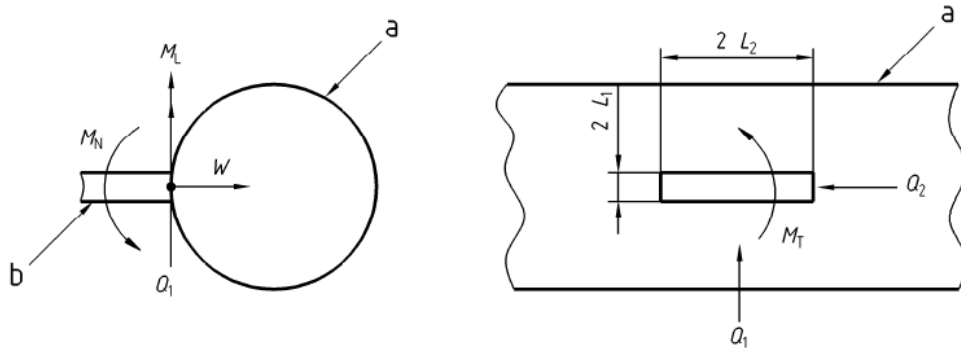


Tutorial on Lug Evaluation using CAEPIPE

This document explains the procedure to perform evaluation of Pipe Wall at Welded Rectangular Attachments as per ASME Section III, Division 1 (2010) – Appendix Y for NC-Class 2 Piping using CAEPIPE Lug Evaluation Module.



General

Lugs (integral attachments) are forged attachments or attachments welded on the pressure-loaded wall of a straight pipe which transfer piping loadings to the steel framework or concrete.

Loads on attachments cause local stresses in the pipe wall. Equations to determine these pipe stresses at lug attachments are given in different codes. These local stresses are then added to the piping system stresses at the attachments. The combined stresses thus obtained are checked for compliance with the appropriate equations given in those codes.

The Lug Evaluation module implemented in CAEPIPE computes local pipe stresses as per the following codes for Rectangular and Hollow Circular cross sectional attachments.

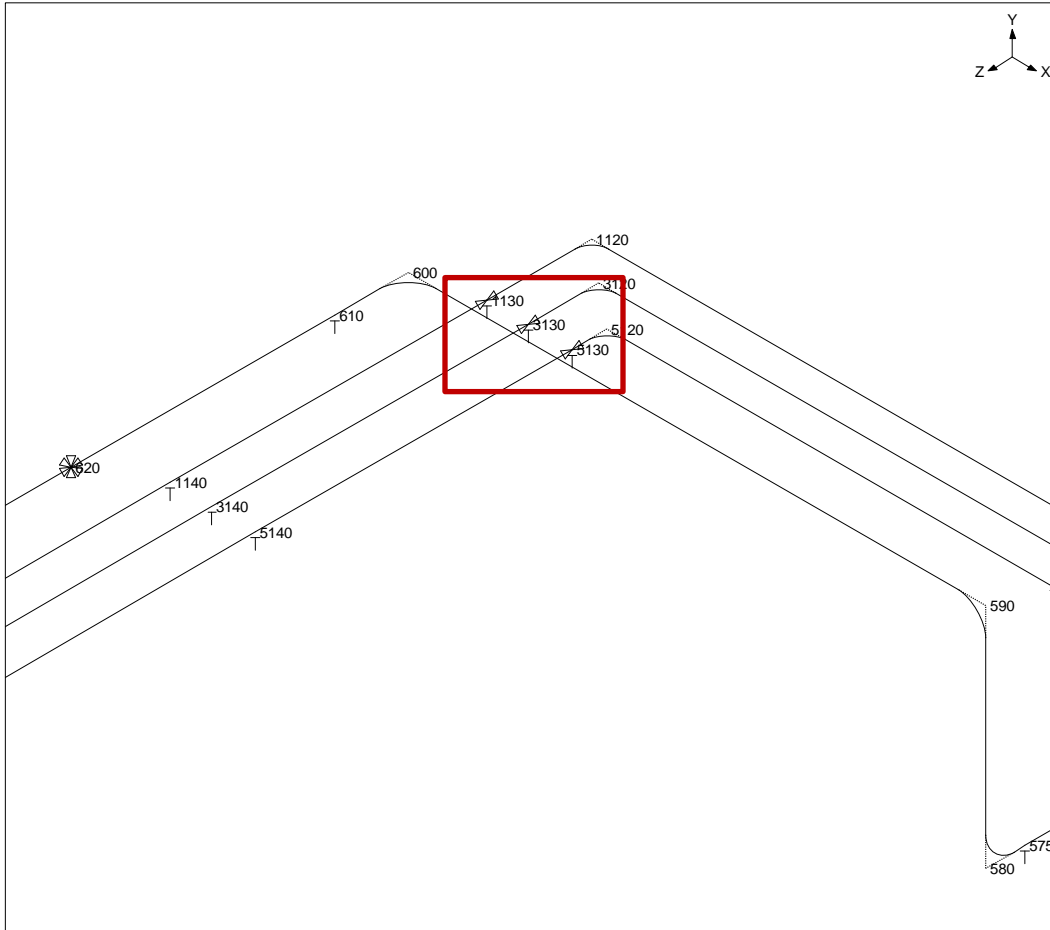
- ASME Section III, Division 1 (2010) – Appendix Y (NC Piping – Class 2)
- ASME Section III, Division 1 (2010) – Appendix Y (ND Piping – Class 3)
- EN 13480-3 (2017), Section 11

