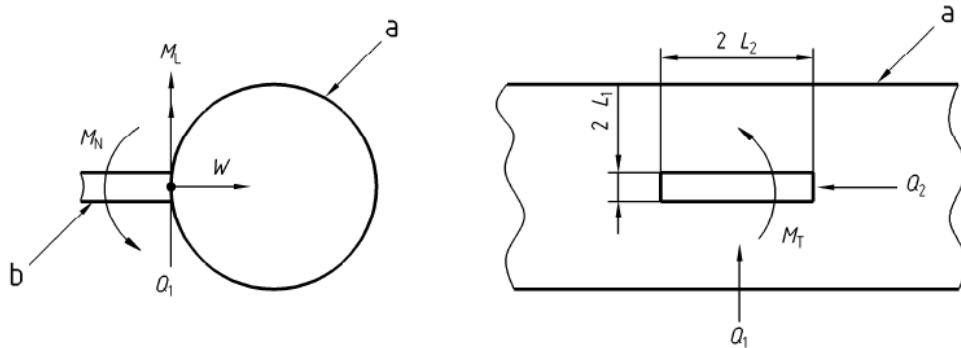


## Tutorial on Lug Evaluation using CAEPIPE

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.

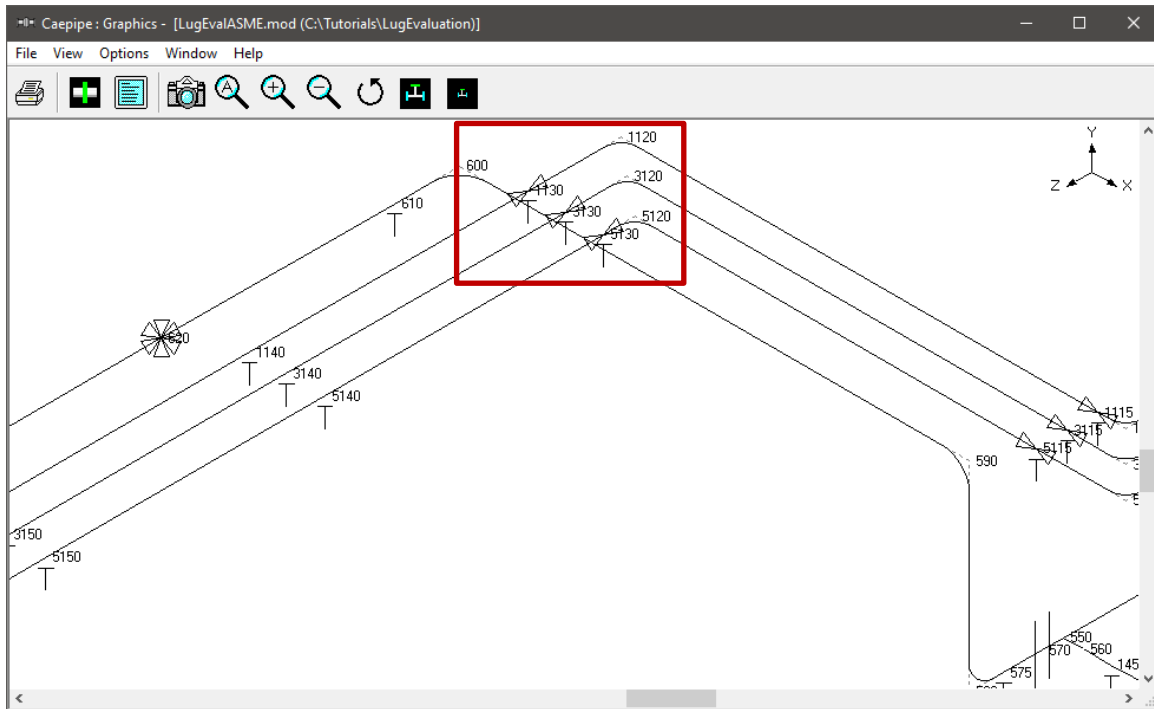
- ASME Section III, Division 1 (2010) – Appendix Y (NC Piping – Class 2)
- ASME Section III, Division 1 (2010) – Appendix Y (ND Piping – Class 3)
- EN 13480-3 (2017), Section 11

