Calvert Cliffs Nuclear Power Plant

1650 Calvert Cliffs Parkway
Lusby, Maryland 20657

CENG
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CALVERT CLIFFS
NUCLEAR POWER PLANT

November 14, 2013

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit No. 2; Docket No. 50-318
Proposed 10 CFR 50.55a Request for Unit 2 Repair of Saltwater Piping Leak (RR-ISI-04-09)

Pursuant to 10 CFR 50.55a Calvert Cliffs Nuclear Power Plant, LLC, (Calvert Cliffs) hereby requests Nuclear Regulatory Commission approval of the following relief to the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Code Section XI, 2004 Edition, no Addenda. This 10 CFR 50.55a request for Calvert Cliffs Unit 2 (RR-ISI-04-09) is provided in Attachment (1) and is submitted proposing installation of a mechanical clamping device on a leak discovered on a 12 inch, Code Class 3, Saltwater System pipe. This 10 CFR 50.55a request, in accordance with Mandatory Appendix IX, Mechanical Clamping Devices for Class 2 and 3 Piping Pressure Boundary, is pursuant to 10 CFR 50.55a(a)(3)(ii) as compliance with all the requirements of American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Code Section XI would pose a hardship without a compensating increase in the level of quality and safety.

This proposed repair is effective for Calvert Cliffs Fourth Ten-Year Inservice Inspection Interval. As required by Mandatory Appendix IX, the mechanical clamping device shall be removed and replaced by a permanent code repair or component replacement at the next scheduled Unit 2 refueling outage which is currently scheduled to begin in February 2015.

Due to the emergent nature of this issue, immediate Nuclear Regulatory Commission review of this 10 CFR 50.55a request is requested.

This letter contains regulatory commitments as listed in Attachment (2).

A047
NRR

Should you have questions regarding this matter, please contact Mr. Douglas E. Lauver at (410) 495-5219.

Very truly yours,

David J. Dellario
Manager – Engineering Services

DJD/KLG/bjd

Attachments: (1) 10 CFR 50.55a Request for Calvert Cliffs Unit 2 Repair of Saltwater Piping Leak (RR-ISI-04-09)

Enclosure: 1. Calculation ILD-CALC-0014, Evaluation of 12-LJ-1-2001 Line Enclosure

(2) Regulatory Commitments

cc: N. S. Morgan
W. M. Dean, NRC
Resident Inspector, NRC
S. Gray, DNR

ATTACHMENT (1)

10 CFR 50.55a REQUEST FOR CALVERT CLIFFS UNIT 2 REPAIR OF SALTWATER PIPING LEAK (RR-ISI-04-09)

Calvert Cliffs Nuclear Power Plant, LLC
November 14, 2013

RR-ISI-04-09
10 CFR 50.55a Request
In Accordance with 10 CFR 50.55a(a)(3)(ii)

--Hardship or Unusual Difficulty
Without Compensating Increase in Level of Quality or Safety--

1. ASME Code Component(s) Affected

Calvert Cliffs Unit 2 Saltwater (SW) System pipe line 12"-LJI-2011. This is a 12 inch schedule STD (12.75 inch OD by 0.375 inch nominal wall) American Society for Testing and Materials A-53 Gr B carbon steel pipe that is rubber lined to prevent interaction of the carbon steel with brackish Chesapeake Bay water. This 12 inch line ties into the 24 inch SW discharge header via a reducing tee. The 24 inch header routes the heat exchanger discharge from both trains of SW to a 30 inch underground pipe and then discharges into the Unit 2 circulating water discharge conduit going back to the Chesapeake Bay.

Design Pressure/Temperature:	50 psig/ 95°F
Operating Pressure/Temperature:	35 psig/ 95°F

2. Applicable Code Edition and Addenda

Calvert Cliffs is currently in its Fourth Ten-Year Inservice Inspection Interval. The Code of Record for this interval is American Society of Mechanical Engineers (ASME) Section XI, 2004 Edition with no Addenda. The subject piping is ASME Section XI, Class 3. The piping Construction Code is American National Standards Institute B31.1, 1967 Edition.

3. Applicable Code Requirement

The applicable Code requirement from which relief is requested is ASME Code Section XI, 2004 Edition, with no Addenda, Appendix IX, Sub paragraph IX-1000(c)(4) which restricts mechanical clamping devices to nominal pipe size (NPS) 6 when the nominal operating temperature or pressure does not exceed 200°F or 275 psig. This proposed 10 CFR 50.55a request is to allow an ASME Section XI, Appendix IX mechanical clamping device to be installed on this NPS 12 pipe.

4. Reason for the Request

During September 2013, a pin-hole leak was identified on line 12"-LJI-2011. This condition is currently being addressed by application of approved Code Case N-513-3. The leak is located approximately five inches downstream of the flange connecting this pipe section to control valve 2-CV-5206. This valve is located in the SW discharge of Component Cooling Water Heat Exchanger Number 21 and controls the flow through this heat exchanger. The leak is located outside the isolable boundary of a single train of SW. During normal operations SW supports normal heat removal from various plant components and in accident conditions supports emergency decay heat removal functions.

This flaw is in a section of SW piping that cannot be isolated during operation and requires special conditions to be isolated when the unit is off line. As it is impractical to complete a repair or replacement to the SW leak without an extended outage, Calvert Cliffs proposes to use an ASME Section XI, IW A-4130 Alternative Requirement, i.e., a mechanical clamping device described in ASME Section XI, Appendix IX until the next refueling outage, scheduled for February, 2015.

Appendix IX restricts such devices, under the SW piping conditions, to NPS 6 while the SW piping is NPS 12. All other applicable requirements of Appendix IX will be met.

Flaw Characterization

The flaw is located in a section of piping that is directly connected to the common system discharge and cannot be removed from service to gain safe access to the inside for detailed inspection so the root cause cannot be definitively ascertained. Based on ultrasonic testing inspection of the area and the fact that this is an isolated incident, there are two possible root causes for the localized corrosion that resulted in the through wall leak.

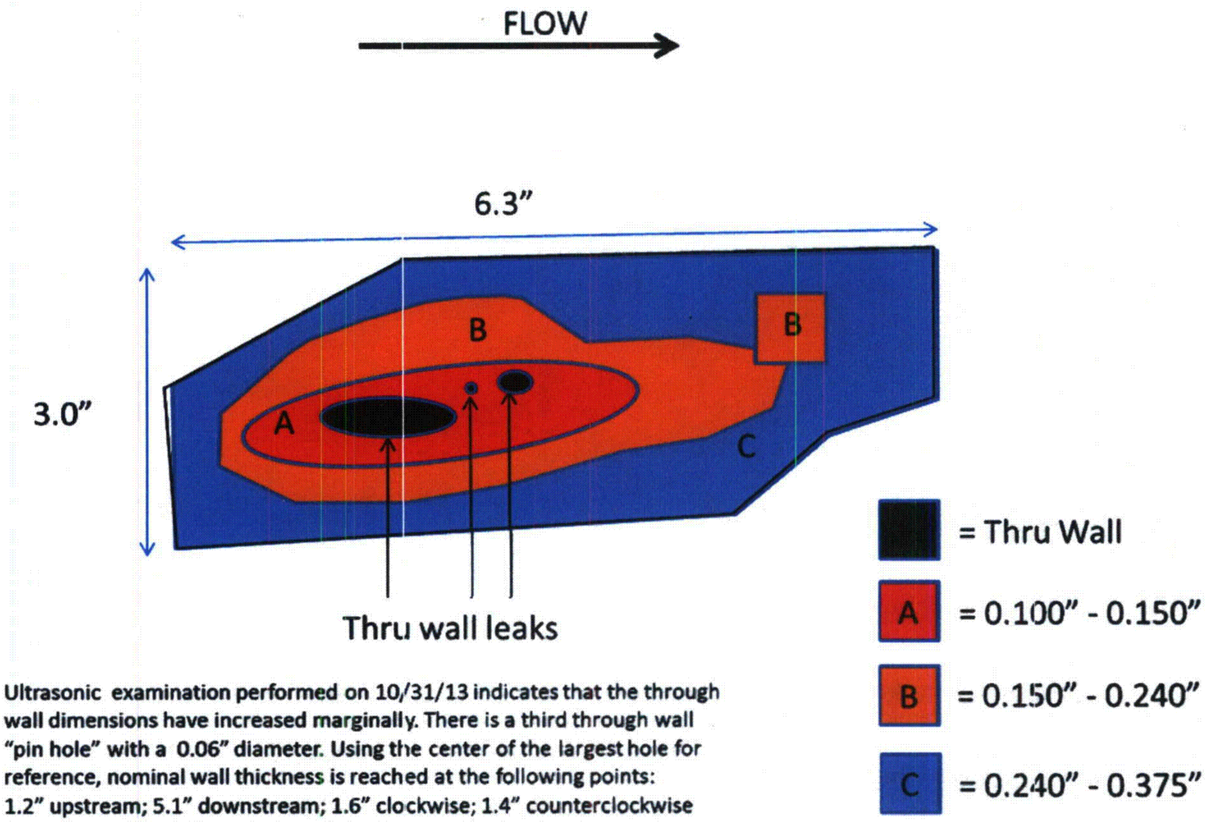
- A manufacturing defect has resulted in a local failure of the rubber lining, such as a seam split, that has allowed SW to come in contact with the carbon steel.
- A flow disturbance from the throttle valve has resulted in localized damage of the rubber liner allowing SW to come in contact with the carbon steel. This cause may also be accelerating the localized corrosion by eroding the passive corrosion layer.

Either of these mechanisms would likely result in the type of failure indicated by the inspections, which appears to be pitting corrosion, a localized form of corrosion where cavities or "holes" are produced in the material.

From nondestructive examination, it appears a portion of the rubber liner is missing at the corroded area indicative of a failure of the liner caused by flow erosion due to some disturbance in the normal flow field at this location. The area of local wall thinning is oval in shape, with the long axis oriented in the direction of flow and approximately twice the short axis. This shape tends to support a flow assisted mechanism, rather than growth of the corrosion by simple attack of the passive layer.

If the cause for this pitting attack is a flow disturbance, it would be expected that growth of the pit would be strongest in the region most affected by the erosive component of the attack. If a chemical attack of the passive layer is the cause for growth of the pit, then the shape should be non-directional and the pit would be rounded in shape. Since the wall thinning is elongated in shape and growing axially in the flow direction more than circumferentially, this supports the theory that the corrosion mechanism and rate is influenced by a local flow disturbance.

Based on this probable cause, it can be concluded that the pitting corrosion is the result of a local flow disturbance, most likely caused by the upstream flow throttling valve, eroding a local region of the rubber liner, exposing the carbon steel pipe to the corrosive brackish water environment. This corrosive site then led to a through wall condition by continuing corrosion coupled with destruction of the passive layer by the eroding flow disturbance.



Ultrasonic examination performed on 10/31/13 indicates that the through wall dimensions have increased marginally. There is a third through wall "pin hole" with a 0.06" diameter. Using the center of the largest hole for reference, nominal wall thickness is reached at the following points: 1.2" upstream; 5.1" downstream; 1.6" clockwise; 1.4" counterclockwise (considering flow.) The wear area has elongated in the downstream direction since the last examination on 10/17/13. Area "A" is now 3.5" long by approximately 1" wide.

<u>Growth Rate Estimation</u>

There are four nondestructive examination reports between early September 2013 and late October 2013. These reports corroborate the most likely cause as being flow disturbance related and indicate that the through wall portion of the flaw will continue to grow until it reaches the edge of the flow disturbed region. Growth rate is estimated by comparing data from the earliest (9/6/2013) and latest (10/31/2013) reports. The growth rate is then extrapolated to obtain estimates of the degraded area by February 2015. The axial growth estimate is described here. A similar approach was used for the circumferential estimate.

In the earliest (9/6/2013) report, return to nominal wall thickness was located 1.6 inches upstream and 4.6 inches downstream. In the latest (10/31/2013) report, return to nominal wall thickness was located 1.2 inches upstream and 5.1 inches downstream.

These reports indicate the axial wall thinning is continuing downstream away from the valve and not progressing upstream. The wall thinned region grew in the period between the two reports from 4.6 inches to 5.1 inches or, approximately 0.5 inches in eight weeks. The monthly growth rate for this data, assuming no arrest or slow down, suggests that the flaw would continue to grow at a rate of approximately 0.25 inch axially per month. This is the "High Growth Estimate". It is more likely that the growth will continue at this rate until it is out of the range of the flow disturbance. Then the growth would slow to a much lower rate that is typical for carbon steel in contact with brackish water. We are estimating the growth rate under this scenario at a conservatively high value of 0.15 inch axially per month. This is the "Low Growth Estimate".

A comparison of the two "Growth Estimates" are:

	High Growth Estimate		Low Growth Estimate	
Direction	**Axial**	**Circumferential**	**Axial**	**Circumferential**
Current Length	6.3 inches	3.0 inches	6.3 inches	3.0 inches
Rate	0.25 inches	0.5 inches	0.15 inches	0.375 inches
Growth Over 16 Months	4.0 inches	8.0 inches	1.2 inches	6.0 inches
Total Final Length	10.3 inches	11.0 inches	7.5 inches	9.0 inches

Note: The circumferential growth shown in the table is a conservative estimation of the circumferential growth due to the difficulty in measuring the smaller circumferential growth in the presence of the liner.