The details on the implementation of this module are provided in the Section titled “Lug Evaluation” of the CAEPIPE Code Compliance Manual.

Tutorial

In the layout shown below, in order to prevent the Axial Movement of the Pipe (Global Z), Rectangular Cross Sectional Attachments are welded to the Pipe at the Nodes 1130, 3130 and 5130.

As an example, this tutorial shows the procedure to qualify ASME B31.1 piping at the Rectangular Attachment at Node 3130 as per ASME Section III, Division 1 (2010) – Appendix Y (NC) using CAEPIPE “Lug Evaluation” module.



Step 1:

From the stress analysis results of CAEPIPE for the piping system shown above, note down the following at Node 3130.

1. Section properties of Run Pipe (OD and Thickness).
2. Sustained (S_L), Expansion (S_E) and Occasional Stresses (S_{LO}) computed at Node 3130 from Sorted Stresses results of CAEPIPE.
3. Allowable Stress Range (SA) and Hot Allowable Stress (SH) for Material at Node 3130.
4. Yield Stress of Material corresponding to Node 3130 from the Material properties.
5. Forces and Moments at Node 3130 for Sustained, Expansion and Occasional load cases from Support Loads and Support Load Summary results of CAEPIPE

Given below are the snapshots corresponding to the different information listed above.

Pipe Section Properties

| # | Name | Nom Dia | Sch | OD (inch) | Thk (inch) | Cor.Al (inch) | M.Tol (%) | Ins.D (lb/ft) |
|---|------|---------|-----|-----------|------------|---------------|-----------|---------------|
| 1 | 16 | 16" | 10 | 16 | 0.25 | 0.04 | 12.5 | |
| 2 | 10 | 10" | 10S | 10.75 | 0.165 | 0.04 | 12.5 | |
| 3 | AVG | Non Std | | 9.6875 | 0.1565 | 0.04 | 12.5 | |
| 4 | 8 | 8" | 10S | 8.625 | 0.148 | 0.04 | 12.5 | |

