimum pitch diameter	0.2127	in	16
Dsmin	External Thread Minimum major diameter	0.2408	in	16
Yieldbolt	External Thread Yield Strength	105,000	psi	5
UTSbolt	External Thread Thread Ultimate Tensile Strength	125,000	psi	5
Enmax	Internal Thread Maximum pitch diameter	0.2224	in	16
Knmax	Internal Thread Maximum minor diameter	0.207	in	16
Yieldhole	Internal Thread Yield Strength	35,000	psi	5
UTShole	Internal Thread Ultimate Tensile Strength	60,000	psi	5

1. Review for Potential Stripping of External Threads (Before Bolt Breaks)

At	Tensile Area of Screw Thread UTSbolt < 100 ksi: At = .7854 (D- .9743/n)^2 UTSbolt ≥ 100 ksi: At = 3.1416 (Esmin/2 - .16238/n)^2	0.030	sq in	15
Le	Required Length of Engagement for External Threads to Develop Full Bolt Load Le = (2*At) / [3.14 Knmax (.5 + .57735 n (Esmin- Knmax)]	0.165	in	15

2. Review for Potential Stripping of Internal Threads (Before Bolt Breaks)

As	= 3.1416 n Le Knmax (1/(2n) + .57735(Esmin - Knmax))	0.061	sq in	15
An	= 3.1416 n Le Dsmin (1/(2n) + .57735 (Dsmin - Enmax))	0.089	sq in	15
J	= (As UTSbolt) / (An UTShole)	1.42	-	15
Q	Required Length of Internal Threads = J * Le	0.234	in	15

3. Load Required to Break Bolt/Screw

Pbolt	Pbolt = At * UTSbolt	3789	lbs	15

Governing Bolt/Thread Failure Load

Threaded Joint Failure Load	Component Failure Review based on minimum load for bolt breakage, external thread strippage or internal thread strippage Failure Load = Minimum (1 , Le'/Le, Le'/Q) x (Pbolt)	3789	lbs	-
Bolt Torque	Torque which will yield undamaged joint with actual engagement Bolt Torque = (Failure Load/Pbolt) D*Yield bolt*At*K/12	10	ft-lbs	-

M=Developed Percent of Bolt Yield Strength	20%	%	-
K=Nut Factor (Fel-Pro N-5000)	0.15	-	14
Bolt Torque = M D Yieldbolt At K / 12	**2.00**	ft-lbs	14

	%Yield
Bolt Stress compared to bolt material strength	20%
External Thread Stress compared to bolt material strength	13%
Internal Thread Stress compared to hole material strength	27%

Part 3B - Plate Thickness for 10" x 11" Plate

Data used in the 10" x 11" plate and bolting analysis is summarized in this section.

Patch Plate Inputs:		Value	Units	REF
Design Temperature		125	F	2
Design Pressure		90	psig	2
Base Metal Information				
Pipe Nominal Wall		0.375	in	2
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Patch Information				
Width	Assume Width is the smaller plate dimension.	10	in	17
Height	Assume Height is the larger plate dimension.	11	in	17
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Opening Dimensions				
Gasket Width		0.75	in	17
Plate overlap		0.125	in	
Width	=Patch Width - 2 (Overlap + Gasket Width)	8.25	in	17
Height	=Patch Height - 2 (Overlap + Gasket Width)	9.25	in	17
Bolting Information				
Diameter		0.25	in	17
Material		SA-193 Gr. B7		17
Allowable Stress	Table I-7.3	25000	psi	5
Yield Stress	Table I-1.3	105000	psi	5
Number of Bolts		8		17
Area of Bolt		0.0318	in^2	16
k for Thread Lubricant N-5000		0.15	-	14

Minimum Required Patch Plate Thickness (ASME Section III, NB-3647.2)

tm	minimum thickness = t + A	
t	calculated thickness = d6*(3*P/16*S)^.5	
d6	Gasket ID	Assume max height/width, increase by 10%, conservative.
P	Design Pressure	Use of design pressure is extremely conservative.
S	Stress Allowable	
A	Mechanical Allowances (NB-3613) = 0	

tm =	(110% *(Height/Width, max)*((3*90)/(16*15000))^0.5+0	0.341	in	
	Meets plate thickness of	**0.375**	**in**	**OK**

Part 4B- Bolt/Gasket Loading for 10" x11" Plate

FLANGE JOINT LOADING/GASKET SEATING CALCULATIONS

ASME Section III Appendix E methodology, modified for square patch plate

GASKET AREA			Value	Units	REF
W	Pressure Width	= Gasket Width + Opening Width	9	in	17
H	Pressure Height	= Gasket Width + Opening Height	10	in	17
Land	Gasket Width		0.75	in	17
b	1/2 Gasket Width	=Land/2	0.375	in	
A	Short Dimension Cover	=Patch Width - 2 (Overlap)	9.75	in	17
B	Long Dimension Cover	=Patch Height - 2 (Overlap)	10.75	in	17
C	Short Dimension Gasket ID	=Patch Width - 2 (Overlap + Gasket Width)	8.25	in	17
D	LongDimension Gasket ID	=Patch Height - 2 (Overlap + Gasket Width)	9.25	in	17
d	Bolt Diameter		0.25	in	17
N	Number of Bolts		8		17
PRESSURE AREA					
P Area	W*H		90	in^2	-
REQUIRED SEATING LOAD (Wm2)					
y			200	lb/in^2	18
G Area	=(A*B)-(C*D)-((N*PI*(d+0.125)^2)/4)		27.6	in^2	18
Wm2	=y* G Area		5523	lb	18
OPERATING SEATING LOAD (Wm1)					
P ext	Patch is on ID, Assume 15 psi external		15	psig	Ass. 3
P Area	=W*H		90	in^2	
m	Gasket Factor		1		18
Wm1	=(P ext*P Area)+(G Area*m*P ext), modified for rectangle		1764	lb	18
REQUIRED BOLT STRESS/TORQUE					
Load	Greater of Wm1 or Wm2		5523	lb	18
Bolt Diameter			0.25	in	17
Load/Bolt	=Load / N		690	lb	-
Bolt Stress	=Load/Bolt/((3.14*Bolt Dia^2)/4)		14065	psi	-
Bolt Torque	=K*d* Load/(N*12)		2.16	ft-lbs	14
			3 ft-lbs specified		