5. Proposed Request and Basis for Use

Our proposed request is to use an ASME Section XI, Appendix IX, mechanical clamping device until a permanent Repair Replacement can be performed. Design of the mechanical clamping device is shown in calculation ILD-CALC-0014 (Enclosure 1). Upon approval of this proposed 10 CFR 50.55a request, Calvert Cliffs Unit 2 will shift from application of Code Case N-513-3 to the IWA-4133 requirement. The mechanical clamping device will meet all applicable requirements of Appendix IX other than the restriction to NPS 6, including the following:

- All seal clamp components are made from austenitic stainless steel which is acceptable for service from a corrosion standpoint in SW service without any coating and is compatible with the system fluid. External areas of piping that will be in contact with brackish water after installation of the clamp are coated to prevent corrosion.
- The clamp design will encompass the projected growth of the flaw as described herein, with additional margin.
- No additional supports are required for the mechanical clamping device.
- Analysis has shown that the piping is capable of remaining intact with the projected growth of the defect. Additional analysis shows that even in the extremely unlikely event that the defect would grow through wall around the circumference, the existing piping and supports will remain intact and the pipeline ends will move approximately 0.125 inch and will remain within the encapsulation provided by the mechanical clamping device.
- The mechanical clamping device has been evaluated for all postulated loads, including seismic Operating Basis Earthquake and Design Basis Earthquake levels, and the stresses remain well below those found in ASME Section XI, Appendix IX, Table IX-3200-1.
- The mechanical clamping device is bolted to the piping. Stainless steel tubing acts as sealing O-rings for the mechanical clamping device to maintain a positive seal. No serrated edges are used in the design of the mechanical clamping device.
- The piping and supports have been evaluated and determined to acceptably remain below the applicable code allowables for all loading conditions.

- The mechanical clamping device is installed in regions of nominal wall thickness away from the local defect, including projected defect growth. Additional margin has been added to the mechanical clamping device size to ensure the defect growth is contained within the mechanical clamping device boundaries.
- The system is a low temperature system and thermal effects are negligible over the length of the mechanical clamping device.
- The current and projected defect size has been evaluated as part of the addition of the mechanical clamping device.
- Provisions have been made in the mechanical clamping device design and location to ensure that both edges of the mechanical clamping device are accessible for ultrasonic testing wall thickness measurement at least every ninety days. Provisions are in place in the event that the defect monitoring reveals that the defect has grown outside of the mechanical clamping device dimensions.
- A leakage monitoring task has been added to facilitate weekly leakage monitoring at the boundary of the mechanical clamping device.

6. Duration of Proposed Request

The mechanical clamping device will remain in place until the next refueling outage scheduled for February 2015 or until Unit 2 enters a shutdown of sufficient duration prior to the refueling outage. At that time, the mechanical clamping device will be replaced by a permanent code repair or replacement.

ENCLOSURE 1

Calculation ILD-CALC-0014, Evaluation of 12-LJ-1-2001 Line Enclosure

Calvert Cliffs Nuclear Power Plant, LLC
November 14, 2013

ILD Calculation Cover Sheet

Date: 11/11/2013 Calculation No: ILD-CALC-0014

Revision No: 1

Calculation Title: Evaluation of 12-LJ-1-2011 Line Enclosure

Project Number: 1002-0040

Revision History:

Rev 0: Initial Issue

Rev 1: Revised wording to show an allowable torque range and updated Team Clamp Design to ~~Rev. 5~~ ECO REV. A

1 RLS 11/11/13

Calculation Type: ☑ Safety Related ☐ Non-Safety Related

Design Verification Required?: ☐ No ☑ Yes (See ILD-EP-0015)

IDV was performed in combination with IDV of CCNPP ECP-13-00947. See ECP-13-00947 for record of IDV.

Name/Signature Required below.

Charlie Musso 11/11/13

Steve Evans 11/11/13

Greg Kramer 11/11/13

Preparer: Michael Tompkins Date: 11/11/13

Reviewer: Michael Morgan Date: 11/11/13

Design Verifier: Robert Stakenborghs Date: 11/11/13

Total Number of Pages 40

ILD-CALC-0014 Rev. 1
November 11, 2013

Evaluation of 12-LJ-1-2011 Line Enclosure

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List of Attachments

Attachment A: Team Industrial Services Document No. 283380EM ECO A .... 16 pages

Revision History

Rev. 0 – Initial Issue.

Rev. 1 – Revised wording to show an allowable torque range and updated Team Clamp Design drawing to Rev A .

1.0 Purpose and Scope

During the early-September 2013 forced Unit 2 shutdown a pin-hole leak was identified on the Calvert Cliffs Unit 2 Salt Water (SW) pipe line 12"-LJ1-2011. The SW pipe with the hole is connected to the discharge of Component Cooling Water (CCW) heat exchanger No. 21. In order to mitigate the adverse effects of the hole in the piping, a clamp is being installed to seal the pipe (Ref. 8.5).

This calculation will qualify the vendor clamp design in accordance with the requirements of ASME Section XI Appendix IX. The CCW piping stress is evaluated in ILD-CALC-0013 (Ref. 8.12). The purpose of this analysis includes:

- Induced stress on the clamp due to normal, upset, and faulted loads (i.e. external pressure force induced on the piping due to the installation of the clamp bolting pressure);
- Ability of the pipe to maintain its structural design function without failure with the inclusion of the measured flaw; and
- Analysis of the clamp joints and hardware for normal, upset, and faulted loads to ensure structural integrity for the operating life of this device.

This calculation is safety related.

2.0 Design Input

Table 2.1: Design Input

#	Dimension	Value	Reference
2.1	Pipe outside diameter	12.75 in	Ref. 8.10 Page 82, Ref. 8.4, and Ref. 8.11 page B17
2.2	Pipe nominal wall thickness	0.375 in	Ref. 8.11
2.3	Pipe operating pressure	35 psig	Ref. 8.9 page 52
2.4	Pipe design pressure	50 psig	Ref. 8.9 page 52
2.5	Pipe material	Welded ASTM A-53 gr. B	Ref.8.10 page 82 & Ref. 8.3 pg 13
2.6	Pipe allowable stress, Sh	12,700 psi	Ref 8.3 page 13
2.7	Clamp inside diameter	14 in	Ref. 8.5
2.8	Clamp min. wall thickness	0.375 in	Ref. 8.5**
2.9	Clamp min. effective outside diameter	14.75 in	Ref. 8.5**
2.10	Length of clamp	16 in	Ref. 8.5
2.11	WTOP Pipe Forces (node 290)*: $F_{x\,WTOP}$, $F_{y\,WTOP}$, $F_{z\,WTOP}$	467 lbf, 1101 lbf, 7 lbf	Ref. 8.12 Attachment E page 362

<table>
<tr><th>#</th><th>Dimension</th><th>Value</th><th>Reference</th></tr>
<tr><td>2.12</td><td>WTOP Pipe Moments (node 290)*: $M_{x\,WTOP}$, $M_{y\,WTOP}$, $M_{z\,WTOP}$</td><td>564 ft-lbf, 16 ft-lbf, 2465 ft-lbf</td><td>Ref. 8.12 Attachment E page 362</td></tr>
<tr><td>2.13</td><td>SEISOB Pipe Forces (node 290)*: $F_{x\,SEISOB}$, $F_{y\,SEISOB}$, $F_{z\,SEISOB}$</td><td>842 lbf, 254 lbf, 143 lbf</td><td>Ref. 8.12 Attachment E page881</td></tr>
<tr><td>2.14</td><td>SEISOB Pipe Moments (node 290)*: $M_{x\,SEISOB}$, $M_{y\,SEISOB}$, $M_{z\,SEISOB}$</td><td>256 ft-lbf, 835 ft-lbf, 459 ft-lbf</td><td>Ref. 8.12 Attachment E page 881</td></tr>
<tr><td>2.13</td><td>SEISDB Pipe Forces (node 290)*: $F_{x\,SEISDB}$, $F_{y\,SEISDB}$, $F_{z\,SEISDB}$</td><td>1462 lbf, 459 lbf, 248 lbf</td><td>Ref. 8.12 Attachment E page 914</td></tr>
<tr><td>2.14</td><td>SEISDB Pipe Moments (node 290)*: $M_{x\,SEISDB}$, $M_{y\,SEISDB}$, $M_{z\,SEISDB}$</td><td>447 ft-lbf, 1448 ft-lbf, 835 ft-lbf</td><td>Ref. 8.12 Attachment E page 914</td></tr>
<tr><td>2.15</td><td>Clamp material</td><td>SA 182 GR F 316</td><td>Ref. 8.5</td></tr>
<tr><td>2.16</td><td>Clamp material allowable stress (S)</td><td>20,000 psi</td><td>Ref. 8.5</td></tr>
<tr><td>2.17</td><td>Stud material</td><td>SA 193 Gr B8M Class 1</td><td>Ref. 8.5</td></tr>
<tr><td>2.18</td><td>Stud major diameter</td><td>0.625 inches</td><td>Ref. 8.5 Sheet 1</td></tr>
<tr><td>2.19</td><td>Tube seal material</td><td>Stainless Steel</td><td>Ref. 8.5</td></tr>
<tr><td>2.20</td><td>Tube seal outside diameter</td><td>0.1875 inches</td><td>Ref. 8.5</td></tr>
<tr><td>2.21</td><td>Number of clamp studs</td><td>16</td><td>Ref. 8.5</td></tr>
<tr><td>2.22</td><td>Side bar width</td><td>1.0 inches</td><td>Ref. 8.5</td></tr>
<tr><td>2.23</td><td>Seal tube channel width</td><td>0.1875 inches</td><td>Ref. 8.5</td></tr>
<tr><td>2.24</td><td>Injected sealant channel width including wall</td><td>0.625 inches</td><td>Ref. 8.5</td></tr>
<tr><td>2.25</td><td>Number of tube seals</td><td>4</td><td>Ref. 8.5</td></tr>
<tr><td>2.26</td><td>Number of injected seals</td><td>2</td><td>Ref. 8.5</td></tr>
<tr><td>2.27</td><td>Distance from tube seals to sidebar edges</td><td>0.09375 inches</td><td>Ref. 8.5</td></tr>
<tr><td>2.28</td><td>Nut factor (K)</td><td>0.2</td><td>Ref. 8.13 page 3-9</td></tr>
<tr><td>2.29</td><td>Maximum estimated corrosion length</td><td>11 in</td><td>Ref. 8.15</td></tr>
<tr><td>2.30</td><td>B31.1 Minimum Wall Thickness Coefficient, y</td><td>0.4</td><td>Ref. 8.14</td></tr>
<tr><td>2.31</td><td>Radial Distances from Clamp Centroid to Stud Centerline</td><td><table><tr><th></th><th>x</th><th>y</th><th>Total</th></tr><tr><td>D1</td><td>1.031</td><td>7.75</td><td>7.818</td></tr><tr><td>D2</td><td>3.094</td><td>7.75</td><td>8.344</td></tr><tr><td>D3</td><td>5.156</td><td>7.75</td><td>9.308</td></tr><tr><td>D4</td><td>7.219</td><td>7.75</td><td>10.591</td></tr></table></td><td>Ref.8.5</td></tr>
<tr><td>2.32</td><td>Modulus of Elasticity of stud and clamp</td><td>27.7×10^6 psi</td><td>Ref. 8.5</td></tr>
<tr><td>2.33</td><td>Stud Tensile Area</td><td>0.226 in^2</td><td>Ref. 8.16 pg 413 & Ref. 8.5</td></tr>
</table>

#	Dimension	Value	Reference
2.34	Allowable Stress of Studs	18,800 psi	Ref. 8.5
2.35	Yield Strength of Studs	30,000 psi	Ref. 8.14
2.36	Manufacturing tolerance of pipe wall thickness	+-12.5% of nominal	Ref. 8.17
2.37	Fastener Length (between nuts), l_t	6.125 in	Ref. 8.5
2.38	Stud Hole Diameter, D_{bh}	0.75 in	Ref. 8.5
2.39	Bolting Flange Width	2.8125 in	Ref. 8.5
2.40	Washer Thickness	0.5 in	Ref. 8.5
2.41	Washer Outside Diameter	1.0625 in	Ref. 8.5
2.42	Nut Head Width	0.9375 in	Ref. 8.16 pg. 1055

* Forces and moments are in local coordinates and are the maximum absolute for Node 290. The global coordinates shown in Figure 4.1 correspond to the local coordinates of node 290 in Ref. 8.12 as follows: X-direction = A-direction, Y-direction = B-direction, and Z-direction = C-direction.

**The clamp wall thickness is conservatively chosen as the minimum wall thickness between the clamp ID and the bolt holes. Also, adding the wall thickness to the ID in DI 2.7 results in the minimum effective OD in DI 2.9.

3.0 Assumptions

3.1 For purposes of evaluating the clamp stresses, the clamp is assumed to be a circular pipe section with the dimensions listed in design input 2.7-2.10. It is determined from clamp drawings in Ref. 8.5 that no large stress concentrations are present in the clamp design that would make the treatment of the clamp as a circular pipe segment assumption non-conservative. In addition, the small drain hole will be plugged and the size of the hole relative to the clamp wall thickness makes any stress intensification negligible. The wall thickness chosen is based on the minimum wall section of the void portion of the clamp (the minimum wall thickness in design input 2.8 exists between the bolt hole and inner void cavity). This is conservative because the actual clamp design contains much more reinforcing material than is assumed.

3.2 The clamp isn't designed to resist axial loads by friction. It is only considered to resist axial loads for the purposes of conservatism with regard to clamp stress. All loads used for this analysis are assumed in a positive direction and summed in such a manner as to conservatively calculate the largest stress (Ref. 8.1).

3.3 The y and z moments are conservatively summed directly (rather than computing the resultant) in the clamp stress analysis for the purposes of evaluating the peak stress and reaction moments. See section 4.1 for additional details.

3.4 The y and z forces are conservatively summed directly (rather than computing the resultant)in the clamp stress analysis for the purposes of evaluating the peak stresses and reaction moments. See section 4.1 for additional details.

3.5 The four 3/16" diameter stainless steel tubing seal channels as well as the geometry of the sealant injected between the tubing seals (resulting in 13/16" sealing width per side bar) are credited as the total sealing area of the clamp. Using the sum of the three sealing areas rather than the overall width of each side bar adds conservatism with regards to the total area over which clamping pressure can be applied to the pipe. See section 4.2 for additional details.

3.6 The clamp is assumed to act as a rigid body for the purposes of evaluating the induced clamping pressure on the pipe. This assumption adds conservatism because the maximum allowable deflection of the clamp (0.05 inches per Reference 8.5) is negligible when compared to the overall dimensions of the clamp. See sections 4.2 and 4.5 for additional details.