Stresses and Allowable Stresses for Run Pipe at Node 3130

| # | Sustained | | | | Expansion | | | | Occasional | | | |
|-----|-----------|----------|----------|-------|-----------|----------|----------|-------|------------|-------------|-------------|-------------|
| | Node | SL (psi) | SH (psi) | SL/SH | Node | SE (psi) | SA (psi) | SE/SA | Node | SL+S0 (psi) | 1.2SH (psi) | SL+S0/1.2SH |
| 134 | 3130 | 740 | 17100 | 0.04 | 1440 | 1460 | 40847 | 0.04 | 5230 | 3555 | 20520 | 0.17 |
| 135 | 1290 | 729 | 17100 | 0.04 | 3600 | 1458 | 41034 | 0.04 | 3840 | 3493 | 20520 | 0.17 |
| 136 | 5060A | 725 | 17100 | 0.04 | 1190 | 1382 | 42048 | 0.03 | 3300 | 3492 | 20520 | 0.17 |
| 137 | 1200 | 725 | 17100 | 0.04 | 3880 | 1301 | 41074 | 0.03 | 700 | 3481 | 20520 | 0.17 |
| 138 | 5095 | 724 | 17100 | 0.04 | 1050 | 1302 | 42005 | 0.03 | 600A | 3444 | 20520 | 0.17 |
| 139 | 1115 | 711 | 17100 | 0.04 | 5110B | 1273 | 41405 | 0.03 | 1370 | 3427 | 20520 | 0.17 |
| 140 | 1190 | 702 | 17100 | 0.04 | 6030 | 1279 | 41886 | 0.03 | 5120B | 3409 | 20520 | 0.17 |
| 141 | 6020 | 702 | 17100 | 0.04 | 3830 | 1239 | 40651 | 0.03 | 3290 | 3404 | 20520 | 0.17 |
| 142 | 3200 | 700 | 17100 | 0.04 | 6020 | 1263 | 42048 | 0.03 | 5260 | 3379 | 20520 | 0.16 |
| 143 | 1570B | 700 | 17100 | 0.04 | 3510 | 1223 | 40897 | 0.03 | 520 | 3374 | 20520 | 0.16 |
| 144 | 1170B | 699 | 17100 | 0.04 | 1095 | 1242 | 41754 | 0.03 | 1610 | 3366 | 20520 | 0.16 |

| # | Sustained | | | | Expansion | | | | Occasional | | | |
|-----|-----------|----------|----------|-------|-----------|----------|----------|-------|------------|-------------|-------------|-------------|
| | Node | SL (psi) | SH (psi) | SL/SH | Node | SE (psi) | SA (psi) | SE/SA | Node | SL+S0 (psi) | 1.2SH (psi) | SL+S0/1.2SH |
| 231 | 540 | 345 | 17100 | 0.02 | 3130 | 310 | 42010 | 0.01 | 6030 | 1214 | 20520 | 0.06 |
| 232 | 3400 | 345 | 17100 | 0.02 | 3220 | 307 | 42477 | 0.01 | 1150 | 1197 | 20520 | 0.06 |
| 233 | 1560 | 345 | 17100 | 0.02 | 3210 | 298 | 42101 | 0.01 | 1095 | 1149 | 20520 | 0.06 |
| 234 | 3710 | 344 | 17100 | 0.02 | 3440 | 298 | 42506 | 0.01 | 1050 | 1141 | 20520 | 0.06 |
| 235 | 1820 | 343 | 17100 | 0.02 | 1780 | 292 | 42464 | 0.01 | 3820 | 1126 | 20520 | 0.05 |
| 236 | 3040 | 340 | 17100 | 0.02 | 1400 | 282 | 42454 | 0.01 | 5060A | 1091 | 20520 | 0.05 |
| 237 | 630 | 338 | 17100 | 0.02 | 1460 | 278 | 42204 | 0.01 | 5270 | 1077 | 20520 | 0.05 |
| 238 | 5050 | 335 | 17100 | 0.02 | 1470 | 267 | 42132 | 0.01 | 1540 | 1069 | 20520 | 0.05 |
| 239 | 1580 | 334 | 17100 | 0.02 | 3590 | 258 | 42398 | 0.01 | 6020 | 1050 | 20520 | 0.05 |
| 240 | 1370 | 321 | 17100 | 0.02 | 260 | 258 | 42506 | 0.01 | 5095 | 1040 | 20520 | 0.05 |
| 241 | 3720 | 314 | 17100 | 0.02 | 1410 | 226 | 42510 | 0.01 | 630 | 945 | 20520 | 0.05 |

Caepipe : B31.1 (2016) Code compliance (Sorted stresses) - [...]