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. Dens (lb/ft <sup>3</sup> )	Ins. Thk (inch)	Lin. Dens (lb/ft <sup>3</sup> )	Lin. Thk (inch)	Soil
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					
5	2	2"	40	2.375	0.154	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	SO (psi)	1.2SH (psi)	SO 1.2SH
119	3130	674	17100	0.04	1430	4833	41918	0.12	700	2605	20520	0.13
120	3510	674	17100	0.04	1800	4804	41859	0.11	1370	2604	20520	0.13
121	3190	670	17100	0.04	590B	4825	42092	0.11	5090A	2588	20520	0.13
122	1850	669	17100	0.04	3090B	4755	41587	0.11	3320	2583	20520	0.13
123	1340	668	17100	0.04	1620	4664	40948	0.11	1280	2573	20520	0.13
124	3880	665	17100	0.04	530	4651	41037	0.11	1230B	2553	20520	0.12
125	610	664	17100	0.04	3110B	4597	40905	0.11	3260A	2552	20520	0.12
126	1210	661	17100	0.04	3610	4722	42414	0.11	3900	2549	20520	0.12

#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL SH	Node	SE (psi)	SA (psi)	SE SA	Node	SO (psi)	1.2SH (psi)	SO 1.2SH
226	1760	267	17100	0.02	3130	474	42076	0.01	1460	928	20520	0.05
227	3220	266	17100	0.02	3835	460	41423	0.01	690	910	20520	0.04
228	1410	264	17100	0.02	5060A	458	41830	0.01	1210	879	20520	0.04
229	1230A	264	17100	0.02	1020	445	42501	0.01	5190	863	20520	0.04
230	3440	263	17100	0.02	3490	434	42277	0.01	3490	847	20520	0.04
231	3170A	261	17100	0.02	3890	421	41885	0.01	1830	830	20520	0.04
232	3070	260	17100	0.02	3500	417	42202	0.01	610	827	20520	0.04
233	3360	259	17100	0.02	120	382	42705	0.01	600A	775	20520	0.04

Caepipe : B31.1 (2020) Code compliance (Sorted stresses) - [LugEv...]

File Results View Options Window Help

#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SO (psi)	1.25H (psi)	SO/1.25H
212	1280	309	17100	0.02	1040	649	42391	0.02	3130	1077	20520	0.05
213	620	303	17100	0.02	1130	635	41563	0.02	3580	1074	20520	0.05
214	1590	302	17100	0.02	3520	625	41879	0.01	3190	1073	20520	0.05
215	3590	301	17100	0.02	3120A	625	42298	0.01	1150	1048	20520	0.05
216	1790	300	17100	0.02	3220	622	42484	0.01	540	1033	20520	0.05
217	1030	296	17100	0.02	130	617	42673	0.01	3500	1032	20520	0.05
218	3260A	293	17100	0.02	5115	592	42023	0.01	5200	1032	20520	0.05
219	1170A	291	17100	0.02	3880	588	42085	0.01	1840	1015	20520	0.05

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

OK Cancel Properties Library

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

Caepipe : Loads on Restraints: Sustained (W+P) - [LugEvalASME.res...]

File Results View Options Window Help

#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)
1	620		27	-432	0
2	1095				34
3	1115		-75		
4	1130				14
5	3095				44
6	3115		-262		
7	3130				-1
8	5095				-296
9	5115		-6		
10	5130				-2

Caepipe : Loads on Restraints: Expansion (T1-T2) - [LugEvalASME.r...