3.7 The forces and moments computed for the node closest to the clamp (in Ref. 8.12 attachment E) are assumed to be applied at the free end of the clamp (i.e. at the origin in Figure 4.1). This is conservative because it will develop the maximum stresses in the component.

3.8 Typically the geometrical distribution of stress in a joined member is a frustum of a hollow cone about the stud hole (Ref. 8.16 pg. 428 and 8.13 Section 6.2.5). Due to the complex geometry near the stud holes, the frustum area is conservatively assumed to be the section defined as a hollow cylinder with the 1.5 times the stud hole diameter forming the outer diameter and the stud hole forming the inner diameter. This is conservative because the actual pressure distribution area is larger. A larger pressure distribution area results in a larger member stiffness and therefore a lower maximum stud stress based on Equation 38 of this analysis.

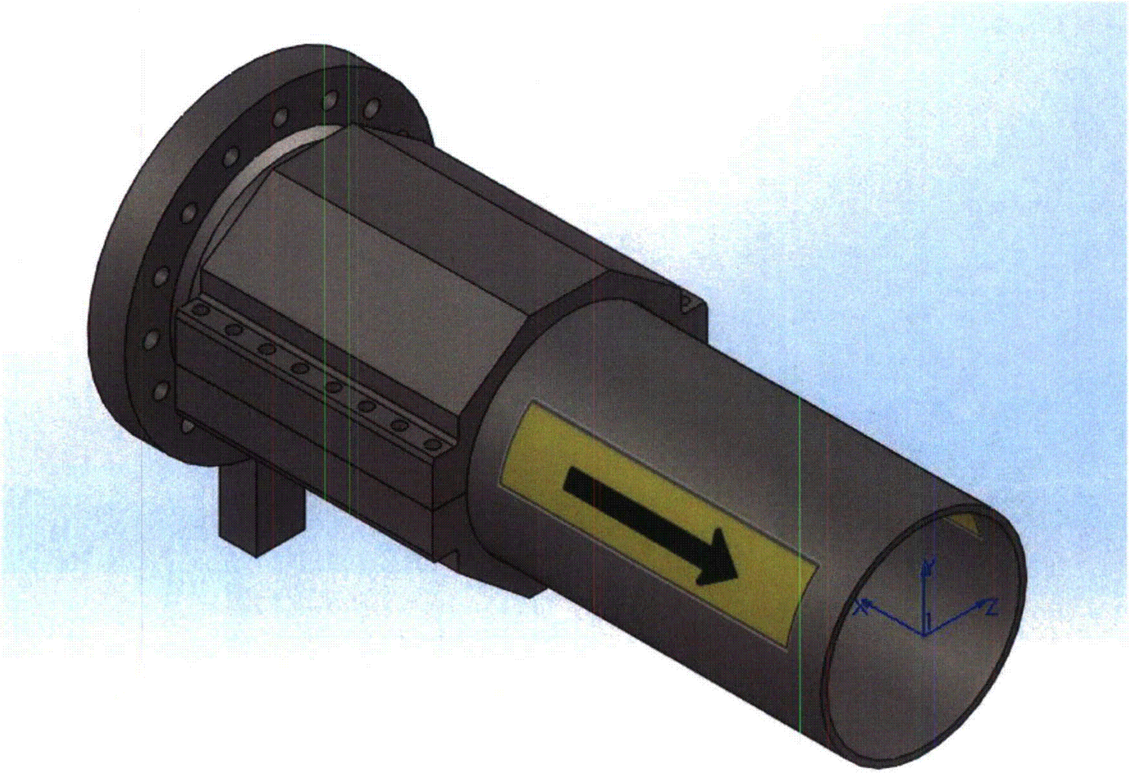
3.9 The clamp material, SA 182 Gr F 316, and stud material, SA 193 Gr B8M, are of similar stainless steel class and have a negligible difference in coefficients of thermal expansion. Therefore, there will be no excessive stresses between the stud and clamp due to thermal expansion.

3.10 The installed clamp will contact the pipe at areas not affected by the localized corrosion and erosion. Thus, the minimum pipe thickness for the purposes of evaluating clamp-induced pressures is the minimum wall thickness due to manufacturing tolerances (see design input 2.36).

4.0 Methodology and Acceptance Criteria

For the purposes of this calculation, the standard coordinate system applied to the analysis herein is as depicted in Figure 4.1 below. This figure also depicts the direction of flow as dictated in Reference 8.4.

Figure 4.1: Universal Coordinate System and Flow Direction of Pipe with Clamp Installed



4.1 Clamp Stress Methodology

The clamp was treated as a hollow, circular beam that was fixed at one end with loads applied to the other to calculate reaction moments. No credit was taken for the pipe structure beneath the clamp, and the clamp is therefore analyzed as absorbing all piping loads.

The moment of inertia, I, was calculated from Ref. 8.1 pg. 974 and substituting design input 2.7 and 2.9. as follows:

$$I = \frac{\pi}{4}\left(r_o^4 - r_i^4\right) \qquad \text{Equation 1}$$

Where r_o is the clamp outer radius and r_i is the clamp inner radius.

Substituting:

$$I = \frac{\pi}{4}\left(\left(\frac{14.75\ \text{in}}{2}\right)^4 - \left(\frac{14\ \text{in}}{2}\right)^4\right) = 437.7\ \text{in}^4$$

The cross sectional area of the clamp is:

$$A = \pi r_o^2 - \pi r_i^2 \qquad \text{Equation 2}$$

$$A = \pi\left(\left(\frac{14.75}{2}\right)^2 - \left(\frac{14}{2}\right)^2\right) = 16.9\ in^2$$

The stiffness factor, k, is calculated as defined in Ref. 8.1 page 256 for axial-compressive loads on beams (see Assum. 3.2):

$$\mathrm{k} = \left(\frac{\mathrm{F_x}}{\mathrm{EI}}\right)^{\frac{1}{2}} \qquad \text{Equation 3}$$

Where F_x is the applied load in the global x-direction (axial force) for a given case (WTOP, SEISOB or SEISDB), E is the modulus of elasticity of the clamp, and I is the moment of inertia of the clamp.

The maximum moment is calculated based on Ref. 8.1 pg. 262 (Case 3a) summed with the value for a cantilevered beam with a point load (Ref. 8.1 pg. 208 Case 1a) with:

$$\mathrm{M_b} = \frac{\mathrm{M_o}}{\cos(\mathrm{kl})} + \mathrm{F_r l} \qquad \text{Equation 4}$$

Where M_b is the resultant moment at the fixed end, M_o is the applied moment (in this case the it is conservatively considered the sum of the applied moment in the global y-direction, M_y, and the applied moment in the global z-direction, M_z, for the respective load cases considered), l is the length of the clamp, and F_r is conservatively considered the sum of the radial forces (the applied load in the global y-direction, F_y, and the applied load in the global z-direction, F_z, for the respective load cases considered).

The bending stress (σ_b) is calculated for each case from (Ref. 8.1 page 158):

$$\sigma_\mathrm{b} = \frac{\mathrm{M_b r_o}}{\mathrm{I}} \qquad \text{Equation 5}$$

And normal stress (σ_n) is calculated for each respective case by (Ref. 8.1 page 141):

$$\sigma_\mathrm{n} = \frac{\mathrm{F_x}}{\mathrm{A}} \qquad \text{Equation 6}$$

The shear stress due to torsion (τ_t) is calculated by the following (Ref. 8.1 pg. 420). The shear stress due to torsion is calculated for each case:

$$\tau_\mathrm{t} = \frac{2\mathrm{M_x r_o}}{\pi(\mathrm{r_o^4 - r_i^4})} \qquad \text{Equation 7}$$

Where M_x is the applied moment about the global x-axis. The average transverse shear stress (τ_r) due to the reaction at the fixed end (F_r) is given by (Ref. 8.1 pg 158) for each case:

$$\tau_\mathrm{r} = \frac{\mathrm{F_r}}{\mathrm{A}} \qquad \text{Equation 8}$$

The hoop stress (σ_h) due to internal pressure is computed from (Ref. 8.1 pg. 608 1b):

$$\sigma_h = \frac{pr_i}{t} \qquad \text{Equation 9}$$

Where t is the minimum clamp thickness and p is the internal pressure.

Conservatively, the longitudinal stress (σ_l) due to internal pressure is given by (Ref. 8.1 pg 609 1c):

$$\sigma_l = \frac{pr_i}{2t} \qquad \text{Equation 10}$$

The total membrane stress is computed conservatively as the summation of all of the average stresses acting across the clamp. For each of the 3 cases evaluated the membrane stresses are:

$$\sigma_{m\ normal} = \tau_{r\ WTOP} + \tau_{t\ WTOP} + \sigma_{n\ WTOP} + \sigma_h + \sigma_l \qquad \text{Equation 11}$$

$$\sigma_{m\ upset} = \tau_{r\ SEISOB} + \tau_{t\ SEISOB} + \sigma_{n\ SEISOB} + \sigma_{m\ normal} \qquad \text{Equation 12}$$

$$\sigma_{m\ faulted} = \tau_{r\ SEISDB} + \tau_{t\ SEISDB} + \sigma_{n\ SEISDB} + \sigma_{m\ normal} \qquad \text{Equation 13}$$

Similarly the bending stresses are combined as follows:

$$\sigma_{b\ normal} = \sigma_{b\ WTOP} \qquad \text{Equation 14}$$

$$\sigma_{b\ upset} = \sigma_{b\ SEISOB} + \sigma_{b\ WTOP} \qquad \text{Equation 15}$$

$$\sigma_{b\ faulted} = \sigma_{b\ SEISDB} + \sigma_{b\ WTOP} \qquad \text{Equation 16}$$

4.2 Pipe External Pressure due to Bolting Methodology

The clamp was treated as a rigid body, assuming no gap between the mating flanges of each clamp half, such that the pressure induced on the pipe is due to the torque applied to each of the 16 studs (design input 2.21).

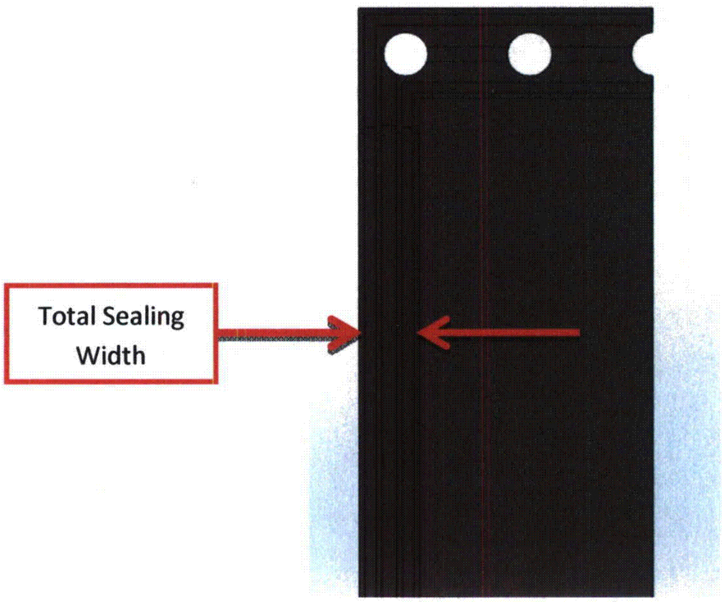
The maximum allowable clamping pressure P_{max} (psi) was determined using Equation 17 based on Ref. 8.14 for design of straight piping components.

$$P_{max} = \frac{2SE(t_m - A)}{D_o - 2y(t_m - A)} \qquad \text{Equation 17}$$

Where SE is the allowable stress in the pipe (psi), t_m (in) is the minimum pipe wall thickness due to manufacturing tolerances (Assumption 3.10)), A is the corrosion allowance (0 inches in this case), D_o is the outside diameter of the pipe, and y is a temperature and material-dependent correction factor (design input 2.30). The allowable stress considered in Equation 17 does not account for seismic loading scenarios of the pipe, due to the fact that this induced pressure is highly localized rather than a global external pressure.

The effective sealing width of each 1 inch sidebar (design input 2.22) is computed by the summation of the width of two of the stainless steel tubing seals (design input 2.20), the width of the injected sealant cavity (design input 2.24) and the void area between the walls of the sealant cavity and the inside width between the two tubes, as shown in Figure 4.2.1 below.

Figure 4.2.1: Seal Channel Geometry



To determine the overall clamp sealing width, the sum of the sealing width of each of the two sidebars (ref. 8.5) was computed. This width was then used to compute the overall sealing area of the clamp on the pipe using Equation 18 below:

$$A_{seal} = \pi D_o L_{seal} \quad \text{Equation 18}$$

Where D_o is the outer diameter of the pipe (in), and L_{seal} is the overall clamp sealing width (in).

The total stud clamping force, F_{stud} (lb_f), may be computed using the following relation of known parameters:

$$F_{stud} = A_{seal} P_{clamp} \quad \text{Equation 19}$$

Note that this force is determined from the maximum allowable pressure force (P_{max} above) that can be exerted on the pipe. This pressure is modified to a lower value (P_{clamp}) to reflect a 3% margin for conservatism in practice.

The above value of F_{stud} is then used to determine the maximum allowable preload force that can be exerted on the clamp by each stud, F_i, by the equation below:

$$F_i = \frac{F_{stud}}{N}$$ Equation 20

Where N is the number of studs installed on the clamp housing.

The required stud nut torque T (in-lb) to achieve the maximum allowable preload, F_i, as determined above is then computed using the following equation from Reference 8.13page 3-3:

$$T = K d_{stud} F_i$$ Equation 21

Where K is the nut factor (design input 2.28), and d_{stud} is nominal stud diameter (in).