File Results View Options Window Help

| # | Sustained | | | | Expansion | | | | Occasional | | | |
|-----|-----------|----------|----------|-------|-----------|----------|----------|-------|------------|-------------|-------------|-------------|
| | Node | SL (psi) | SH (psi) | SL/SH | Node | SE (psi) | SA (psi) | SE/SA | Node | SL+50 (psi) | 1.25H (psi) | SL+50/1.25H |
| 220 | 1690 | 382 | 17100 | 0.02 | 3430 | 372 | 42450 | 0.01 | 3130 | 1553 | 20520 | 0.08 |
| 221 | 3070 | 377 | 17100 | 0.02 | 3490 | 367 | 42207 | 0.01 | 540 | 1490 | 20520 | 0.07 |
| 222 | 3800 | 372 | 17100 | 0.02 | 1770 | 364 | 42396 | 0.01 | 1380 | 1473 | 20520 | 0.07 |
| 223 | 5140 | 367 | 17100 | 0.02 | 1830 | 359 | 42261 | 0.01 | 610 | 1473 | 20520 | 0.07 |
| 224 | 560 | 364 | 17100 | 0.02 | 3500 | 352 | 42136 | 0.01 | 570 | 1425 | 20520 | 0.07 |
| 225 | 620 | 361 | 17100 | 0.02 | 250 | 348 | 42535 | 0.01 | 3095 | 1394 | 20520 | 0.07 |
| 226 | 1020 | 359 | 17100 | 0.02 | 1840 | 344 | 42186 | 0.01 | 1045 | 1382 | 20520 | 0.07 |
| 227 | 5230 | 355 | 17100 | 0.02 | 3570 | 343 | 42298 | 0.01 | 5220 | 1303 | 20520 | 0.06 |
| 228 | 1770 | 354 | 17100 | 0.02 | 130 | 336 | 42582 | 0.01 | 560 | 1298 | 20520 | 0.06 |
| 229 | 3590 | 352 | 17100 | 0.02 | 3230 | 333 | 42265 | 0.01 | 3420 | 1253 | 20520 | 0.06 |
| 230 | 3150 | 345 | 17100 | 0.02 | 3810 | 317 | 42448 | 0.01 | 1115 | 1233 | 20520 | 0.06 |

Material # 1

Material name: A53B

Description: A53 Grade B (Seamless)

Type: CS : Carbon steel

Density: 0.283 (lb/in3)

Nu: 0.3

Joint factor: 1.00

Yield strength: 30000 (psi)

OK Cancel Properties Library

Support Loads for Sustained, Expansion and Occasional Load Cases at Node 3130

Caepipe : Loads on Restraints: Sustained (W+P) -...

File Results View Options Window Help

| # | Node | Tag | FX (lb) | FY (lb) | FZ (lb) |
|----|------|-----|---------|---------|---------|
| 1 | 620 | | 48 | -448 | 0 |
| 2 | 1095 | | | | -27 |
| 3 | 1115 | | -85 | | |
| 4 | 1130 | | | | 12 |
| 5 | 3095 | | | | -72 |
| 6 | 3115 | | 13 | | |
| 7 | 3130 | | | | 1 |
| 8 | 5095 | | | | -104 |
| 9 | 5115 | | -55 | | |
| 10 | 5130 | | | | -2 |