File Results View Options Window Help

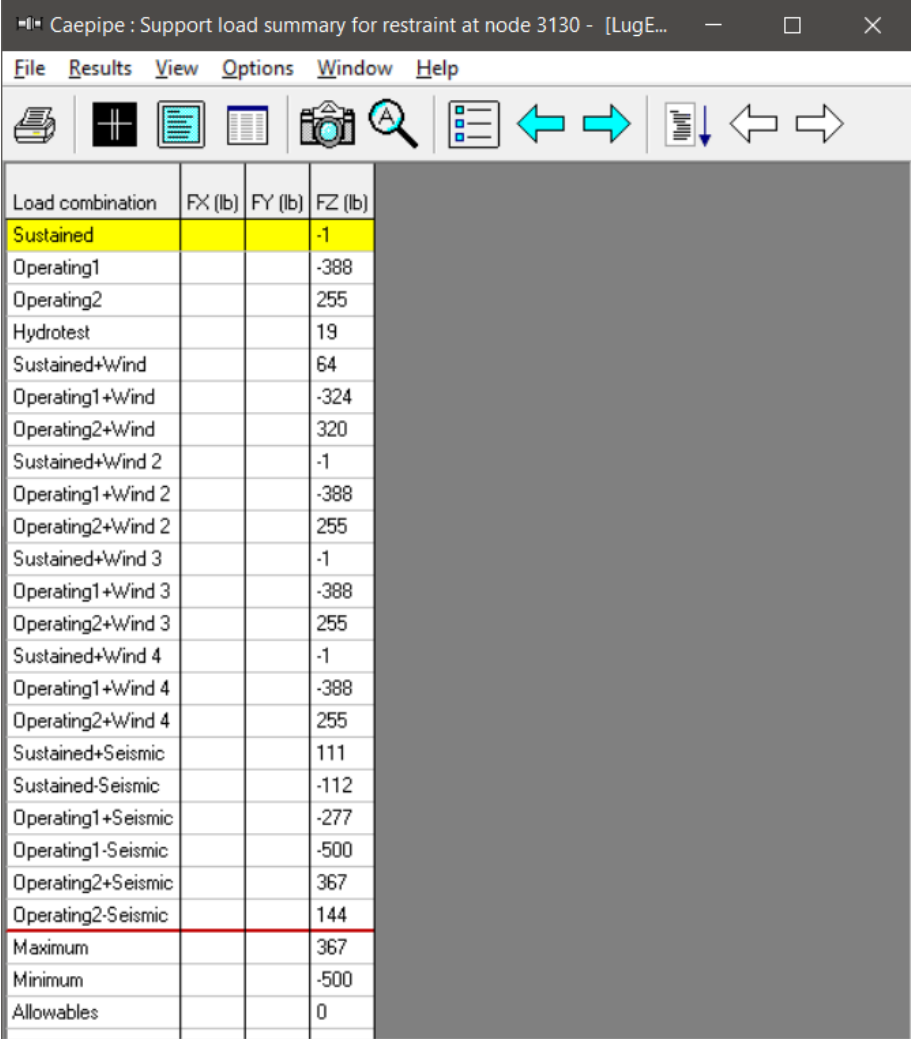
#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)
1	620		469	142	112
2	1095				92
3	1115		39		
4	1130				-670
5	3095				-1439
6	3115		-588		
7	3130				-644
8	5095				562
9	5115		110		
10	5130				-3

Caepipe : Loads on Restraints: Wind - [LugEvalASME.res (C:\Tutoria...