4.3 Structural Evaluation of Pipe Wall with Flaw

The structural adequacy of the pipe containing the through-wall leak was evaluated at an eroded condition using the ASME B31.1 methodology for evaluating the need for reinforcement of branch connections due to internal pressure for a given branch hole size. The need for reinforcement material is determined to ensure that the pipe has sufficient structural strength after the branch is added. If the pipe wall is thick enough to ensure structural adequacy for the size branch hole, then no further reinforcement is required. In this case, the material (pipe wall) remaining around the eroded area must be thick enough to provide the required reinforcement for a hole which encompasses the largest expected eroded hole size, based on flaw growth.

The most severe estimate for erosion is used to evaluate an encompassing branch hole size. From 2.29, the largest eroded length is 11". Therefore, an 11" diameter branch hole size will be used to estimate the required reinforcement area from the surrounding pipe.

The minimum required thickness of 12"-LJ1-2011 salt water pipe (at un-eroded condition) is first determined by Eq. 22 below.

$$t_{mh} = \frac{P * D_{oh}}{2*(SE+P*y)}$$ Equation 22

Where t_{mh} is the minimum wall thickness required to withstand the internal pressure (in), P is the design pressure of the 12"-LJ1-2011 salt water pipe (psi), D_{oh} is the outer diameter (in), SE is the maximum allowable stress in the material due to internal pressure (psi), and y is a temperature and material dependent coefficient.

The area required to reinforce a branch hole, A_7, can be calculated by Equation 23.

$$A_7 = t_m * d_1$$ Equation 23

Where d_1 is the inside centerline longitudinal dimension of the finished branch opening in the run of pipe (in).

The inside centerline longitudinal dimension, d_1, used in Eq. 23 is calculated with Eq. 24.

$$d_1 = D_{ob} - 2 * T_b \qquad \text{Equation 24}$$

Where D_{ob} is the outer diameter of the branch connection (the 11" diameter eroded section), and T_b is the branch connection thickness which is zero since the postulated branch is being evaluated as a hole.

The area provided by excess pipe material, A_1, is calculated from Equation 25.

$$A_1 = (2 * d_2 - d_1) * (T_h - t_m) \qquad \text{Equation 25}$$

Where T_h is the actual thickness of the pipe (which conservatively accounts for a 12.5% manufacturing tolerances) and d_2 is the half width of the reinforcing zone and is calculated from Equation 26.

$$d_2 = \min\left(\max\left(d_1\,,\ T_b + T_h + \frac{d_1}{2}\right), D_{oh}\right) \qquad \text{Equation 26}$$

4.4 Fastener Analysis

4.4.1 <u>Joint Stiffness</u>

The fastened section of the clamp required inspection to determine the force distribution between the stud and the member. The stiffness constant factor provides the relationship between the force applied to the joint and the force applied to the stud. This relationship is given in Equation 27 (Ref. 8.16 pg 436)

$$C = \frac{k_f}{k_f + k_m} \qquad \text{Equation 27}$$

Where C is the stiffness constant of the joint, k_f is the fastener stiffness and k_m is the stiffness of the member.

The fastener, in this case the stud, stiffness is calculated using Equation 28 (Ref. 8.16 pg. 427).

$$k_f = \frac{A_t E}{l_t} \qquad \text{Equation 28}$$

Where A_t is the tensile area, E is the modulus of elasticity of the material, and l_t is the threaded length of the stud between the nuts, which includes any thickness added by washers (Design Input 2.37).

Under normal circumstances the member stiffness is determined using a conical frustum centered about the stud hole that encompass the area that absorbs the stud load. However, due to the shape of the clamp, the use of a conical frustum would encompass areas beyond the clamp's dimensions. Therefore, the area of pressure distribution is reduced to a hollow cylindrical area surrounding the stud hole (see Assum. 3.8). Since only one washer is used per stud, each member stiffness will be calculated differently due to their differing pressure distribution areas and lengths.

The pressure-distribution area (A_p) is defined as the area encompassed by either the washer outside diameter or the nut head width (D_{bo}) minus the stud hole diameter (D_{bh}) (Ref. 8.16 pg. 431):

$$A_p = \frac{\pi D_{bo}^2}{4} - \frac{\pi D_{bh}^2}{4} \qquad \text{Equation 29}$$

The member stiffness (k_m) is given by Equation 28, except A is substituted with the pressure-retaining area (Equation 29), and l is the length of one member, either the length of the bolting flange and the washer thickness or just the length of the bolting flange.

The member stiffnesses are summed by the following equation (Ref. 8.16 pg. 427).

$$\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} \qquad \text{Equation 30}$$

Where k_1 is calculated using the washer outside diameter and includes the washer thickness, and k_2 is calculated using the nut head width and only the bolting flange length. The washer may be simply added to the thickness of a member due to the fact that their pressure distribution areas and moduli of elasticity are identical.

With the combined member stiffness and the fastener stiffness calculated, the stiffness constant of the joint may be calculated using Equation 27.

The loads applied to the joint may now be calculated and broken into forces applied to the stud.

4.4.2 Stud Loading

In order to conservatively calculate the applied stud load, the clamp was treated as a rigid member (Assumption 3.6). Tensile and shear stresses were accounted for when determining the applied stud load in the normal, upset, and faulted cases. The forces and moments are assumed to be acting about a coordinate system located at the centroid of the clamp, but identical in global orientation to that shown in Figure 4.1.

Four tensile forces acted on the clamp stud. The first of which was a moment about the axial direction, M_a. Since the axial moment acts equidistant to all studs, it was divided by the distance from the x-axis to the stud centerline and the total number of joints in order to obtain a tensile force per joint. This is illustrated in Equation 31.

$$F = \frac{M_a}{z \cdot N} \qquad \text{Equation 31}$$

Where M_a is the axial moment, z is the z-distance from the moment axis to the stud centerline, and N is the total number of joints

The pressure acting on the inner surface area of the clamp also contributes to the tension in the studs. This force acts equally on all studs as well, and was therefore calculated using Equation 32.

$$F = \frac{P \cdot 2 \cdot \pi \cdot r \cdot l}{N} \qquad \text{Equation 32}$$

Where r is the inner radius of the clamp, l is the length of the clamp void that sees the piping pressure, and P is the internal design pressure.

The third tensile force acting on the studs is induced by the moment about the z-axis (assumed to be translated to the center of the clamp in Figure 4.1). This moment does not act equally on all studs but does act equally on the four sets of studs located at four distinct distances from the moment axis. Equations 33, 34, 35, and 36 (Ref. 8.16 pg. 456) relate the moment to the four distances and four forces at their respective distances.

$$M = 4F_1x_1 + 4F_2x_2 + 4F_3x_3 + 4F_4x_4 \qquad \text{Equation 33}$$

$$\frac{F_1}{F_2} = \frac{x_1}{x_2} \qquad \text{Equation 34}$$

$$\frac{F_2}{F_3} = \frac{x_2}{x_3} \qquad \text{Equation 35}$$

$$\frac{F_3}{F_4} = \frac{x_3}{x_4} \qquad \text{Equation 36}$$

Where M is the moment, x_1, x_2, x_3, and x_4 are the various distances to the stud centerlines from the moment axis, and F_1, F_2, F_3, and F_4 are the associated forces acting on the stud centerlines. Each force is multiplied by 4 to account for the four studs at the same distance from the moment axis. Distances are arranged such that distance x_1 is the shortest distance from the moment axis to stud centerline and distance x_4 is the greatest distance (see design input 2.31). Equations 33, 34, 35, and 36 can be combined to solve for F_4 as shown in Equation 37.

$$F_4 = \frac{Mx_4}{4(x_1^2+x_2^2+x_3^2+x_4^2)} \qquad \text{Equation 37}$$

Solving for F_4 returns the largest force induced by M on a joint and, for conservatism, was used in calculating the applied load for all 16 joints.

The final force adding tension to the studs was induced by F_y, which imposes equal but opposite forces in the y-direction on the two ends of the clamp. This creates a moment about the z-axis equal to the product of F_y and the total length of the clamp, L (Equation 38). With this moment applied about the centroid, the forces may be determined using Equation 37 and appropriate distances from the moment axis to the stud centerline.

$$M = F_y \cdot L \qquad \text{Equation 38}$$

The magnitude of the four tensile forces were then summed into a single force which is the total force applied per joint. The applied force per joint is then multiplied by the stiffness constant factor to determine the force applied to the stud. This is shown in Equation 39

$$P_b = CP \qquad \text{Equation 39}$$

Where P_b is the portion of the external tensile load taken by the stud and P is the external tensile load applied to the joint. The preload is then added to the force applied to the stud to determine the normal load case force on the stud. The tensile stress per stud is then calculated by dividing the normal load case force by the stud tensile area, which is .226 in^2 (Design Input 2.33).

Shear forces were also considered when determining the applied stud load. Two shear forces were inspected while determining the stud stress.

The first shear force was caused by a force in the z-direction, F_z, acting on opposite ends of the clamp with equal and opposite forces, creating a moment on the clamp equal to F_z multiplied by the total length of the clamp. The induced moment acts about the y-axis at the centroid and therefore does not act equally on all studs but does act on the four distinct stud distances from the centroid of the clamp. Equation 37 is again used to determine the resulting force at distance 4. Due to the orientation of the moment axis and the stud centerline, radial distances were used to calculate the force on each stud. This required the square root of the sum of the squares of the x and y distances (SRSS) to determine the appropriate distance from stud centerline to moment axis.

The moment about the y-axis, M_y, also contributed to the shear force in the studs. The force per stud created by this moment is not equal from stud to stud. For this reason, Equation 37 is used, again with radial distances, to determine the greatest resulting force per stud.

These two shear forces were then added to determine the total shear force per stud. The shear force per stud was then divided by the bolt area (Design Input 2.33) to determine the shear stress caused by the two shear forces. The sum of the tensile and shear stresses was then taken to calculate the total stud stress. Stresses for normal, upset, and faulted cases may then be evaluated, using Equations 40, 41, and 42 (Ref. 8.14), and compared to the stud's allowable stress (Design Input 2.34).

$$Normal = S_{WTOP}$$ Equation 40

$$Upset = S_{WTOP} + S_{SESIOB}$$ Equation 41

$$Faulted = S_{WTOP} + S_{SEISDB}$$ Equation 42

Where S is the calculated stress for the respective load case. In addition to ensuring the allowable stresses are not exceeded, the nut must also lock into place on the stud. In order for this to occur, the stress induced by the preload must exceed 20% of the stud's yield strength (Ref. 8.13).

4.5 Acceptance Criteria

4.5.1 Clamp Stress

The results of the clamp stress analysis are considered acceptable if it is shown that the clamp stress is less than the allowable stress in accordance with Ref. 8.2. The clamp stress allowables are as follows:

Table 4-1 – ASME Table IX-3200-1 Stress Limits For Design and Service Loadings (Ref. 8.2)

Service Limits	**Stress Limits** (1)
Design and Level A (Normal)	$\sigma_m < 1.0\,S$ $\sigma_m + \sigma_b < 1.5\,S$
Level B (Upset)	$\sigma_m < 1.1\,S$ $\sigma_m + \sigma_b < 1.65\,S$
Level D (Faulted)	$\sigma_m < 2.0\,S$ $\sigma_m + \sigma_b < 2.4\,S$

Notes:
(1) The symbols used in Table 4-1 are defined as follows:
σ_m = membrane stress
σ_b = bending stress
S = allowable stress= 20,000 psi for the clamp material (design input 2.16)

4.5.2 Pipe External Pressure due to Bolting

The pressure induced on the piping by the clamp is considered acceptable if the pressure does not exceed the maximum allowable pressure as calculated using methodology presented in Reference 8.14, i.e. $P_{clamp} < P_{max}$.

4.5.3 Structural Evaluation of Pipe Wall with Flaw

The eroded defect hole size (evaluated as a branch opening) is considered acceptable if the area provided by excess 12"-LJ1-2011 pipe material is greater the required reinforcing area i.e. $A_1 > A_7$.

4.5.4 Fastener Analysis

The stud stress is considered acceptable if the stud stress in the faulted case is less than the stud's allowable stress for normal conditions, which is 18,800 psi (Design Input 2.34).

The stud preload is considered acceptable if the preload exceeds the force applied to the stud.

$$Stud\ Preload > Stud\ Applied\ Load$$

The nut locking is considered to be acceptable as long as the preload induced stress exceeds 20% of the stud's yield strength (Ref. 8.13), or 30,000 psi (Design Input 2.35).

5.0 Documentation of Computer Code

Not applicable.

6.0 Calculations and Results

6.1 Clamp Stress

The results of Substituting the relevant design input into Equations 1 through 10 is shown in Table 6-1.

Table 6-1 Summary of Stress Results

	WTOP	SEISOB	SEISDB
Bending moment (M_b) in*lbf Equation 4	47,500	21,880	38,708
Bending stress (σ_b) psi Equation 5	800	369	652
Normal stress (σ_n) psi Equation 6	28	50	86
Shear stress due to torsion (τ_t) psi Equation 7	57	26	45
Shear stress due to reaction (τ_r) psi Equation 8	65	23	42
Hoop stress (σ_h) psi Equation 9	933	N/A	N/A
Longitudinal stress (σ_l) Equation 11	467	N/A	N/A

Substituting into Equation 11 with results from Table 4-1:

$$\sigma_{m\ normal} = 65\ psi + 57\ psi + 28\ psi + 933\ psi + 467\ psi = \mathbf{1,550\ psi}$$

Substituting into equation 12 from the results in Table 4-1:

$$\sigma_{m\,upset} = 50\,psi + 26\,psi + 23\,psi + 1{,}550\,psi = \mathbf{1,649\,psi}$$

Substituting into equation 13 from the results in Table 4-1

$$\sigma_{m\,faulted} = 42\,psi + 45\,psi + 86\,psi + 1{,}550\,psi = \mathbf{1,723\,psi}$$

Substituting into Equations 14 through 16 results in:

$$\sigma_{b\,normal} = 800\,psi$$

$$\sigma_{b\,upset} = 1{,}169\,psi$$

$$\sigma_{b\,faulted} = 1{,}452\,psi$$

Equations 11 through 13 are then summed with the bending loads (Equations 14 through 16) for each case in accordance with Ref. 8.2.