Caepipe : Loads on Restraints: Wind 4 - [LugEval... - □ ×

File Results View Options Window Help

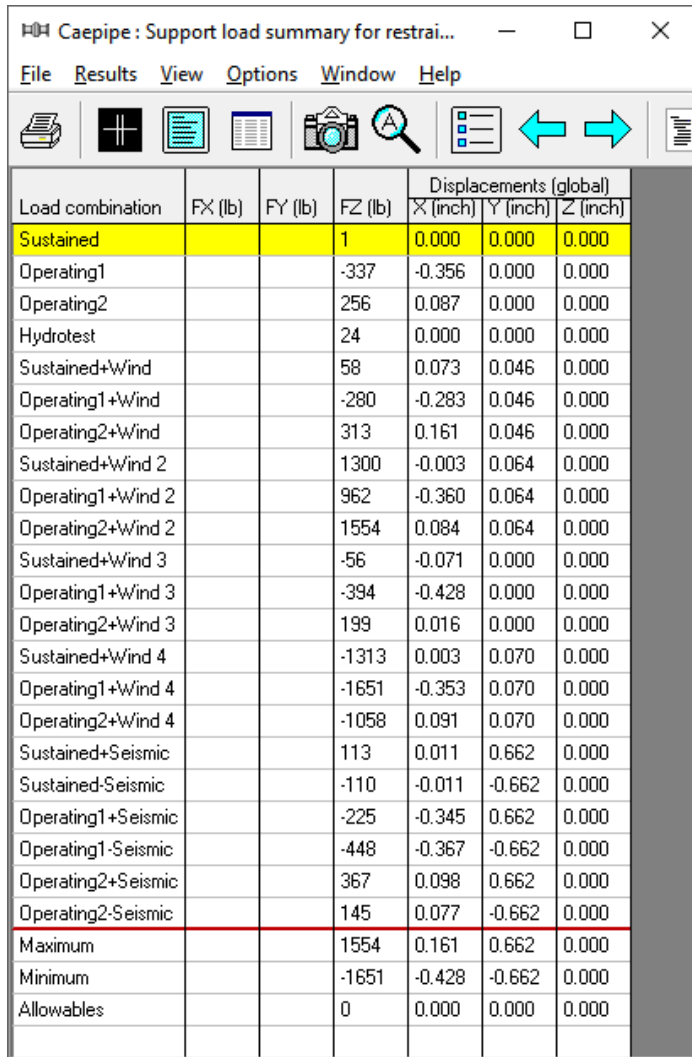
| # | Node | Tag | FX (lb) | FY (lb) | FZ (lb) |
|----|------|-----|---------|---------|---------|
| 1 | 620 | | 173 | 299 | -2134 |
| 2 | 1095 | | | | -582 |
| 3 | 1115 | | -29 | | |
| 4 | 1130 | | | | -1286 |
| 5 | 3095 | | | | -751 |
| 6 | 3115 | | -64 | | |
| 7 | 3130 | | | | -1314 |
| 8 | 5095 | | | | -585 |
| 9 | 5115 | | -83 | | |
| 10 | 5130 | | | | -1343 |

Caepipe : Loads on Restraints: Expansion (T1-T2)... - □ ×

File Results View Options Window Help

| # | Node | Tag | FX (lb) | FY (lb) | FZ (lb) |
|----|------|-----|---------|---------|---------|
| 1 | 620 | | 393 | 136 | 91 |
| 2 | 1095 | | | | -66 |
| 3 | 1115 | | 103 | | |
| 4 | 1130 | | | | -587 |
| 5 | 3095 | | | | -874 |
| 6 | 3115 | | 25 | | |
| 7 | 3130 | | | | -593 |
| 8 | 5095 | | | | 108 |
| 9 | 5115 | | -55 | | |
| 10 | 5130 | | | | -2 |