Rounded up to next whole number

Part 5B - Bolting for 10" x 11" Plate

ICW Pipe -Pipe Code CS-1 (SA-106 Grade B Used, Assumption 1)

Bolts: SA-193 Grade B7, 1/4"-20 UNC-2A

		Value	Units	REF
D	Bolt Basic Major Diameter (nominal diameter)	0.250	in	17
n	Threads per inch	20	-	17
	Thread Class (External)	2A	-	17
Le'	Actual Thread Engagement	0.250	in	17
Esmin	External Thread Minimum pitch diameter	0.2127	in	16
Dsmin	External Thread Minimum major diameter	0.2408	in	16
Yieldbolt	External Thread Yield Strength	105,000	psi	5
UTSbolt	External Thread Thread Ultimate Tensile Strength	125,000	psi	5
Enmax	Internal Thread Maximum pitch diameter	0.2224	in	16
Knmax	Internal Thread Maximum minor diameter	0.207	in	16
Yieldhole	Internal Thread Yield Strength	35,000	psi	5
UTShole	Internal Thread Ultimate Tensile Strength	60,000	psi	5

1. Review for Potential Stripping of External Threads (Before Bolt Breaks)

At	Tensile Area of Screw Thread UTSbolt < 100 ksi: At = .7854 (D- .9743/n)^2 UTSbolt ≥ 100 ksi: At = 3.1416 (Esmin/2 - .16238/n)^2	0.030	sq in	15
Le	Required Length of Engagement for External Threads to Develop Full Bolt Load Le = (2*At) / [3.14 Knmax (.5 + .57735 n (Esmin- Knmax)]	0.165	in	15

2. Review for Potential Stripping of Internal Threads (Before Bolt Breaks)

As	= 3.1416 n Le Knmax (1/(2n) + .57735(Esmin - Knmax))	0.061	sq in	15
An	= 3.1416 n Le Dsmin (1/(2n) + .57735 (Dsmin - Enmax))	0.089	sq in	15
J	= (As UTSbolt) / (An UTShole)	1.42	-	15
Q	Required Length of Internal Threads = J * Le	0.234	in	15

3. Load Required to Break Bolt/Screw

Pbolt	Pbolt = At * UTSbolt	3789	lbs	15

Governing Bolt/Thread Failure Load

Threaded Joint Failure Load	Component Failure Review based on minimum load for bolt breakage, external thread strippage or internal thread strippage Failure Load = Minimum (1 , Le'/Le, Le'/Q) x (Pbolt)	3789	lbs	-
Bolt Torque	Torque which will yield undamaged joint with actual engagement Bolt Torque = (Failure Load/Pbolt) D*Yield bolt*At*K/12	10	ft-lbs	-

M=Developed Percent of Bolt Yield Strength	30%	%	-
K=Nut Factor (Fel-Pro N-5000)	0.15	-	14
Bolt Torque = M D Yieldbolt At K / 12	**3.00**	ft-lbs	14

	%Yield
Bolt Stress compared to bolt material strength	30%
External Thread Stress compared to bolt material strength	20%
Internal Thread Stress compared to hole material strength	41%

Part 3C - Plate Thickness for 7.5" x 11.5" Plate

Data used in the 7.5" x11.5" plate and bolting analysis is summarized in this section.

Patch Plate Inputs:		Value	Units	REF
Design Temperature		125	F	2
Design Pressure		90	psig	2
Base Metal Information				
Pipe Nominal Wall		0.375	in	2
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Patch Information				
Width	Assume Width is the smaller plate dimension.	7.5	in	17
Height	Assume Height is the larger plate dimension.	11.5	in	17
Material		SA-106 Gr B		Assumption 1
Allowable Stress	Assume SA-106 Gr. B or equiv., Table I-7.1	15000	psi	5, Att. 1
Opening Dimensions				
Gasket Width		0.75	in	17
Plate overlap		0.125	in	
Width	=Patch Width - 2 (Overlap + Gasket Width)	5.75	in	17
Height	=Patch Height - 2 (Overlap + Gasket Width)	9.75	in	17
Bolting Information				
Diameter		0.25	in	17
Material		SA-193 Gr. B7		17
Allowable Stress	Table I-7.3	25000	psi	5
Yield Stress	Table I-1.3	105000	psi	5
Number of Bolts		8		17
Area of Bolt		0.0318	in^2	16
k for Thread Lubricant N-5000		0.15	-	14

Minimum Required Patch Plate Thickness (ASME Section III, NB-3647.2)

tm	minimum thickness = t + A	
t	calculated thickness = d6*(3*P/16*S)^.5	
d6	Gasket ID	Assume max height/width, increase by 10%, conservative.
P	Design Pressure	Use of design pressure is extremely conservative.
S	Stress Allowable	
A	Mechanical Allowances (NB-3613) = 0	

tm =	(110% *(Height/Width, max)*((3*90)/(16*15000))^0.5+0	0.360	in	
	Meets plate thickness of	**0.375**	**in**	**OK**