Normal: $\sigma_{m\,normal} + \sigma_{b\,normal} = 1{,}550\text{ psi} + 800\text{ psi} = \mathbf{2,350\,psi}$ Equation 40

Upset: $\sigma_{m\,upset} + \sigma_{b\,upset} =$ Equation 41

$$= 1{,}649\text{ psi} + 1{,}169\text{ psi} = \mathbf{2,818\,psi}$$

Faulted: $\sigma_{m\,faulted} + \sigma_{b\,faulted}$ Equation 42

$$= 1{,}723\text{ psi} + 1{,}453\text{ psi} = \mathbf{3,176\,psi}$$

All forces are less than the allowables as shown in Table 6-2 and are therefore acceptable. Also note that the low stress ensures that margin would be maintained after any stress intensification factors were applied due to the drain hole or other slight deviations from the circular geometry. This therefore reaffirms Assumption 3.1.

Table 6-2: Clamp Design & Service Loading Stress Summary

		Stress (psi)	Allowable (psi)
Normal	$\sigma_{m\,normal}$	1,550	20,000
	$\sigma_{m\,normal} + \sigma_{b\,normal}$	2,350	30,000
Upset	$\sigma_{m\,upset}$	1,649	22,000
	$\sigma_{m\,upset} + \sigma_{b\,upset}$	2,818	33,000
Faulted	$\sigma_{m\,faulted}$	1,723	40,000
	$\sigma_{m\,faulted} + \sigma_{b\,faulted}$	3,175	48,000

6.2 Pipe External Pressure due to Bolting

The maximum allowable clamping pressure is calculated via the substitution of applicable design input values into Equation 17.

$$P_{max} = \frac{2(12{,}700)0.328}{12.75 - 2(0.4)0.328} = 667\ psi$$

As noted in section 4.2, the maximum allowable clamping stress was subject to a correction factor of 3% in effort to provide a safety margin against over-tightening of the clamp studs.

$$\mathrm{P_{clamp}} = 0.97(\mathrm{P_{max}}) = 650\ \mathrm{psi} \qquad \text{Equation 43}$$

The effective sealing width of the clamp was computed by subtracting the total width of the stainless steel tubing seals and injected sealant void from the overall side bar width in accordance with design inputs 2.20, 2.22, and 2.24.

$$\mathrm{L_{seal}} = 2\left(2 * \frac{3}{16} + \frac{7}{16}\right) = 1.625\ \mathrm{inches} \qquad \text{Equation 44}$$

The overall sealing area of the clamp was computed in accordance with Equation 18 and design input 2.1 and the results of Equation 44.

$$A_{seal} = \pi(12.75)1.625 = 65.090\ in^2$$

Equation 19 was implemented to determine the total stud clamping force using the total sealing area and the results of Equation 43.

$$F_{bolt} = 65.090(650) = 42{,}308\ lb_f$$

The maximum allowable preload force due to each stud is then calculated using Equation 20 and design input 2.21.

$$F_i = \frac{42{,}308}{16} = 2{,}644.3\ lb_f$$

The required stud torque is correlated to the maximum allowable preload on each stud by Equation 21. Design input relevant to Equation 21 include design inputs 2.18 and 2.28.

$$T = (.2(0.625)2644.3)/12 = 27.5\ ft - lbs$$

From the results obtained from Equation 21, a maximum of 27.5 ft-lbs of torque can be applied to each of the 16 clamp studs without risk of compromising the structural integrity of the pipe. Due to the fact that this torque was calculated with a corrected pressure (P_{clamp}), the acceptance criteria of $P_{clamp} < P_{max}$ is met.

6.3 Structural Evaluation of Pipe Wall with Flaw

The minimum wall thickness in the pipe is calculated to be 0.025" from Eq. 22.

$$t_m = \frac{50\text{psi} * 12.75\text{in}}{2 * (12{,}700\text{psi} + 50\text{psi} * 0.4)} = 0.025\text{in}$$

The required reinforcement area is calculated to be 0.276 in^2 from Eq. 23.

$$A_7 = .025in * 11in = 0.276\ in^2$$

The excess area provided by 12" saltwater pipe is calculated below from Eq. 25.

$$A_1 = (2 * 11in - 11in) * (0.328in - .025in) = 3.33in^2$$

6.4 Fastener Analysis

The results of substituting the relevant design input into Equations 27 through 29 are shown in the table below.

Table 6.4: Summary of Stiffness Calculations

Fastener Stiffness	k_f=1.02e6 lbf/in	Equation 28
Stiffness Area of Member 1 (w/washer)	A_{p1}=.445 in^2	Equation 29
Stiffness Area of Member 2 (w/ nut head)	A_{p2}=.249 in^2	Equation 29
Stiffness of Member 1 (w/ washer)	k_1=3.72e6 lbf/in	Equation 28
Stiffness of Member 2 (w/ nut head)	k_2=2.44e6 lbf/in	Equation 28
Total Member Stiffness	k_m=1.47e6 lbf/in	Equation 30
Stiffness Constant of Joint	C=0.409	Equation 27

The results of substituting the relevant design input into Equations 28 through 38 are shown in Table 6.5.

Table 6.5: Summary of Tensile Forces on Joints

All values per stud unless noted	**Equation**	**WTOP**	**SEISOB**	**SEISDB**
Total Moment from by F_y (ft*lbf)	38	1468	339	612
Tension from Moment created by F_y(lbf)	37	356	82	148
Tension from M_a(lbf)	31	55	25	43
Tension from M_z at Greatest Dist. (lbf)	37	598	111	202
Tension from Internal Pressure (lbf)	32	1924	N/A	N/A
Total Tensile Force (lbf)	Summed	2932	218	394

Table 6.6: Summary of Shear Forces on Joints

All values per stud unless noted	Equation	WTOP	SEISOB	SEISDB
Total Moment from F_z (ft*lbf)	38	9	191	331
Shear from Moment from F_z (lbf)	37	0.9	18	32
Shear from M_y at Great Distance (lbf)	37	1.5	80	140
Total Shear Force [SF] (lbf)	Summed	2.4	99	171

Table 6.7: Summary of Stud Analysis

All values per stud unless noted	Equation	WTOP	SEISOB	SEISDB
Equivalent Applied Tensile Load [T] (lbf)	39	1200	89	161
Tensile Load Plus Preload [FN] (lbf)	38	3844	N/A	N/A
Tensile Stress in Stud [σ] (psi)	FN/A	17008	395	713
Shear Stress in Stud [τ] (psi)	SF/A	11	438	759
Summed Tensile & Shear Stresses [S] (psi)	τ+σ	17019	832	1472

Design and Service Loading Stud Loads without Preload

$$Normal = T_{WTOP} = 1200\ lbf$$

$$Upset = T_{WTOP} + T_{SEISOB} = 1289\ lbf$$

$$Faulted = T_{WTOP} + T_{SEISDB} = 1361\ lbf$$

Design and Service Loading Stud Loads with Preload

$$Normal = FN + T_{WTOP} = 3844\ lbf$$

$$Upset = FN + T_{WTOP} + T_{SEISOB} = 3933\ lbf$$

$$Faulted = FN + T_{WTOP} + T_{SEISDB} = 4005\ lbf$$

Design and Service Loading Stud Stresses

$$Normal = S_{WTOP} = 17019\,psi$$

$$Upset = S_{WTOP} + S_{SEISOB} = 17852\,psi$$

$$Faulted = S_{WTOP} + S_{SEISDB} = 18491\,psi$$

7.0 Conclusion

7.1 Clamp stress

All combined stresses are less than the allowables in accordance with Ref. 8.2. Therefore, the clamp seal stress is acceptable.

Table 7-1: Design and Service Loading Stress Summary

		Stress (psi)	Allowable (psi)
Normal	$\sigma_{m\,normal}$	1,550	20,000
	$\sigma_{m\,normal} + \sigma_{b\,normal}$	2,350	30,000
Upset	$\sigma_{m\,upset}$	1,649	22,000
	$\sigma_{m\,upset} + \sigma_{b\,upset}$	2,818	33,000
Faulted	$\sigma_{m\,faulted}$	1,723	40,000
	$\sigma_{m\,faulted} + \sigma_{b\,faulted}$	3,175	48,000

7.2 Pipe External Pressure due to Bolting

As evidenced within Section 6.2, the computation of the maximum allowable bolt torque is computed such that the pressure induced on the pipe by the clamp (P_{clamp}) will not exceed the maximum allowable applied pressure (P_{max}). Thus, the acceptance criteria of $P_{clamp} < P_{max}$ is satisfied. Table 7-2 below tabulates the results of the calculations performed pursuant to sections 4.2 and 6.2.

Table 7-2: Pipe External Pressure due to Bolting Summary

Maximum Allowable Clamping Pressure (P_{max}) psi Equation 17	667
Corrected Allowable Clamping Pressure (P_{clamp}) psi Equation 43	650
Overall Clamp Sealing Area (A_{seal}) in^2 Equation 18	65.090
Total Stud Clamping Force (F_{bolt}) lbf Equation 19	42,308
Max. Allowable Preload per Stud (F_i) lbf Equation 20	2644.3
Max. Allowable Stud Torque (T) ft-lb Equation 21	27

The stud torque calculated in Table 7-2 is the maximum allowable torque that can be applied to the clamp nuts such that the pressure induced on the pipe by the clamp does not exceed 650 psi as computed by Equation 43. Thus, 27 ft lbs is the maximum allowable upper limit for bolt torque.

7.3 Structural Evaluation of Pipe Wall with Flaw

The required reinforcing area, A_7 = 0.276in^2, is less than the reinforcing area provided by excess pipe material, A_1 = 3.33in^2. The results of this analysis show that the piping integrity may be maintained without the addition of the pipe clamp (reinforcement). Therefore, a defect whose size is bounded by a 11" diameter circle is acceptable per the methodology of Ref. 8.14.

7.4 Fastener Loading

The Stud Stress is considered acceptable because the stud stress in the faulted case is less than the stud's allowable stress for normal loads.

$$Faulted\ Case\text{: } 18{,}491\ psi < Bolt\ Allowable\text{: } 18{,}800\ psi$$

The stud preload is considered acceptable because the preload exceeds the expected faulted applied load (WTOP Applied Tensile Load plus SEISDB) accepted by the studs.

$$Stud\ Preload\text{: } 2644\ lbf > Stud\ Applied\ Load\text{: } 1361\ lbf$$

Due to the fact that the stress induced by the preload of 2644 lbf/0.226 in^2 = 11,699 psi is greater than 20% of the stud's yield strength (0.2 x 30,000 psi = 6,000), the nut can act as a locking device.

The stud preload stress and nut locking forces have sufficient margin such that a torque range of 23 ft lbs to 27 ft lbs is acceptable. The torque range is necessary to account for torque wrench accuracy.

8.0 References

8.1 Roark's Formulas for Stress and Strain, Eighth Edition

8.2 2004 ASME SECTION XI Appendix 9

8.3 CCNPP Calculation M-93-038 Rev. 1, "Component Cooling Pump Room Piping – Unit 2"

8.4 CCNPP Drawing 91374 Sheet 1 Rev. 18, "Component Cooling Water Pump Room Piping – Salt Water Cooling System – Unit 2"

8.5 Team Industrial Services Document No. 283380EM ECO Rev. A (Included as Attachment A)

8.6 Calvert Cliffs Engineering Standard ES-040 Rev. 00, "Piping Design Criteria"

8.7 CCNPP Calculation CA00700 Rev. 0, "Modification to Pipe Supports Associated with Salt Water Piping System"

8.8 CCNPP Calculation CA00702 Rev. 0, "Evaluation of Pipe Supports for Salt Water Piping System due to Minor Deviation from Design Condition and/or Proximity to Adjacent Anchor Bolts"

8.9 Calvert Cliffs M-601 Piping Class Summary Sheets Rev. 49

8.10 Calvert Cliffs M-600 Piping Class Sheets Rev. 76

8.11 Crane Technical Paper No. 410, "Flow of Fluids Through Valves, Fittings, and Pipe," Reprinted 2006

8.12 ILD-CALC-0013 Rev. 0, "Impact of Pipe Clamp on Calvert Cliffs Nuclear Power Plant Component Cooling Water Piping Stress"

8.13 EPRI-TR-104213, "Bolted Joint Maintenance and Applications Guide", Published December 1995

8.14 ASME B31.1-1967, "Power Piping"

8.15 Attachment A to Form 7, ECP-13-000947 Rev. 0

8.16 Shigley's Mechanical Engineering Design, Ninth Edition, Budynas & Nisbett

8.17 ASTM A53 "Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless"

TEAM INDUSTRIAL SERVICES, INC.
TECO MANUFACTURING, INC.

Engineering Change Order

Item#/SWO#	283380EM
ECO#	14178
NCR#	0
Letter	B
Category	Nuclear-Safety Related
Reason for Change	Customer Request

☐ QC Final Inspection Required

Changed by	HH
Change date	11/13/2013
Checked by	RD
Checked date	11-13-13
*Approved by	RD Roy Ryk
*Approval date	11/13/2013

***Approval Required for Safety - Related Nuclear Jobs.**

Manufacturing Received By

Date

QC Received By

Date

☐ Stock Item

Requested Change

1. Remove Confidential & Proprietary note off of drawing and calcs

Effect On Structural Integrity of Clamp

N/A

Changes Made

B1. Void Drawing
B2. Add Drawing
B3. Void Calcs
B4. Add Calcs

TEAM® Industrial Services, Inc.