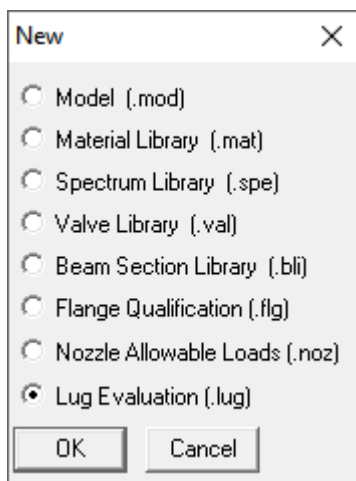
Support Load Summary for Node 3130



| Load combination | FX (lb) | FY (lb) | FZ (lb) | Displacements (global) | | |
|--------------------|---------|---------|---------|------------------------|----------|----------|
| | | | | X (inch) | Y (inch) | Z (inch) |
| Sustained | | | 1 | 0.000 | 0.000 | 0.000 |
| Operating1 | | | -337 | -0.356 | 0.000 | 0.000 |
| Operating2 | | | 256 | 0.087 | 0.000 | 0.000 |
| Hydrotest | | | 24 | 0.000 | 0.000 | 0.000 |
| Sustained+Wind | | | 58 | 0.073 | 0.046 | 0.000 |
| Operating1+Wind | | | -280 | -0.283 | 0.046 | 0.000 |
| Operating2+Wind | | | 313 | 0.161 | 0.046 | 0.000 |
| Sustained+Wind 2 | | | 1300 | -0.003 | 0.064 | 0.000 |
| Operating1+Wind 2 | | | 962 | -0.360 | 0.064 | 0.000 |
| Operating2+Wind 2 | | | 1554 | 0.084 | 0.064 | 0.000 |
| Sustained+Wind 3 | | | -56 | -0.071 | 0.000 | 0.000 |
| Operating1+Wind 3 | | | -394 | -0.428 | 0.000 | 0.000 |
| Operating2+Wind 3 | | | 199 | 0.016 | 0.000 | 0.000 |
| Sustained+Wind 4 | | | -1313 | 0.003 | 0.070 | 0.000 |
| Operating1+Wind 4 | | | -1651 | -0.353 | 0.070 | 0.000 |
| Operating2+Wind 4 | | | -1058 | 0.091 | 0.070 | 0.000 |
| Sustained+Seismic | | | 113 | 0.011 | 0.662 | 0.000 |
| Sustained-Seismic | | | -110 | -0.011 | -0.662 | 0.000 |
| Operating1+Seismic | | | -225 | -0.345 | 0.662 | 0.000 |
| Operating1-Seismic | | | -448 | -0.367 | -0.662 | 0.000 |
| Operating2+Seismic | | | 367 | 0.098 | 0.662 | 0.000 |
| Operating2-Seismic | | | 145 | 0.077 | -0.662 | 0.000 |
| Maximum | | | 1554 | 0.161 | 0.662 | 0.000 |
| Minimum | | | -1651 | -0.428 | -0.662 | 0.000 |
| Allowables | | | 0 | 0.000 | 0.000 | 0.000 |

Step 2:

Lug Evaluation module is separate from a piping stress model file and hence, can be accessed from File Menu > Open/New command.



Step 3:

Double-clicking anywhere in the window shown (or select the option Edit menu > Edit (Ctrl+E)) opens a dialog with input fields which you can now edit. You will need to enter all of your data obtained above in this dialog including the Rectangular Attachment Dimensions as shown below.

L1 = 0.25 inch (see the picture from previous page for L1 and L2)

L2 = 1.50 inch

Evaluation of Piping at Lug Attachment [X]

Lug Evaluation Code: ASME Sec III, Div 1 - NC (2010) [v] Level: C [v]

Rectangular Attachment Hollow Circular Attachment

Outside Diameter of Run Pipe (OD): 10 [v] (inch)

Nominal Wall Thickness of Run Pipe (Thk): 0.165 [v] (inch)

Half Length of Attachment in Circumferential Direction (L1): 0.25 [v] (inch)

Half Length of Attachment in Longitudinal Direction (L2): 1.5 [v] (inch)

Sustained Stress at Run Pipe (Eq.8): 740 [v] (psi)

Expansion Stress at Run Pipe (Eq.10): 310 [v] (psi)

Sustained + Occasional Stress at Run Pipe (Eq.9): 1553 [v] (psi)

Settlement Stress at Run Pipe (10a): [v] (psi)

Thermal + Sustained Stress at Run Pipe (Eq. 11): [v] (psi)

Allowable Stress at Maximum Temperature (sh): 17100 [v] (psi)

Allowable Stress Range (sa): 42010 [v] (psi)

Yield Strength (sy): 30000 [v] (psi)

Creep Stress (fcr): [v] (psi)