Part 4C - Bolt/Gasket Loading for 7.5" x 11.5" Plate

FLANGE JOINT LOADING/GASKET SEATING CALCULATIONS

ASME Section III Appendix E methodology, modified for square patch plate

GASKET AREA			Value	Units	REF
W	Pressure Width	= Gasket Width + Opening Width	6.5	in	17
H	Pressure Height	= Gasket Width + Opening Height	10.5	in	17
Land	Gasket Width		0.75	in	17
b	1/2 Gasket Width	=Land/2	0.375	in	
A	Short Dimension Cover	=Patch Width - 2 (Overlap)	7.25	in	17
B	Long Dimension Cover	=Patch Height - 2 (Overlap)	11.25	in	17
C	Short Dimension Gasket ID	=Patch Width - 2 (Overlap + Gasket Width)	5.75	in	17
D	LongDimension Gasket ID	=Patch Height - 2 (Overlap + Gasket Width)	9.75	in	17
d	Bolt Diameter		0.25	in	17
N	Number of Bolts		8		17
PRESSURE AREA					
P Area		W*H	68.25	in^2	-
REQUIRED SEATING LOAD (Wm2)					
y			200	lb/in^2	18
G Area		=(A*B)-(C*D)-((N*PI*(d+0.125)^2)/4)	24.6	in^2	18
Wm2		=y* G Area	4923	lb	18
OPERATING SEATING LOAD (Wm1)					
P ext		Patch is on ID, Assume 15 psi external	15	psig	Ass. 3
P Area		=W*H	68.25	in^2	
m		Gasket Factor	1		18
Wm1		=(P ext*P Area)+(G Area*m*P ext), modified for rectangle	1393	lb	18
REQUIRED BOLT STRESS/TORQUE					
Load		Greater of Wm1 or Wm2	4923	lb	18
Bolt Diameter			0.25	in	17
Load/Bolt		=Load / N	615	lb	-
Bolt Stress		=Load/Bolt/((3.14*Bolt Dia^2)/4)	12537	psi	-
Bolt Torque		=K*d* Load/(N*12)	1.92	ft-lbs	14
			2 ft-lbs specified		

Rounded up to next whole number

Part 5C - Bolting for 7.5" x 11.5" Plate

ICW Pipe -Pipe Code CS-1 (SA-106 Grade B Used, Assumption 1)

Bolts: SA-193 Grade B7, 1/4"-20 UNC-2A

				REF
D	Bolt Basic Major Diameter (nominal diameter)	0.250	in	17
n	Threads per inch	20	-	17
	Thread Class (External)	2A	-	17
Le'	Actual Thread Engagement	0.250	in	17
Esmin	External Thread Minimum pitch diameter	0.2127	in	16
Dsmin	External Thread Minimum major diameter	0.2408	in	16
Yieldbolt	External Thread Yield Strength	105,000	psi	5
UTSbolt	External Thread Thread Ultimate Tensile Strength	125,000	psi	5
Enmax	Internal Thread Maximum pitch diameter	0.2224	in	16
Knmax	Internal Thread Maximum minor diameter	0.207	in	16
Yieldhole	Internal Thread Yield Strength	35,000	psi	5
UTShole	Internal Thread Ultimate Tensile Strength	60,000	psi	5

1. Review for Potential Stripping of External Threads (Before Bolt Breaks)

At	Tensile Area of Screw Thread UTSbolt < 100 ksi: At = .7854 (D- .9743/n)^2 UTSbolt ≥ 100 ksi: At = 3.1416 (Esmin/2 - .16238/n)^2	0.030	sq in	15
Le	Required Length of Engagement for External Threads to Develop Full Bolt Load Le = (2*At) / [3.14 Knmax (.5 + .57735 n (Esmin- Knmax)]	0.165	in	15

2. Review for Potential Stripping of Internal Threads (Before Bolt Breaks)

As	= 3.1416 n Le Knmax (1/(2n) + .57735(Esmin - Knmax))	0.061	sq in	15
An	= 3.1416 n Le Dsmin (1/(2n) + .57735 (Dsmin - Enmax))	0.089	sq in	15
J	= (As UTSbolt) / (An UTShole)	1.42	-	15
Q	Required Length of Internal Threads = J * Le	0.234	in	15

3. Load Required to Break Bolt/Screw

Pbolt	Pbolt = At * UTSbolt	3789	lbs	15

Governing Bolt/Thread Failure Load

Threaded Joint Failure Load	Component Failure Review based on minimum load for bolt breakage, external thread strippage or internal thread strippage Failure Load = Minimum (1 , Le'/Le, Le'/Q) x (Pbolt)	3789	lbs	-
Bolt Torque	Torque which will yield undamaged joint with actual engagement Bolt Torque = (Failure Load/Pbolt) D*Yield bolt*At*K/12	10	ft-lbs	-

M=Developed Percent of Bolt Yield Strength	20%	%	-
K=Nut Factor (Fel-Pro N-5000)	0.15	-	14
Bolt Torque = M D Yieldbolt At K / 12	**2.00**	ft-lbs	14

	%Yield
Bolt Stress compared to bolt material strength	20%
External Thread Stress compared to bolt material strength	13%
Internal Thread Stress compared to hole material strength	27%

Part 6- Interaction Between Multiple Openings

ASME III, Section NC-3643.3(e) defines reinforcement requirements for multiple openings:

> When any two or more adjacent openings are so closely spaced that their reinforcement zones overlap, the two or more openings shall be reinforced in accordance with NC-3643.3(c) and (d), with a combined reinforcement that has strength equal to the combined strength of the reinforcement which would be required for the separate openings. No portion of the cross-section shall be considered as applying to more than one opening or be evaluated more than once in a combined area.

ASME III, Section NC-3643.3(f) defines reinforcement zone:

> The reinforcement zone is a parallelogram the length of which shall extend a distance d_2, on each side of the centerline of the branch pipe and the width of which shall start at the inside surface of the run pipe and extend to a distance, L, from the outside surface of the run pipe, when measured in the plane of the branch connection.

From Part 2, Cases 1 and 2, d_2 is the hole size for the location.

Based on review of PCA Engineering, Inc. UT readings (Att. 3):
The openings for closest holes are spaced sufficiently apart that the reinforcement zones do not overlap. Therefore, additional reinforcement criteria per ASME III, Section NC-3643.3(f) is not required.

6.0 Results

Pipe

The Minimum Wall Criteria is 0.090 Inches

The minimum wall criteria is controlled by the hoop stresses.

Calculation assumes general wall reduction due to Internal Corrosion
Additional local wall thinning may be acceptable with further analysis, provided the wall thickness of the surrounding area is greater than the above minimum wall criteria.

Reinforcement

Part 2, shows that hole sizes up to 30" diameter do not require additional reinforcement, provided the wall thickness in the surrounding areas is ≥0.328".

Plate Thickness

To consolidate stock, the required plate thickness is compared to design plate thickness of 0.375".

3.5" x 3.5" Plate

Required closure plate thickness is 0.065 Inches
Minimum Bolt Torque (1/4" -20UNC) is 2.00 Ft-lbs

Note that the thread engagement in the ICW piping does not meet standard design to assure the bolt breaks before stripping the threads. However, field torque limitations will prevent stripping of the hole.