Registration # F-003143

Engineering Change Order Request

Requested By: CUSTOMER	Drawing # / Engineering Order #: 283380EM
Department: BRANCH 204	Branch Job #: 204-10335
Received By: HH Date: 11/13/13	Date Effective: 11/13/13 ☒Immediate ☐Phase In ☐Record only

Description of Change:

1. Remove the Confidential and Proprietary note on the Drawing and Calcs
2.
3.
4.
5.
6.

Reason For Change:

1. CUSTOMER REQUEST
2.
3.
4.
5.
6.

TEAM® Industrial Services

Registration# F-003143

Engineering Department. Tel: (281) 388-5695 Fax: (281) 388-5690

ROUTING SLIP & COVER SHEET FOR NUCLEAR SAFETY RELATED JOBS

Branch Work Order #: 204-10335	Status: Priority	Caller: DAVE REDFIELD
Customer: CCNPP	Safety Review #: 283380	Engr Order #: 283380EM

	Name:	Signature:	Date:	Time:
Data Taken By:	Adrian Williams		10/14/2013	3:15 pm
Designed By:	Adrian Williams Mike Bautsch Simon Labrosse-Gelinas Heather Hodges		10/14/2013 10/31/2013 11/1/2013 11/08/2013	4:45 pm 3:30 pm 8:00 pm 10:45 am
Verified By:	Simon Labrosse-Gelinas Heather Hodges Adrian Williams Mike Lowe Roy Delgado		10/14/2013 10/31/2013 11/1/13 11/4/13 11/8/13	7:30 pm 8:45 pm 3:15 PM 11:30 am
Shop Received By:				
QC Received By:				

Specifications:			
Design Pressure:	50 psi	Design Temperature:	95 °F
Service:	SALT WATER	Torque Value:	25 ft-lb; (+/- 1.5 ft-lb) (A1)
Total Weight:	233.7 lb	Void:	26.3 in^3 BC
Sealant Type:	#6 & G-FIBER	Maximum Injection Pressure:	1050 PSI + STATIC

QC FINAL INSPECTION REQUIRED

Nuclear - Safety Related
CMTRs and COCs Required
PMI Required

Bill of Materials:		
Description:	Material:	Qty:
CLAMP	SA 182 GR F316	2 HALVES
CLAMP STUDS	SA 193 GR B8M CLASS 1	16
CLAMP NUTS	SA 194 GR 8M	32
TUBING	STAINLESS STEEL	232 INCHES
INJECTION VALVES	STAINLESS STEEL	20
DRILL THRU PLUGS	STAINLESS STEEL	4
WASHERS	SA 240 / 479 GR 316	16
PIPE PLUG	STAINLESS STEEL	1

A ECO# 14170 11/11/2013

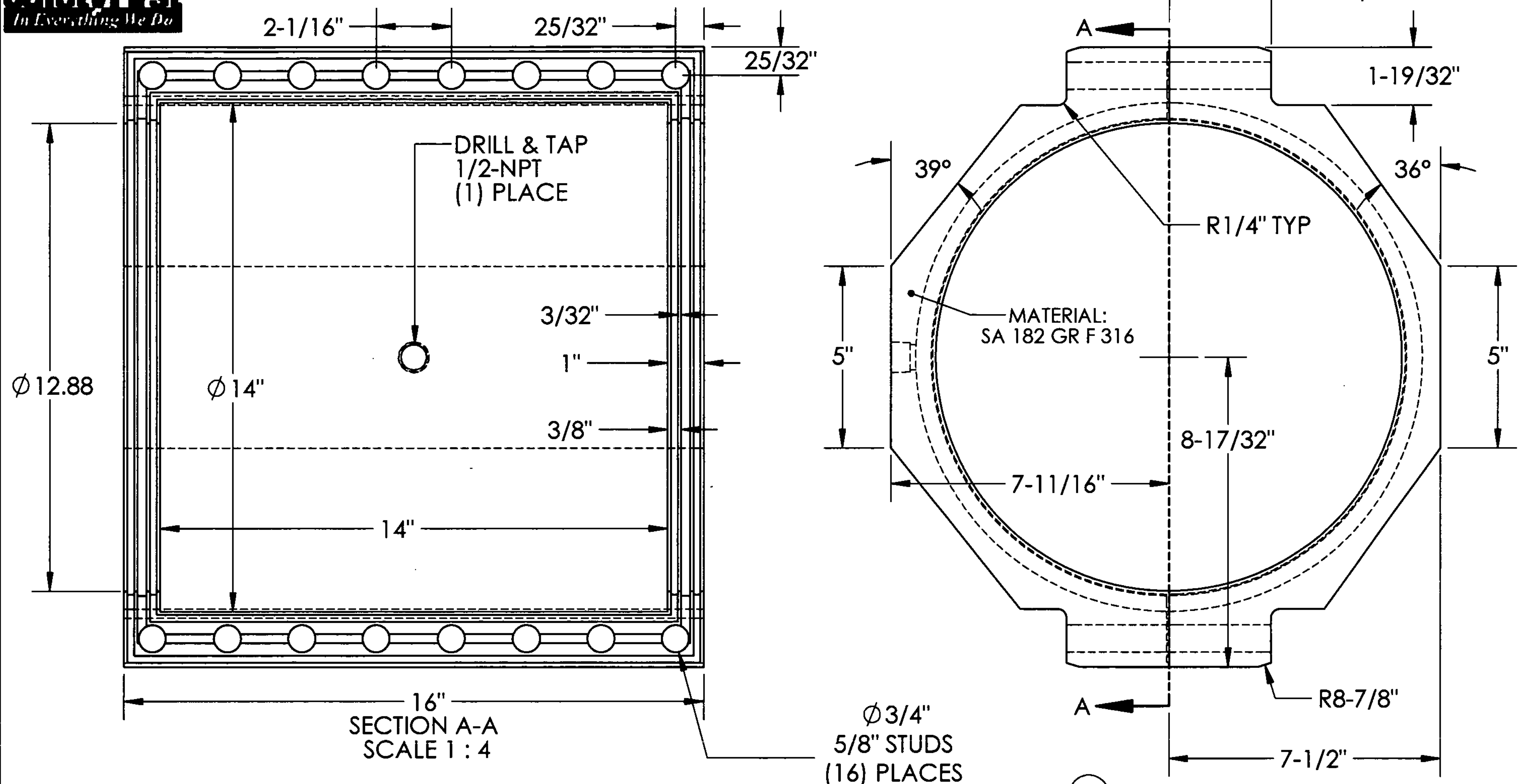
B ECO# 14178 11/13/13

Rev. 3/3/2010

SafetyFirst *In Everything We Do*

"SAFETY FIRST - QUALITY ALWAYS"

Safety First
In Everything We Do



TORQUE: 25 FT*LB (±1.5 FT*LB) (A1)

(B2) ADD

B ECO# 14178
DATE: 11/13/13

A ECO# 14170
DATE: 11/11/13

1. APPROVED TO MANUFACTURE
2. 3/16" X 0.09" TUBING GROOVES IN BORES AND SIDEBARS
3. 1/4" X 1/8" SEALANT GROOVES IN BORES & SIDEBARS
4. INSTALL STAINLESS TUBING
5. DRILL & TAP (8) 1/8-NPT INJ PORTS IN SIDEBARS
6. DRILL & TAP (6) 1/8-NPT INJ PORTS IN EACH ENDPLATE
7. DRILL & TAP (4) 1/4-NPT INJ PORTS IN CAVITY
• (DO NOT DRILL THRU)
8. (2) HALVES REQUIRED
9. ALL DIMENSIONS ARE TYPICAL UNLESS NOTED
10. COMMERCIAL GRADE DEDICATION REQUIRED BY TEAM
11. NUCLEAR SAFETY RELATED
12. DO NOT WELD; DO NOT PAINT
13. PMI REQUIRED
14. SEND WITH (1) 1/2" PIPE PLUG
15. SEND WITH (16) 1/2" THICK WASHERS, 1-1/16" OD WITH 11/16" CENTERED THROUGH HOLE

TEAM® Industrial Services, Inc.

REGISTRATION # F-003143

PERIMETER VOL 26.3 IN^3 BC

WT. 233.7 LBS VOL IN^3 BC

ENGINEERING ORDER# 283380EM		UNLESS OTHERWISE SPECIFIED MACHINED SURFACES BREAK SHARP CORNERS .005 TOLERANCES: FRACTIONAL ±1/32 ANGULAR ±1/2° TWO PALCE DECIMAL ±0.01 THREE PLACE DECIMAL ±0.005 ALL DIMENSIONS IN INCHES	CCNPP LINE ENCLOSURE
DRAWING # N/A			
TECO PART # N/A			
WPS: NOT ALLOWED			
DRAWN BY: ABW/MB/SLG/HH	11/8/2013		SIZE A / REV B
CHECKED BY:SLG/HH/ABW	11/1/2013		SCALE: 1:8 / SHEET 1 OF 1

TEAM® Industrial Services, Inc.

Registration # F-003143

MATERIAL SPECIFICATIONS

☐ Non-Critical/Nuclear ☒ Critical/Nuclear

Drawn By: ABW/MB/SLG/HH Date: 11/4/13

Checked By: SLG/ABW/MGL Date: 11/4/13

Engineering Order No.: 283380EM

Enclosures	Material Specification	CMTR	COC	NR
PIPE				
FITTING				
ROLLED PLATE				
BLOCK / PLATE / SIDEBARS	**SA 182 GR F316**	X	X	
ENDPLATES				
STRONGBACK BARS				
S.B. EARS/FINGERS				
Fasteners				
STUDS ENCLOSURE	**SA 193 GR B8M CLASS 1**	X	X	
STUDS STRONGBACK				
NUTS ENCLOSURE	**SA 194 GR 8M**	X	X	
NUTS STRONGBACK				
SET SCREWS				
HTS				
FLANGE				
TEE				
RUN (if fabricated)				
BRANCH (if fabricated)				
FITTING				
WELD-O-LET				
VALVE				
FES				
Miscellaneous				
TUBING	**STAINLESS STEEL**		X	
INJECTION VALVES	**STAINLESS STEEL**	X	X	
DRILL THRU PLUGS	**STAINLESS STEEL**	X	X	
WASHERS	**SA 240 / 479 GR 316**	X	X	
PIPE PLUG	**STAINLESS STEEL**	X	X	

TEAM® Industrial Services, Inc.

DAVE:
856-628-2817

LRS ENGINEERING DATA COVER SHEET

Form 901.4 R2
08/17/12

Branch Work Order #: ~~20~~-10335	Routine: ☐ Priority: ☒	Engr Order #: 283380E
Customer: CCNPP	LRS: ☒ PRP: ☐ Other: ☐	Safety Review # (CJ): 283380
Customer #: 64546	Ship To:	Existing BP #:
Technician Name(s): REDFIELD /CLARK	Date: 10-14-13	Operations / Tech Support Rep (If Applicable):

PRESSURE			TEMPERATURE			
Design: ~~30~~ 50			Design: 95	MDMT: (minimum design metal temp)		Service: SALT WATER
Operating: 35			Operating: 95			Line Material: C/S
Flange Rating: 150	Schedule: ~~80~~ 40	Line Size: 12	Quantity: 1	Sealant Selection: 6-G-FIBER		Material Requested: S/S

Package Requirements:
(Check all that are immediately needed)
- ☑ Drawings
- ☑ Calculations
- ☒ Price (If so ☐ ballpark or ☒ by engineering)

Date and Time Required: ____________

(Check one only)
- ☐ For Immediate Manufacture
- ☒ Wait for Approval of Package / Price
- ☐ Price Only / No Calculations/Drawings
- ☐ Job is competitive bid

Fax/Email Prints and Calculations: (PLEASE PRINT CLEARLY)
- ☐ To Customer Name: ____________ Fax No: ____________
- ☑ To Branch E-mail: DAVID CAMMISA
- ☐ To Other ____________
- ☐ Notify Branch Supervisor after faxing Name: ____________ Phone No: ____________
- ☐ Immediately ☐ Next Business Day

Special Requirements:
- ☐ Stress Relief Required by Customer
- ☐ PE Stamp
- ☐ CRN Province: ______
- ☐ NDE TYPE: ______
- ☑ MTR'S OR COC'S
- ☐ Charpy _____ ft-lb at _____ °F
- ☐ Strongback needed for separation?
- ☐ Strongback needed for vibration?
- ☐ Are there specific codes or additional requirements for this customer?
- ☐ Weight concern? Customer target weight? ______
- ☐ Are weight supports needed? How much weight per support? ______
- ☐ If Lifting Lugs are required, where should they be located? ______
- ☒ Other DRAIN VLV PORT IN VOID - 3/4"

1/2" d&t- NOT 3/4"

PRP PRODUCTS

Type of construction:	Seal Material:	Other Requirments:
☐ Solid Block	☐ Buna-N	☐ Anodes Life: ______ Qty ______
☐ Welded Construction	☐ EPDM	☐ Coating ______
☐ Casting	☐ Aflas	☐ Hinges
☐ Banded	☐ Viton	☐ Vent Valve Size ______
☐ Other ______	☐ Other ______	☐ Other ______

DS 137
STRAIGHT LINE ENCLOSURE

GIVEN BY:	DR	DATE:	10-14-13	PLANT:	CCNPP	UNIT:	2
CHKD. BY:	DC	DATE:	10-14-13	SURFACE CONDITION:	GOOD		
LINE SIZE:	12"	SEVERITY OF LEAK:	1 ON 10	SHIP TO:			