Weld Type: Full Penetration [v]

| Loads applied to the Attachment | Sustained | Occasional | Thermal | Settlement | Abs. Max. | |
|---------------------------------|-----------|------------|----------|------------|----------------------|---------------|
| Thrust Load (W) | [v] | [v] | [v] | [v] | (W ^{max}) | [v] (lb) |
| Circumferential Shear Load (Q1) | [v] | [v] | [v] | [v] | (Q1 ^{max}) | [v] (lb) |
| Longitudinal Shear Load (Q2) | 1 [v] | -1314 [v] | -593 [v] | [v] | (Q2 ^{max}) | 1651 [v] (lb) |
| Torsional Moment (MT) | [v] | [v] | [v] | [v] | (MT ^{max}) | [v] (ft-lb) |
| Circumferential Moment (MN) | [v] | [v] | [v] | [v] | (MN ^{max}) | [v] (ft-lb) |
| Longitudinal Moment (ML) | [v] | [v] | [v] | [v] | (ML ^{max}) | [v] (ft-lb) |

OK [v] Cancel [v]

Step 4:

Once all the data values are input, save the model (filename will have a .lug extension). Now, select File menu > Analyze to evaluate, which will be shown right below the input information.

| Forces and Moments at Pipe surface: Thermal | | | |
|--|------------|---------|-------|
| Circumferential Moment applied to the Attachment (MN): | 0 (ft-lb) | | |
| Longitudinal Moment applied to the Attachment (ML): | 0 (ft-lb) | | |
| Thrust Load applied to the Attachment (W): | 0 (lb) | | |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 (lb) | | |
| Longitudinal Shear Load applied to the Attachment (Q2): | -593 (lb) | | |
| Torsional Moment applied to the Attachment (MT): | 0 (ft-lb) | | |
| Circumferential Moment applied to the Attachment (MN): | 0 (ft-lb) | | |
| Longitudinal Moment applied to the Attachment (ML): | 0 (ft-lb) | | |
| Forces and Moments at Pipe surface: Settlement | | | |
| Thrust Load applied to the Attachment (W): | 0 (lb) | | |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 (lb) | | |
| Longitudinal Shear Load applied to the Attachment (Q2): | 0 (lb) | | |
| Torsional Moment applied to the Attachment (MT): | 0 (ft-lb) | | |
| Circumferential Moment applied to the Attachment (MN): | 0 (ft-lb) | | |
| Longitudinal Moment applied to the Attachment (ML): | 0 (ft-lb) | | |
| Abs. Max. Forces and Moments occurring simultaneously at Pipe surface | | | |
| Thrust Load applied to the Attachment (W ^{***}): | 0 (lb) | | |
| Circumferential Shear Load applied to the Attachment (Q1 ^{***}): | 0 (lb) | | |
| Longitudinal Shear Load applied to the Attachment (Q2 ^{***}): | 1651 (lb) | | |
| Torsional Moment applied to the Attachment (MT ^{***}): | 0 (ft-lb) | | |
| Circumferential Moment applied to the Attachment (MN ^{***}): | 0 (ft-lb) | | |
| Longitudinal Moment applied to the Attachment (ML ^{***}): | 0 (ft-lb) | | |
| ASME Sec III, Div 1(2010) Appendix Y (NC - Class 2) | | | |
| Evaluation of Piping at Rectangular Attachments | | | |
| Section Y-3410: Pipe Stresses at Attachment | | | |
| | Calculated | Allowed | Ratio |
| Sustained Stress (S _s) [Eq. 8]: (psi) | 742 | 25650 | 0.029 |
| Sustained + Occasional (S _o) [Eq. 9]: (psi) | 4210 | 54000 | 0.078 |
| Thermal Exp. Stress (S _e) [Eq. 10]: (psi) | 1508 | 42010 | 0.036 |
| Settlement Stress (S _d) [Eq. 10a]: (psi) | 0 | 51300 | 0.000 |
| Sustained + Thermal Exp. Stress (S _{te}) [Eq. 11]: (psi) | 1200 | 59110 | 0.020 |
| Additional check for Full Penetration Weld | | | |
| | Calculated | Allowed | Ratio |
| Stress (S _{NT} ^{***}) as per Y-3410 Eq. 5: (psi) | 3335 | 60000 | 0.056 |
| Shear Stress as per Y-3410 Eq. 6: (psi) | 3335 | 30000 | 0.111 |

The above results confirm that the calculated local pipe stresses (inclusive of stresses from piping system analysis) at the rectangular lug attachment at Node 3130 are well within the respective stress allowable as per ASME Section III, Division 1 (2010) Appendix Y (NC-Class 2 Piping) code.