10"x 11" Plate

Required closure plate thickness is 0.341 Inches
Minimum Bolt Torque (1/4" -20UNC) is 3.00 Ft-lbs

Note that the thread engagement in the ICW piping does not meet standard design to assure the bolt breaks before stripping the threads. However, field torque limitations will prevent stripping of the hole.

7.5" x 11.5" Plate

Required closure plate thickness is 0.360 Inches
Minimum Bolt Torque (1/4" -20UNC) is 2.00 Ft-lbs

Note that the thread engagement in the ICW piping does not meet standard design to assure the bolt breaks before stripping the threads. However, field torque limitations will prevent stripping of the hole.

Interaction Between Multiple Openings

Based on review of PCA Engineering, Inc. UT readings (Att. 3):
The openings for closest holes are spaced sufficiently apart that the reinforcement zones do not overlap. Therefore, additional reinforcement criteria per ASME III, Section NC-3643.3(f) is not required.

Pipe Stress Input

Location

Unit	**1**
CR / CSI Loc No.	**NA**
Line Number	I-30"-CW-29, -30
Description	CCW HX to Discharge Canal
Diameter	30"
Schedule	0.375"
Design Pressure	90 psi
Temperature	125°F
Piping Isometric and Revison	8770-G-125, CW-F-10 & CW-F-3
Original Design Spec and Edition	USAS B31.7, Class 3

Civil Pipe Stress Input

	Units	
Stress Code and Edition	-	ASME Section III 1971-S73 / Class 3
Stress Iso and Revison	-	R-SK-172-11 & 12, R5
Nodes	-	17
Stress Calc and Revison	-	1000 R5 & 1001 R5
Long Pressure Stress	psi	2633
EQ _8_ Deadweight (P)+(Dead Weight) **	psi	502
EQ _9_ Upset (P)+(DWt+OBE Inertia) **	psi	1134
EQ _9_ Emergency (P)+(DWt+DBE Inertia) **	psi	1765
EQ _10_ Thermal (Thermal)**	psi	4553
EQ ___ SAM (P)+(DWt +Thermal + Seismic Anc. Moments OBE) **	psi	N/A
Stress Allowable Hot: Sh	psi	15000
Allowable Stress Range for Exp. Stresses: Sa	psi	22500
**Boxed Values are Moment Stress Only (Pressure Stress Has Been Subtracted Out)		

Civil Input:

Values are worst case of 1000 and 1001

Prepared By: [signature] 2·1·2012

Verified By: [signature] 2/1/2012

Stress Intensifiction Factor Review

The bolted patch plate repair methodology provides a branch connection but does not impose any moment inducing loads from branch piping. ASME Section III Edition 1971 through Summer 1973 Addenda provides stress intensification factors (SIFs) for various configurations which impose moment loading of piping components but does not address a branch hole with or without a bolted covering.

Stress indices and stress intensification factors (SIFs) are used in the design of piping systems that must meet Code requirements. SIFs are fatigue correlation factors that compare the fatigue life of piping components (for example, tees and branch connections) to that of girth butt welds in straight pipe subjected to bending moments.

As the subject opening with a bolted cover is not subjected to increased bending moments or externally applied loads, a SIF does not need to be applied to the configuration. Code criteria regarding reinforcement zones for a branch penetration apply.

Similarly, a SIF is not required for multiple openings. Code criteria regarding overlap of reinforcement zones for adjacent penetrations apply.

Prepared By: Gordon McKenzie Date: 12-15-11

Verified By: [signature] Date: 12-15-11

Approved By: [signature] Date: 12.15.11

PCA Engineering, Inc. UT readings, taken 2-4-12

Wallace, Carol

From: Smit, Marty
Sent: Saturday, February 04, 2012 1:23 PM
To: Russer, David
Cc: Atkinson, Paul; Wallace, Carol; Marshall, Steve; Ramani, Sharam; Harmon, John; Wolaver, Mark; Hollowell, Ed; Rodriguez, Omar (PSL); Jenkins, Jeffery; Oscarson, Kevin; Ensmenger, Paul
Subject: UT data of CW-29 buried pipe results from 020312 pipe ID survey
Attachments: Layout CW-29 Cells 1-6.pdf

Attached find the current file from PCA showing the location of the pipe ID corrosion defects on the CW-29 underground ICW piping downstream of the CCW pit perimeter wall. The pipe run inspected is located on northbound run of CW-29 about 20 - 30 feet downstream of the elbow near the outbound ICW penetration in the east side of Unit 1 CCW pit. A few defects are thru wall.

The sketch of the ICW pipe ID surface, is laid out lengthwise from south to north. The "elevation" view is of the pipe split length- wise down the top centerline when viewed from the right (south) end at the elbow. The diagram shows a "plan" view of the pipe unrolled to a flat panel, with the 3 o'clock half on the top and th4e 6 o'clock half on the bottom.

The pipe downstream of this location has had a limited inspection through a soiled surface. Additional surface cleaning may reveal additional defects. Therefore, discovery on CW-29 may not yet be complete.