TYPE SEAL PERIM

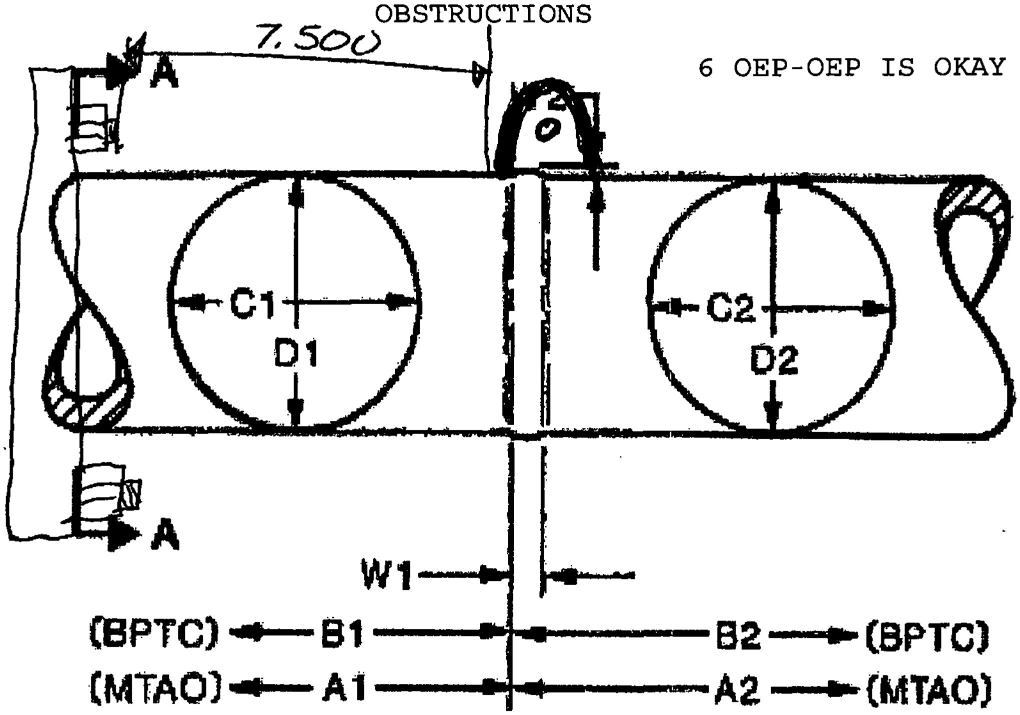
☐ CRUNCH ☐ PACKING
☐ TONGUE ☒ TUBING
☐ OTHER _____

SKIN TEMP.
LINE:_____ FLG._____

DIMENSIONAL DATA

7.5" OEP-OEP MAX STAIGHT LINE ENCLOSURE. LANDING BTWN THE FLG AND LUG. NO OBSTRUCTIONS

LTR.	DIM.
A1	
B1	
C1	12 3/4
D1	12 3/4
W1	
W2	
A2	
B2	
C2	12 3/4
D2	12 3/4

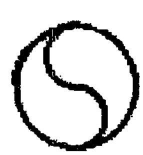


LOCATION OF BLOW:
3 O'CLOCK

OBSTRUCTIONS

NOTES

VIEW A-A



do not drill thru void (besides their specific d/t hole)

ARTICLE IX-3000
DESIGN REQUIREMENTS

IX-3100 GENERAL DESIGN REQUIREMENTS

The following design requirements shall be included in a Repair/Replacement plan and shall be considered in the analyses of the clamping device (IX-3200) and piping (IX-3300).

(a) Requirements to address environmental and corrosive effects of seal composition, seal installation, and system fluid on piping, clamping device, and bolting.

(b) The defect size used in the design of the clamping device shall include any projected growth.

(c) If additional supports are required to satisfy IX-3200 or IX-3300, they shall be considered non-pressure-retaining items and shall be designed in accordance with the requirements of the Construction Code for the system or as permitted by IWA-4220.

IX-3200 CLAMPING DEVICE

The following additional requirements apply to the design of the clamping device.

(a) No credit shall be taken for structural capability of the seal.

(b) Pressure retaining clamping device items shall be designed based on a stress analysis using the stress limits identified in Table IX-3200-1 for the loading conditions specified in the Owner's requirements for the system.

(c) The clamping device shall be mechanically connected to the piping. Seal welds may be added to prevent leakage. Serrated contact surfaces of the clamping device are acceptable, provided they do not affect the structural integrity of the piping.

(d) If the clamping device is designed to carry, by friction, longitudinal loads normally transmitted by the piping, including postulated full circumferential severance of the piping at the defect location, it shall be designed to produce clamping friction of at least five times the friction load required to prevent slippage. If a coefficient of friction greater than 0.3 is used for friction-type connections, the coefficient of friction for each interface design (e.g., serrated or nonserrated), and each combination of interface material P-Numbers, shall be experimentally determined.

TABLE IX-3200-1
STRESS LIMITS FOR DESIGN AND SERVICE LOADINGS

Service Limits	Stress Limits[1]
Design and Level A (Normal)	$\sigma_m < 1.0\ S$ $\sigma_m + \sigma_b < 1.5\ S$
Level B (Upset)	$\sigma_m < 1.10\ S$ $\sigma_m + \sigma_b < 1.65\ S$
Level C (Emergency)	$\sigma_m < 1.5\ S$ $\sigma_m + \sigma_b < 1.8\ S$
Level D (Faulted)	$\sigma_m < 2.0\ S$ $\sigma_m + \sigma_b < 2.4\ S$

NOTES:
(1) The symbols used in Table IX-3200-1 are defined as follows:
σ_m = general membrane stress, psi (kPa). Average stress across the solid cross section produced by mechanical loads; excludes effects of discontinuities and concentrations.
σ_b = bending stress, psi (kPa). Linearly varying portion of stress produced by mechanical loads; excludes effects of discontinuities and concentrations.
S = allowable stress value, psi (kPa), at temperature, provided in the Construction Code.

IX-3300 PIPING SYSTEM

The following additional requirements apply to the evaluation of the piping system.

(a) Piping system vibration shall be considered when vibration is the apparent cause of the defect or the defect can be propagated by vibration.

(b) The piping system configuration with the clamping device shall be evaluated in accordance with the Owner's requirements, and either the Construction Code or Section III.

(c) Effects of the stiffness and weight of the clamping device shall be considered in the evaluation of the piping systems. When the defect is caused by erosion or corrosion, the base material thickness at the load transfer area shall be determined and projected to the time of removal of the clamping device. The projected wall thickness shall be used when evaluating the piping system.

(d) Constraining effects of the clamping device shall be considered when evaluating effects of thermal expansion of the piping system.

(e) The Owner shall consider the effect of the defect and its expected growth, in the piping system evaluation.

TEAM	Quality System Supplement Corporate	FORM 104.2 Rev: 6 Page 1 of 2

NUCLEAR AUTHORIZATION CHECKLIST (NACL) - TMS Division

- **PART A:** Use to document Contract Review for material only orders and in conjunction with **PART B** for service related work.

Limit 3 jobs per Team Job # / CJ #. All three jobs must be within the same service line

Submitted by: DAVID REDFIELD	Branch: 204		Date: 10-14-13
Team Job #: 204-10335	Customer Contract/WO#/PO#:		Utility: CENG
Plant / Location: CCNPP / CALVERT CLIFFS	Contact: KURT BODINE		Phone #:
Personnel: 1. REDFIELD	2. CLARK	3.	4.
Shift:	Additional Personnel:		

Pre-Job Check List: *A new form must be completed each day, by each shift and prior to any work being performed.*

1. *All Pre-Job Steps must be initialed by the Team Industrial Services, Inc. technician who is leading activities at the work site prior to performing any work.*
2. *The Owner Representative must initial Step 8 prior to any work being performed.*
3. *All TEAM employees on the job must sign Step #12 prior to any work being performed.*

Steps:	Yes	No	N/A	Initial	Date	Comments:
1. Has JSA been completed?	☑	☐	☐	DR	10-14	
2. Has Tech. Support been contacted? (Critical Job Review)	☑	☐	☐	DR	10-14	CJ#: 283380
3. Have Team personnel READ and do they UNDERSTAND the Owner Engineering Control?	☑	☐	☐	DR	10-14	E.C. #:
4. Have Team personnel verified procedure(s) to be used?	☑	☐	☐	DR		Procedure#: LR1 AT
5. Have Team personnel READ and UNDERSTOOD the Owner W.O. Scope?	☑	☐	☐	DR	10-14	W.O. #:
6. Have Team personnel been briefed on Owner W.O. Scope and received copy of W.O.?	☑	☐	☐	DR	10-14	
7. Have Team personnel had a Rad. Protection Brief?	☑	☐	☐	DR	10-14	
8. Has Owner Representative verified all Steps have been performed?	☑	☐	☐	DR	10-14	*Owner Rep. to Initial. DKB

9. Materials: S/S	Certificate of Conformance (COC): Yes ☑ No ☐
10. Ship to: PLANT	Special Handling Requirements: Yes ☐ No ☑
11. Additional Requirements/Comments:	
12. Signatures of all Team Personnel: David Redfield David Clark	

- **PART B:** Used in conjunction with **PART A** for all service related work. **PART B is not required for material only orders.**

For Technical Support Use Only

Number of Jobs reviewed: 1☐ 2☐ 3☐	Comments:
Reviewed by:	
Signature:	Date:

Job #1 Information		Requirements	
Service Line: SALT WATER	Leak Severity: 1	**Notifications:** Safety Related: Yes ☑ No ☐ Quality Assurance: Yes ☑ No ☐ Health Physics: Yes ☑ No ☐	
Line Size: 12	Service: SALT WATER		
Unit: 2	Exp. Rate: .02 ml	Procedure #: LR1 / TRP-3303	Rev. #:
Op. Temp: 95	Op. Press: 35	**Materials & Equipment**	
Design Temp: 95	Design Press: 50	Sealant Type: 6	Lot #:
Equip. ID #: ~~[illegible]~~ DR 10-14 21-CC HX SW OUTLET		Sealant Type: 6-FIBER	Lot #:
Comments/Description of Job:		**Fabrication Data**	
		Mill Tests: Yes ☑ No ☐	Sec. III: Yes ☐ No ☑
Has the Customer expressed mechanical integrity concerns for the component?		Yes ☐ No ☑	
Plant Rep. (print): DKurt Bodine	Initials: DKB	Design Calcs.: Yes ☑ No ☐	Engr. Dwgs.: Yes ☑ No ☐
TISI Tech. (print): DAVID REDFIELD	Initials: DR	Positive Material Identification:	Yes ☑ No ☐

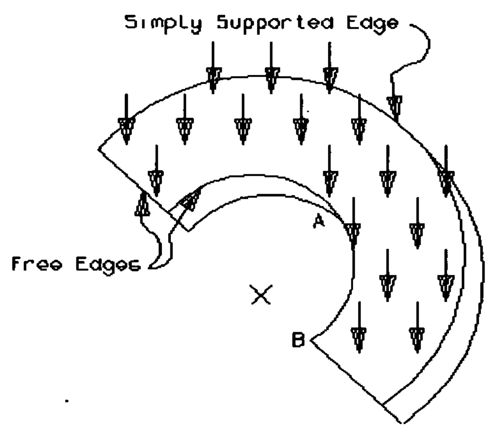
Split Circular Endplate Analysis

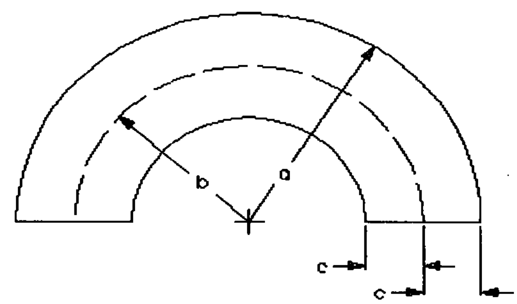
B ECO# 14178
DATE: 11/13/13

(B4) ADD

References: ASME Boiler and Pressure Vessel Code, Section II, Part D, (Table for Maximum Allowable Stresses, 2004 Edition

Formulas for Stress and Strain by Roark and Young, Fifth Edition, Table 24, Case 31





Data:

Design Pressure	$P := 50 \cdot psi$	Modulus of Elasticity	$E := 0.276654 \cdot 10^8 \cdot psi$
Design Temperature	$T := 95 \cdot deg$	Poisson's Ratio	$\nu := 0.31$
Split Endplate OD	$OD := 15.0 \cdot in$	Maximum Allowable Deflection	$y_{max} := 0.05 \cdot in$
Cover Wall Thickness	$t_{wall} := 0.5 \cdot in$	Joint Efficiency	$JE := 1$
Split Endplate Thickness	$t_{endpl} := 1.0 \cdot in$	External Corrosion Allowance	$ExtCA := 0 \cdot in$
Opening Hole Diameter ***(Conservative)***	$HD := 10.0 \cdot in$	Internal Corrosion Allowance	$IntCA := 0 \cdot in$
		$OD := OD - 2 \cdot ExtCA$	$OD = 15 \cdot in$
Maximum Allowable Stress	$S_{allow} := 20000 \cdot psi$	$t_{wall} := t_{wall} - ExtCA - IntCA$	$t_{wall} = 0.5 \cdot in$
		$t_{endpl} := t_{endpl} - ExtCA - IntCA$	$t_{endpl} = 1 \cdot in$

Inside Radius $$IR := \frac{[OD - 2(t_{wall})]}{2}$$

$IR = 7 \cdot in$

Note: "OD" is based on the inside cavity + 2 x times the minimum wall thickness.