Step 5:

You can print the Report by using the Print command. You can also preview the report by clicking the Preview button on the print dialog.

Caepipe : Print Preview, Page 1 (of 2)

File View Options Help

Print Prev Page Next Page Close

Caepipe Page 1

Evaluation of Piping at Lug Attachment as per ASME Sec III, Div 1 - NC (2010)

Input Data:
Lug Evaluation Code: ASME Sec III, Div 1 - NC (2010)
Level: C
Lug Type: Rectangular
Weld Type (Penetration): Full Penetration

| | | |
|--|-------|--------|
| Outside Diameter of Run Pipe (OD): | 10 | (inch) |
| Nominal Wall Thickness of Run Pipe (Thk): | 0.185 | (inch) |
| Half Length of Attachment in Circumferential Direction (L1): | 0.25 | (inch) |
| Half Length of Attachment in Longitudinal Direction (L2): | 1.5 | (inch) |
| Sustained Stress at Run Pipe (Eq.8): | 740 | (psi) |
| Expansion Stress at Run Pipe (Eq.10): | 310 | (psi) |
| Sustained + Occasional Stress at Run Pipe (Eq.9): | 1553 | (psi) |
| Settlement Stress (Eq.10a): | 0 | (psi) |
| Thermal + Sustained Stress (Eq.11): | 0 | (psi) |
| Allowable Stress at Maximum Metal Temperature (sh): | 17100 | (psi) |
| Allowable Stress Range (sa): | 42010 | (psi) |
| Yield Stress (sy): | 30000 | (psi) |

Forces and Moments at Pipe surface: Sustained

| | | |
|--|---|---------|
| Thrust Load applied to the Attachment (W): | 0 | (lb) |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 | (lb) |
| Longitudinal Shear Load applied to the Attachment (Q2): | 1 | (lb) |
| Torsional Moment applied to the Attachment (MT): | 0 | (ft-lb) |
| Circumferential Moment applied to the Attachment (MN): | 0 | (ft-lb) |
| Longitudinal Moment applied to the Attachment (ML): | 0 | (ft-lb) |

Forces and Moments at Pipe surface: Occasional

| | | |
|--|-------|---------|
| Thrust Load applied to the Attachment (W): | 0 | (lb) |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 | (lb) |
| Longitudinal Shear Load applied to the Attachment (Q2): | -1314 | (lb) |
| Torsional Moment applied to the Attachment (MT): | 0 | (ft-lb) |
| Circumferential Moment applied to the Attachment (MN): | 0 | (ft-lb) |
| Longitudinal Moment applied to the Attachment (ML): | 0 | (ft-lb) |

Forces and Moments at Pipe surface: Thermal

| | | |
|--|------|---------|
| Thrust Load applied to the Attachment (W): | 0 | (lb) |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 | (lb) |
| Longitudinal Shear Load applied to the Attachment (Q2): | -593 | (lb) |
| Torsional Moment applied to the Attachment (MT): | 0 | (ft-lb) |
| Circumferential Moment applied to the Attachment (MN): | 0 | (ft-lb) |
| Longitudinal Moment applied to the Attachment (ML): | 0 | (ft-lb) |

Forces and Moments at Pipe surface: Settlement

| | | |
|--|---|---------|
| Thrust Load applied to the Attachment (W): | 0 | (lb) |
| Circumferential Shear Load applied to the Attachment (Q1): | 0 | (lb) |
| Longitudinal Shear Load applied to the Attachment (Q2): | 0 | (lb) |
| Torsional Moment applied to the Attachment (MT): | 0 | (ft-lb) |
| Circumferential Moment applied to the Attachment (MN): | 0 | (ft-lb) |
| Longitudinal Moment applied to the Attachment (ML): | 0 | (ft-lb) |

Version 8.10 LUG_XEE03_ASME_RA.lug Aug 9,2018