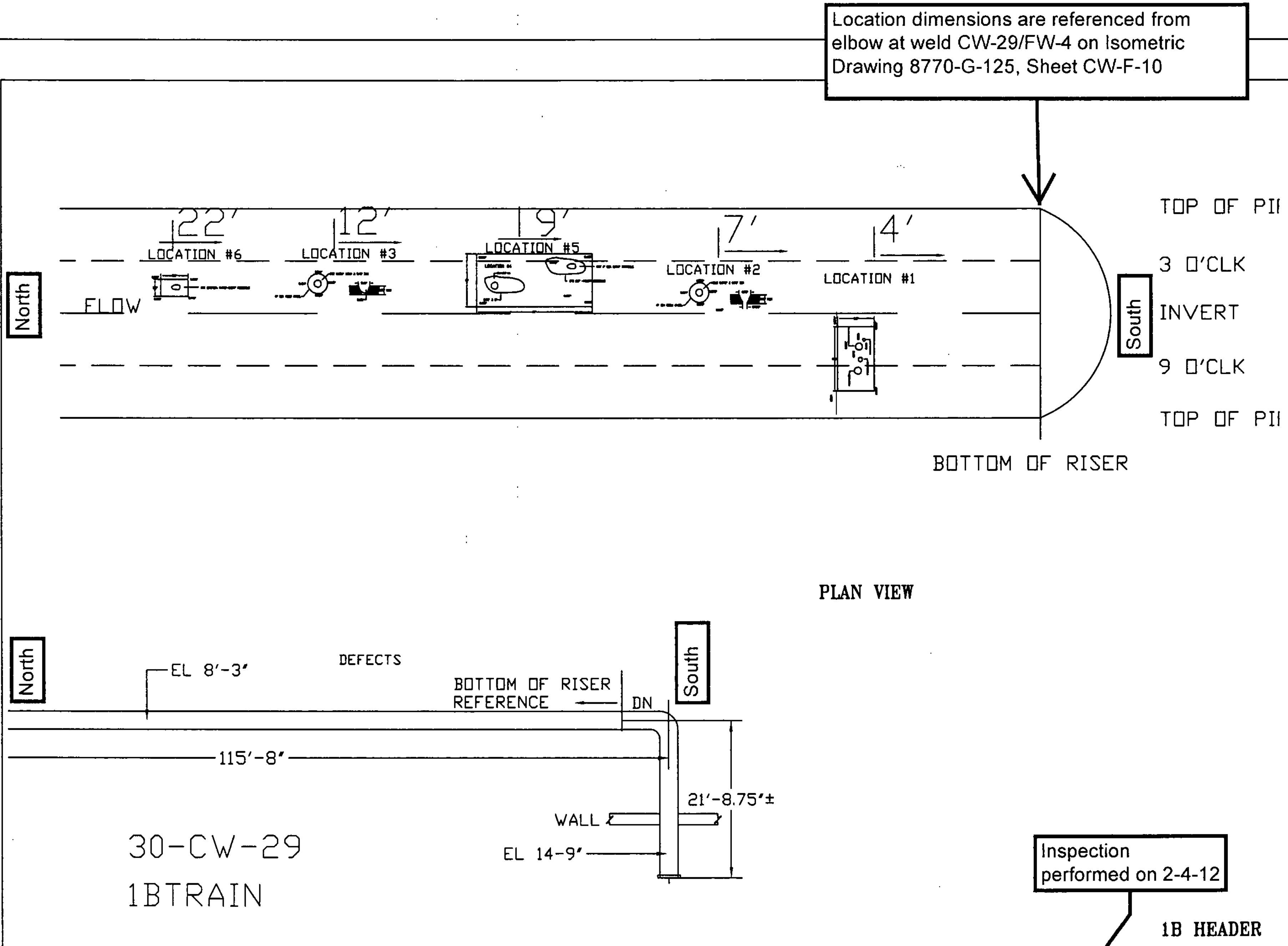
There are a few relatively small diameter defects with a "conical" profile that shows corrosion initialing from the ID off the pipe.

Cold patch plates are suggested by PCA to prevent heat affected damage on the OD coating that results from weld repairs. The size of the proposed patch plates is shown on the detail sketches of the wall defects. Pictures of the defects are also included.

Information in Text Boxes was added by Carol Wallace based on Discussion with Richard Montgomery of PCA.

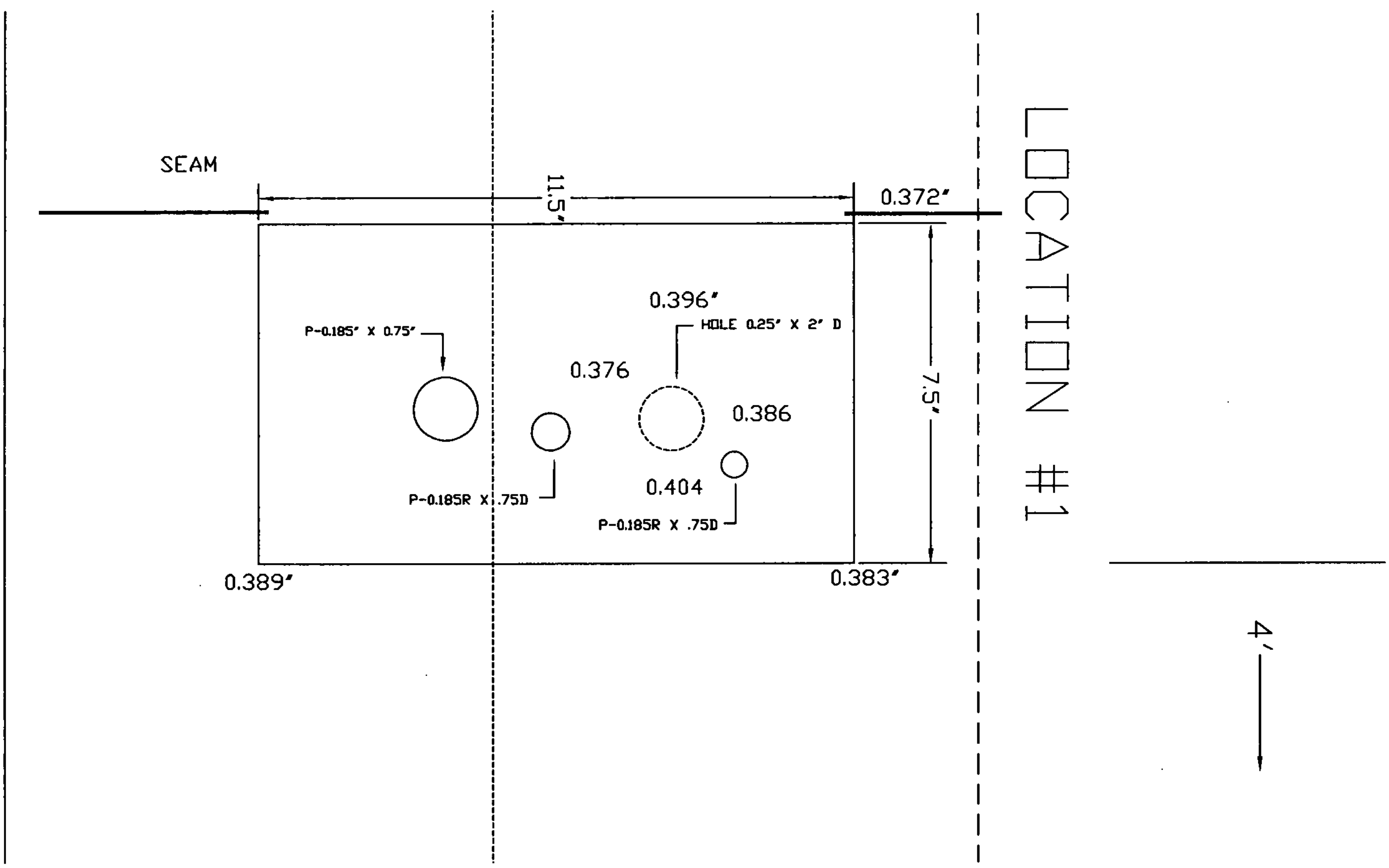
P-0.185"Rx0.75"D means Pit (versus a hole) with 0.185" remaining wall thickness and pit diameter of 0.75" at the pipe ID.