File Results View Options Window Help

#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)
1	620		2675	-8	-33
2	1095				-59
3	1115		691		
4	1130				76
5	3095				-120
6	3115		513		
7	3130				64
8	5095				-1
9	5115		610		
10	5130				79

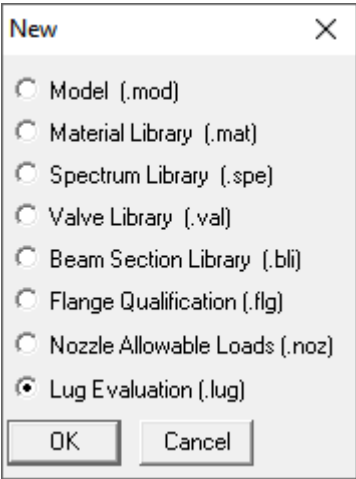
**Support Load Summary for Node 3130**



Load combination	FX (lb)	FY (lb)	FZ (lb)
Sustained			-1
Operating1			-388
Operating2			255
Hydrotest			19
Sustained+Wind			64
Operating1+Wind			-324
Operating2+Wind			320
Sustained+Wind 2			-1
Operating1+Wind 2			-388
Operating2+Wind 2			255
Sustained+Wind 3			-1
Operating1+Wind 3			-388
Operating2+Wind 3			255
Sustained+Wind 4			-1
Operating1+Wind 4			-388
Operating2+Wind 4			255
Sustained+Seismic			111
Sustained-Seismic			-112
Operating1+Seismic			-277
Operating1-Seismic			-500
Operating2+Seismic			367
Operating2-Seismic			144
Maximum			367
Minimum			-500
Allowables			0

**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 in page 1 for L1 and L2)

L2 = 1.50 inch

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

Rectangular Attachment  Hollow Circular Attachment

Outside Diameter of Run Pipe (OD): 10 (inch)

Nominal Wall Thickness of Run Pipe (Thk): 0.165 (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): 674 (psi)

Expansion Stress at Run Pipe (Eq.10): 474 (psi)

Sustained + Occasional Stress at Run Pipe (Eq.9): 1077 (psi)

Settlement Stress at Run Pipe (10a): (psi)

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

Allowable Stress at Maximum Temperature (sh): 17100 (psi)

Allowable Stress Range (sa): 42076 (psi)

Yield Strength (sy): 20520 (psi)

Creep Stress (fcr): (psi)

Weld Type: Full Penetration

Loads applied to the Attachment	Sustained	Occasional	Thermal	Settlement	Abs. Max.	
Thrust Load (W)					(W <sup>max</sup> )	(lb)
Circumferential Shear Load (Q1)					(Q1 <sup>max</sup> )	(lb)
Longitudinal Shear Load (Q2)	-1	64	-644		(Q2 <sup>max</sup> )	500 (lb)
Torsional Moment (MT)					(MT <sup>max</sup> )	(ft-lb)
Circumferential Moment (MN)					(MN <sup>max</sup> )	(ft-lb)
Longitudinal Moment (ML)					(ML <sup>max</sup> )	(ft-lb)

OK Cancel

**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.

	Calculated	Allowed	Ratio
Sustained Stress (Ssl) [Eq. 8]: (psi)	676	25650	0.026
Sustained + Occasional (Sol) [Eq. 9]: (psi)	1208	36936	0.033
Thermal Exp. Stress (Se) [Eq. 10]: (psi)	1775	42076	0.042
Settlement Stress (Sd) [Eq. 10a]: (psi)	0	51300	0.000
Sustained + Thermal Exp. Stress (Ste) [Eq. 11]: (psi)	1303	59176	0.022
Additional check for Full Penetration Weld			
	Calculated	Allowed	Ratio
Stress (SNT <sup>***</sup> ) as per Y-3410 Eq. 5: (psi)	1010	41040	0.025
<b>Shear Stress as per Y-3410 Eq. 6: (psi)</b>	<b>1010</b>	<b>20520</b>	<b>0.049</b>

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): 0.165 (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): 674 (psi)  
Expansion Stress at Run Pipe (Eq.10): 474 (psi)  
Sustained + Occasional Stress at Run Pipe (Eq.9): 1077 (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): 42076 (psi)  
Yield Stress (sy): 20520 (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):	64 (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):	-644 (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**):	500 (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)

Version 10.40 LUG\_XEE03\_ASME\_RA.lug Jun 25,2021