Analysis:

Solving for Modulus of Rigidity

$$G := \frac{E}{2 \cdot (1 + \nu)} \qquad G = 1.056 \times 10^7 \cdot psi$$

Solving for variables

$$a := \frac{OD - 2 \cdot t_{wall}}{2} \qquad a = 7 \cdot in \qquad c := \frac{a - \frac{HD}{2}}{2} \qquad c = 1 \cdot in$$

$$b := a - c \qquad b = 6 \cdot in$$

Solving for Constants

$$K := 0.42338\cdot\left(\frac{b-c}{b+c}\right)^4 - 1.58614\cdot\left(\frac{b-c}{b+c}\right)^3 + 2.85046\cdot\left(\frac{b-c}{b+c}\right)^2 - 3.17277\cdot\left(\frac{b-c}{b+c}\right) + 2.48483$$

$K = 1.205$

B ECO# 14178
DATE: 11/13/13
(B4) ADD

$$\gamma := \sqrt{\frac{2\cdot b}{c} + 4\cdot\left(1 - \frac{.625\cdot t_{endpl}}{2\cdot c}\right)\cdot\frac{G}{E}\cdot\left(1+\frac{b}{c}\right)^2} \qquad \gamma = 7.964$$

$$\gamma_1 := \frac{\gamma}{\sqrt{2}}\cdot\sqrt{1 + \sqrt{1 - \frac{4\cdot b^2}{c^2\cdot\gamma^4}}} \qquad \gamma_1 = 7.928$$

$$\gamma_2 := \frac{\gamma}{\sqrt{2}}\cdot\sqrt{1 - \sqrt{1 - \frac{4\cdot b^2}{c^2\cdot\gamma^4}}} \qquad \gamma_2 = 0.757$$

$$\lambda_1 := 4\cdot\left(1 - \frac{.625\cdot t_{endpl}}{2\cdot c}\right)\cdot\frac{G}{E}\cdot\left(1\cdot + \frac{b}{c}\right)^2 \qquad \lambda_1 = 51.431$$

$$\lambda := \frac{\gamma_1\cdot\left(\frac{b}{c} - \gamma_1^2 + \lambda_1\right)\cdot\left(\frac{b}{c} - \gamma_2^2\right)\cdot\tanh\left(\frac{\gamma_1\cdot\pi}{2}\right)}{\gamma_2\cdot\left(\frac{b}{c} - \gamma_2^2 + \lambda_1\right)\cdot\left(\frac{b}{c} - \gamma_1^2\right)\cdot\tanh\left(\frac{\gamma_2\cdot\pi}{2}\right)} \qquad \lambda = 0.115$$

$$c_1 := \frac{1}{\left(\frac{b}{c} - \gamma_1^2\right)\cdot(\lambda - 1)\cdot\cosh\left(\frac{\gamma_1\cdot\pi}{2}\right)} \qquad c_1 = 1.551\times 10^{-7}$$

$$c_2 := \frac{1}{\left(\frac{b}{c} - \gamma_2^2\right)\cdot\left(\frac{1}{\lambda} - 1\right)\cdot\cosh\left(\frac{\gamma_2\cdot\pi}{2}\right)} \qquad c_2 = 0.013$$

Stress at A (maximum)

$$\sigma_t := \frac{6\cdot P\cdot c\cdot b}{t_{endpl}^2}\cdot\left(\frac{b}{c} - \frac{1}{3}\right)\cdot\left[c_1\cdot\left(1 - \gamma_1^2\cdot\frac{c}{b}\right) + c_2\cdot\left(1 - \gamma_2^2\cdot\frac{c}{b}\right) + \frac{c}{b}\right]\cdot K \qquad \sigma_t = 2196.938\cdot psi \quad < \quad S_{allow} = 20000\cdot psi$$

Deflection at B (maximum)

$$y := \frac{24\cdot P\cdot c^2\cdot b^2}{E\cdot t_{endpl}^3}\cdot\left(\frac{b}{c} - \frac{1}{3}\right)\cdot\left(c_1\cdot\cosh\left(\frac{\gamma_1\cdot\pi}{2}\right) + c_2\cdot\cosh\left(\frac{\gamma_2\cdot\pi}{2}\right) + \frac{c}{b}\right) \qquad y = 0.002\cdot in \quad < \quad y_{max} = 0.05\cdot in$$

(Ymax is assumed based on testing)

Minimum Cover Wall Thickness

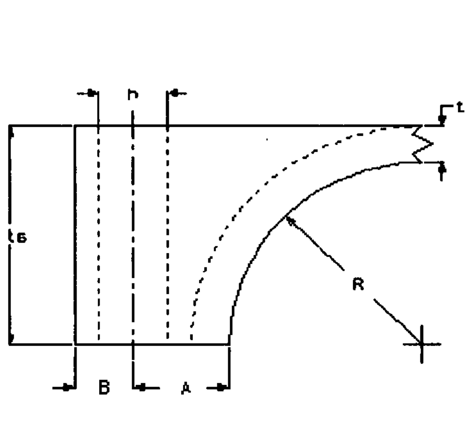
$$t_{reqd} := \frac{P\cdot IR}{2JE\cdot S_{allow} + 0.4\cdot P} + \frac{P\cdot IR}{JE\cdot S_{allow} - 0.6\cdot P} \qquad t_{reqd} = 0.02627\cdot in \quad < \quad t_{wall} = 0.5\cdot in$$

Line Enclosure Analysis

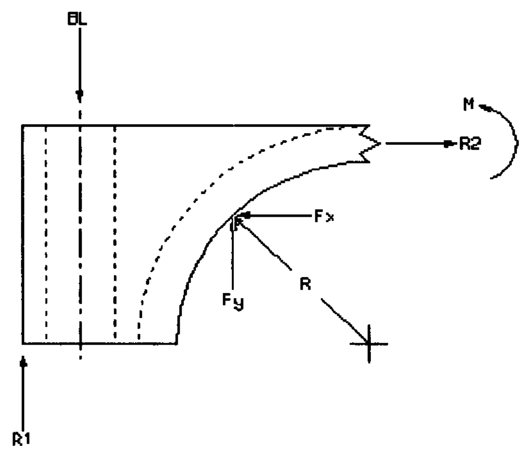
B ECO# 14178
DATE: 11/13/13
(B4) ADD

Purpose:
This analysis will calculate the internal stresses and bolt load of a line enclosure.

References:
ASME Boiler & Pressure Vessel Code, Section II, Part D, (Table for Maximum Allowable Stresses), 2004 Edition
ASME Boiler & Pressure Vessel Code, Section III, ND-3324.3 Case B
Team Industrial Services, Teco Manufacturing, Engineering Department, ISO-9001 Quality Manual, EP8.7



Dimensions



Free Body Diagram

Data:

Design Pressure		$P = 50 \cdot psi$	Length Between Centerline of Seals	$LS := 15.625 \cdot in$
Design Temperature		$T = 95 \cdot deg$	Sidebar Length (at Centerline)	$LB := 16 \cdot in$
Inside Radius	$R := IR - IntCA$	$R = 7 \cdot in$	# of Studs per Half	$NS2 := 8$
Cover Thickness	$t := t_{wall} + IntCA$	$t = 0.5 \cdot in$	Hole Size	$h := 0.75 \cdot in$
Cavity to Stud CL		$A := 0.75 \cdot in$	Stud Tensile Area	$TA := 0.226 \cdot in^2$
End of Sidebar to Stud CL		$B := 0.78125 \cdot in$	Stud Allowable Stress	$S_S := 18800 \cdot psi$
Sidebar Thickness		$ts := 2.8125 \cdot in$	Enclosure Allowable Stress	$S_{allow} = 20000 \cdot psi$

External Corrosion Allowance $ExtCA = 0 \cdot in$

Internal Corrosion Allowance $IntCA = 0 \cdot in$

$R := R + IntCA$	$R = 7 \cdot in$	$B := B - ExtCA$	$B = 0.781 \cdot in$
$t := t - ExtCA - IntCA$	$t = 0.5 \cdot in$	$LB := LB - 2 \cdot ExtCA$	$LB = 16 \cdot in$
$A := A - IntCA$	$A = 0.75 \cdot in$	$ts := ts - ExtCA$	$ts = 2.813 \cdot in$

B ECO# 14178
DATE: 11/13/13

(B4) ADD

Analysis:

Solving for forces and moments

$F := P \cdot R \cdot LS$ $\quad F_v := F$ $\quad F_v := F$

$F = 5.469 \times 10^3 \cdot lbf$ $\quad F_x = 5.469 \times 10^3 \cdot lbf$ $\quad F_y = 5.469 \times 10^3 \cdot lbf$

Setting forces in x direction equal to 0

$R_2 := F_x$ $\quad R_2 = 5468.75 \cdot lbf$

Setting moments around centerpoint of cavity equal to 0

$$BL := F \cdot \frac{A + B - \frac{t}{2}}{B} \qquad BL = 8968.75 \cdot lbf \qquad BL := if(BL < F, F, BL) \qquad BL = 8968.75 \cdot lbf$$

Allowable Bolt Load

$BL_a := TA \cdot S_S \cdot NS2$ $\quad BL_a = 33990.4 \cdot lbf$

Stresses in Shell (thin walled enclosure)

$$\sigma := \frac{P \cdot R}{t} + \frac{P \cdot R}{2 \cdot t} \qquad \sigma = 1050 \cdot psi$$

Sidebar Stress (at Bolt Centerline)

$R_1 := BL - F$ $\quad R_1 = 3.5 \times 10^3 \cdot lbf$

$$\sigma_{b2} := \frac{R_1 \cdot B \cdot \frac{ts}{2}}{\frac{1}{12} \cdot (LB - NS2 \cdot h) \cdot ts^3} \qquad \sigma_{b2} = 207.407 \cdot psi$$

$$\tau_s := \frac{3}{2} \cdot \frac{F}{(LB - NS2 \cdot h) \cdot ts} \qquad \tau_s = 291.667 \cdot psi$$

Results:

Bolt Load	Less Than	Allowable
$BL = 8968.75 \cdot lbf$		$BL_a = 33990.4 \cdot lbf$
Stresses in Shell (thin walled enclosure)		
$\sigma = 1050 \cdot psi$		$S_{allow} = 20000 \cdot psi$
Sidebar Stresses (@ bolt centerline)		
$\sigma_{b2} = 207.41 \cdot psi$		$S_{allow} = 20000 \cdot psi$
Shear Stresses in Sidebar		
$\tau_s = 291.67 \cdot psi$		$0.8 \cdot S_{allow} = 16000 \cdot psi$

Torque Analysis: 5/8" STUDS - Max Torque

Reference: An Introduction To The Design And Behavior Of The Bolted Joint by Bickford, Second Edition, Page 133.

Data:

A ECO# 14170
Date: 11/11/13
(A3) ADD

B ECO# 14178
DATE: 11/13/13
(B4) ADD

Stud Tensile Area		$TA = 0.226 \cdot in^2$
Stud Allowable Stress		$S_S = 18800 \cdot psi$
Allowable Strength of Stud	$Fp := TA \cdot S_S$	$Fp = 4248.8 \cdot lbf$
Torque Application Factor		$A := 0.60$
Pitch of Threads		$Pitch := \frac{1}{11} \cdot in$
Coefficient of Friction Nut/Stud		$\mu t := 0.15$
Effective Contact Radius of Threads		$rt := 0.2822 \cdot in$
Half Angle of Threads		$\beta := 30 \cdot deg$
Coefficient of Friction Nut/Joint		$\mu n := 0.15$
Effective Contact Radius Nut/Joint		$rn := 0.4219 \cdot in$

Analysis:

$$Torque := Fp \cdot A \cdot \left(\frac{Pitch}{2 \cdot \pi} + \frac{\mu t \cdot rt}{\cos(\beta)} + \mu n \cdot rn \right) \qquad Torque = 26.9 \cdot ft \cdot lbf \quad \text{OR} \quad Torque = 322.821 \cdot in \cdot lbf$$

Torque Analysis: 5/8" STUDS

Reference: An Introduction To The Design And Behavior Of The Bolted Joint by Bickford, Second Edition, Page 133.

Data:

Stud Tensile Area		$TA = 0.226 \cdot in^2$
Stud Allowable Stress		$S_S = 18800 \cdot psi$
Allowable Strength of Stud	$Fp := TA \cdot S_S$	$Fp = 4248.8 \cdot lbf$
Torque Application Factor		$A := 0.55$
Pitch of Threads		$Pitch := \frac{1}{11} \cdot in$
Coefficient of Friction Nut/Stud		$\mu t := 0.15$
Effective Contact Radius of Threads		$rt := 0.2822 \cdot in$
Half Angle of Threads		$\beta := 30 \cdot deg$
Coefficient of Friction Nut/Joint		$\mu n := 0.15$
Effective Contact Radius Nut/Joint		$rn := 0.4219 \cdot in$

Analysis:

$$Torque := Fp \cdot A \cdot \left(\frac{Pitch}{2 \cdot \pi} + \frac{\mu t \cdot rt}{\cos(\beta)} + \mu n \cdot rn \right) \qquad Torque = 24.66 \cdot ft \cdot lbf \quad \text{OR} \quad Torque = 295.919 \cdot in \cdot lbf$$

Weight and Void

B ECO# 14178
DATE: 11/13/13
(B4) ADD

Void Injection Valves $NIV := 20$

PERIMETER Void Calculations:

$$Void := \frac{1}{4}\cdot\frac{1}{8}\cdot in^2\cdot(35\cdot in - 0.75\cdot in\cdot 16) + \left[(0.75\cdot in)^2 - (0.5589\cdot in)^2\right]\cdot\frac{\pi}{4}\cdot(5.5625\cdot in)\cdot 16 \ldots$$
$$+ \frac{1}{4}\cdot\frac{1}{8}\cdot in^2\cdot(12.88\cdot\pi)\cdot 2\cdot in + \left[(0.6875\cdot in)^2 - (0.5589\cdot in)^2\right]\cdot\frac{\pi}{4}\cdot(0.5\cdot in)\cdot 32$$

$Void = 22.746\cdot in^3$

$Void := Void + \left(NIV\cdot 0.18\cdot in^3\right)$

$Void = 26.346\cdot in^3$

Weight (Clamp Weight from SolidWorks Model)

$Clamp := 98.85\cdot lb + 102.80\cdot lb$ $Clamp = 201.65\cdot lb$

$StudsNuts := 16\cdot 0.087\cdot\frac{lb}{in}\cdot 12\cdot in + 32\cdot 0.11\cdot lb$ $StudsNuts = 20.224\cdot lb$

$Washer := 0.07\cdot lb\cdot 16$ $Washer = 1.12\cdot lb$

$Sealant := Void\cdot 1.35\cdot 0.041\cdot\frac{lb}{in^3}$ $Sealant = 1.458\cdot lb$

$InjValves := NIV\cdot 0.50\cdot lb$ $InjValves = 10\cdot lb$

$Drill\_Thru\_Plug := 0.11lb\cdot 4$ $Drill\_Thru\_Plug = 0.44\cdot lb$

$Weight := Clamp + StudsNuts + Sealant + InjValves + Drill\_Thru\_Plug$

$Weight = 233.772\cdot lb$

ATTACHMENT (2)

REGULATORY COMMITMENTS

ATTACHMENT (2)

REGULATORY COMMITMENTS

The table below lists the action committed to in this submittal. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

Regulatory Commitment	Date
Verify that the installed mechanical clamping device is removed and replaced by a permanent code repair or component replacement.	04/01/2015