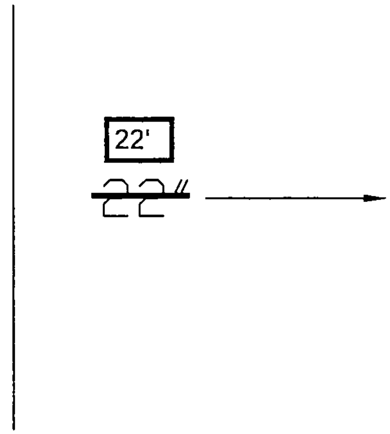
HOLE 0.25" x 2" diameter means Hole with diameter 0.25" at OD and 2" at ID.



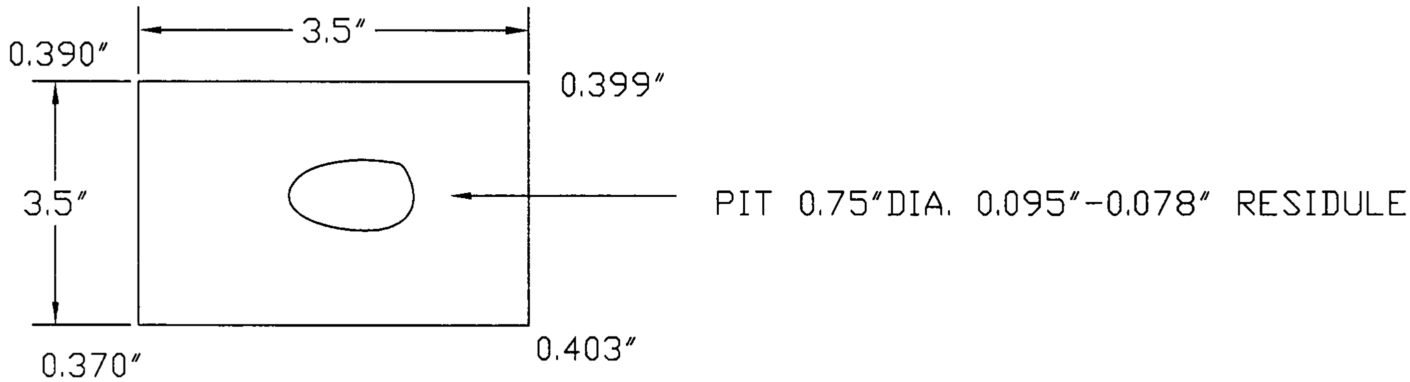
PCA ENGINEERING, INC. 57 CANNONBALL RD POMPTON LAKES, NJ	FPL PSL 1	30-CCW-29 DISCHARGE COATING REPAIRS	DRAWN: R.H.M. DATE: 01/10/2012	DWG. NO. A301251

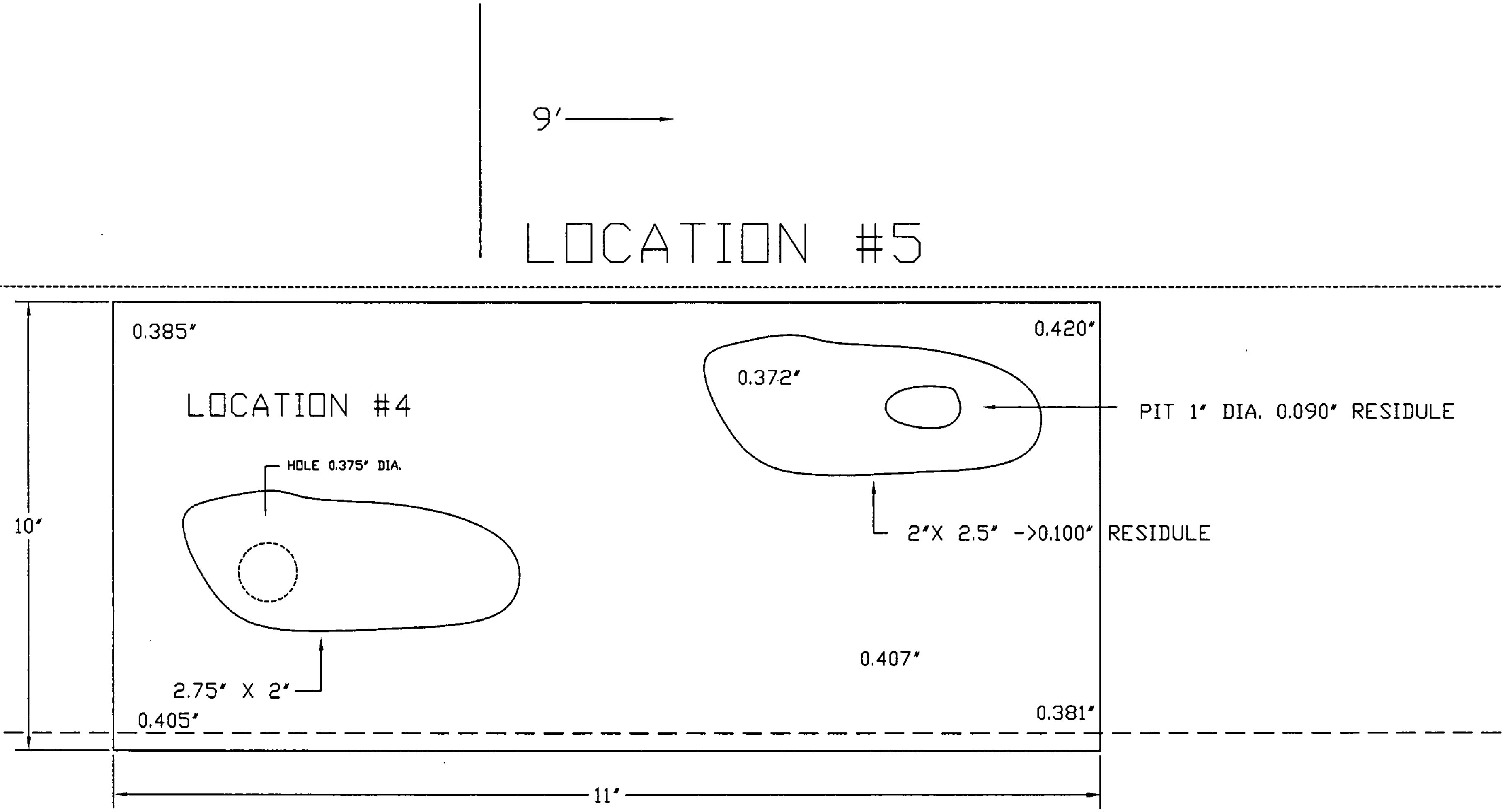
7/6/10 Pier #8.dwg

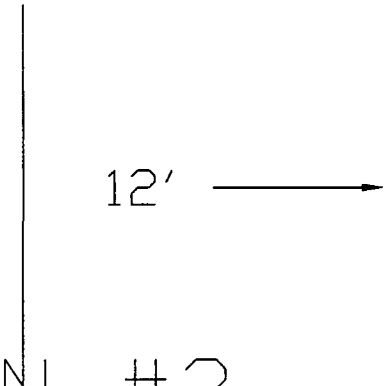

SEAM
11.5"
0.372"
0.396"
HOLE 0.25" X 2" D
P-0.185" X 0.75"
0.376
0.386
P-0.185R X .75D
0.404
P-0.185R X .75D
0.389"
0.383"
7.5"
LOCATION #1
4'



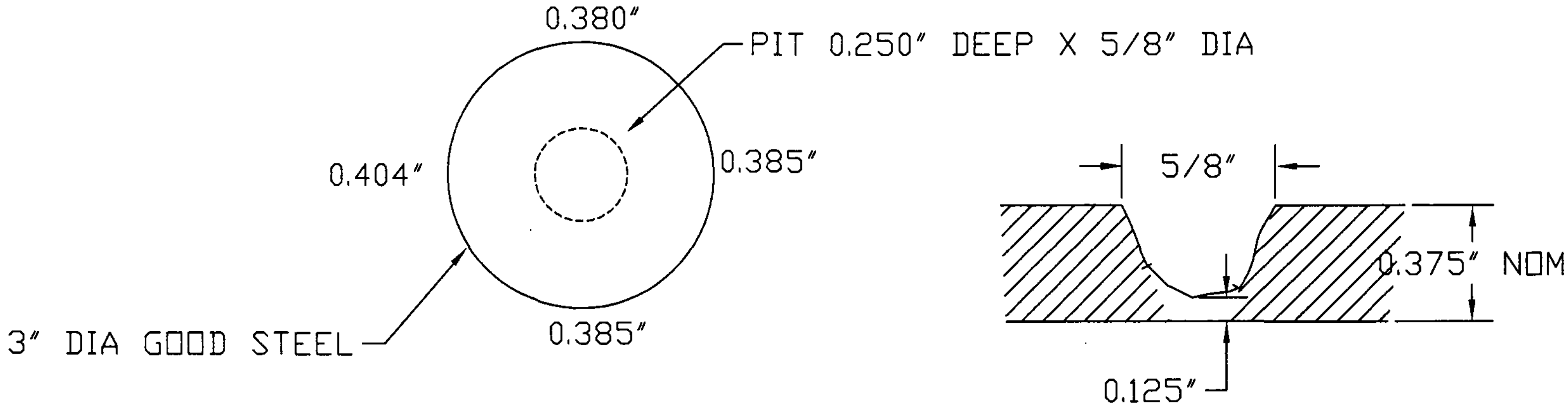
LOCATION #6

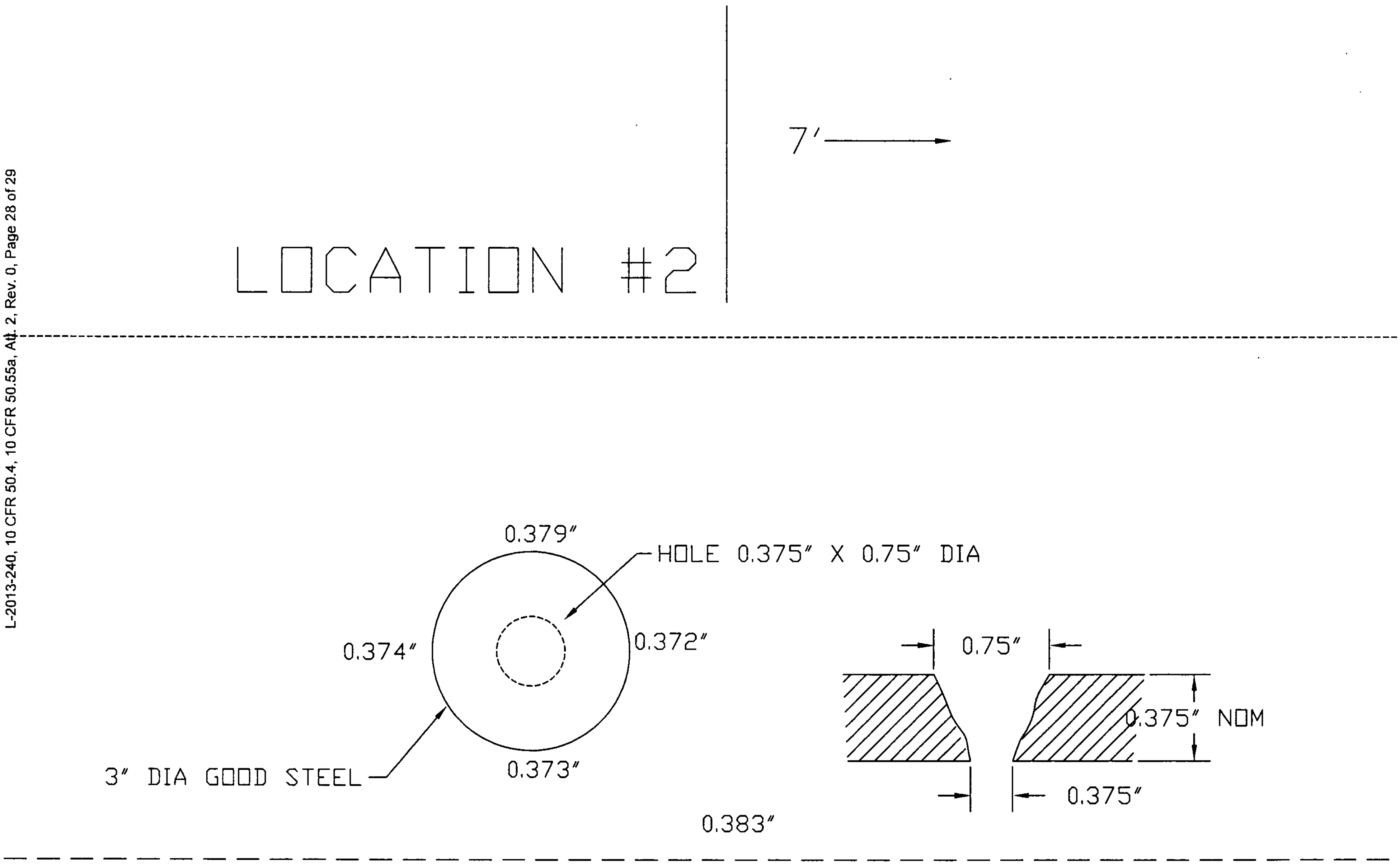



9'
LOCATION #5
0.385"
0.420"
0.372"
LOCATION #4
PIT 1" DIA. 0.090" RESIDULE
HOLE 0.375" DIA.
10"
2"X 2.5" ->0.100" RESIDULE
0.407"
2.75" X 2"
0.405"
0.381"
11"


12'

LOCATION #3


0.380"
PIT 0.250" DEEP X 5/8" DIA
0.404"
0.385"
0.385"
3" DIA GOOD STEEL
5/8"
0.375" NOM
0.125"


7′
LOCATION #2
0.379″
HOLE 0.375″ X 0.75″ DIA
0.374″
0.372″
0.373″
3″ DIA GOOD STEEL
0.75″
0.375″ NOM
0.375″
0.383″

Patch Plate Addition:

The purpose of this evaluation is to determine the impact on the affected pipe stresses and pipe support loads resulting from adding internal patch plates to the I-30"-CW-29 and CW-30 piping lines (ICW Piping). The subject piping is evaluated within calculation CW-2930-U1, Rev. 0. Per NAMS, the piping is classified as Quality Group C, Seismic Category I, or Class 3 Code piping.

The patch plates are 3/8" thick held in place with 1/4"-20 studs (SA-193 Gr. B7), and vary in overall size, and total number of studs. Review of patch plate drawings within EC-275443 and EC-275645 reveals that the largest patch plate is 11"x11". Conservatively considering a 12"x12" plate results in an added weight of 20 lb (12"x12"x0.375"x0.284 lb/in^{3}x1.2 (bolting) = 18.4 lb). The ICW Piping is 30" OD having a wall thickness 0.375" (3/8"), and a weight of 118.7 lb/ft. The piping is shown on isometric drawing 8770-G-125, Sheet CW-F-10, Rev. 5. In accordance with the calculation of record CW-2930-U1, Page-10, the worst case OBE factor is 0.68, thus SSE is 1.36 (SSE = 2xOBE). Therefore, to account for seismic excitation the evaluated weight will be 30 lb (20 lb x 1.36g = 27.2 lb).

In accordance with Specification SPEC-M-004, the SA-193 Gr. B7, 1/4-20 studs have Tensile Stress of 125 ksi, and a Yield Stress 105 ksi, and As is 0.0318 in^2. Thus the shear stress on a 1/4-20 stud resulting from the seismic loading of the patch plate is 943.4 psi < 21,000 psi (Shear Allowable per AISC 9th Edition) with the entire load on one bolt (flow force is negligible). The effect on the pipe stresses due to added patch plate (weight increase) will be evaluated using the results of the analysis of record as shown below:

Weight ratio factor = (added patch plate weight)/(analysis of record piping weight) = (30 lb +119 lb) / 119 lbs = 1.25.

Since the percent increase in the pipe stresses is directly proportional to the weight increase, conservatively the deadweight and seismic stresses (maximum stress), including the unaffected pressure stresses, will be adjusted by the weight ratio factor (Note: CW-30 is worst case).

In addition, to account for the effect of any frequency change due to the increased weight, the above maximum seismic stresses will also conservatively be increased by a dynamic factor of 1.5.

Analysis of record EQ. 8 stress = 9,467 psi
New EQ. 8 stress = 9,467 x (1.25) = 11,834 psi < 1.0 SH = 15,000 psi; thus o.k.

Analysis of record EQ. 9 stress (Seismic SSE) = 7,461 psi
New EQ. 9 faulted stress = 7,461 x (1.25) x (1.5) = 13,989 psi < 1.8 SH = 27,000 psi; thus o.k.

Multiple plates: per drawing 8770-G-125, Sheet CW-F-3, Rev. 23, at CW-30 three (3) plates have been installed in close proximity to one another. There are two (2) 8"x8" plates and one 11"x11" plate. The combined weight of these plates is 26.5 lb x 1.2 (bolting) = 31.8 lb. The conservatisms used in the above evaluation for the weight ratio for 30 lb is considered to be envelope the three plate scenario.

Based on the above, the affected piping section meets the stress requirements of the design criteria for each individual patch plate location.

Prepared By: [signature] Date: 8/1/2013

Verified By: [signature] Date: 8/1/13

Approved By: [signature] Date: 8/1/13