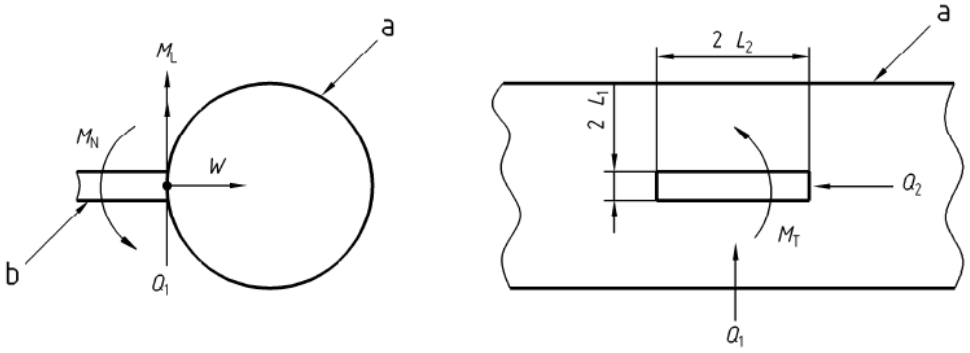
Tutorial on Lug Evaluation using CAEPIPE

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.

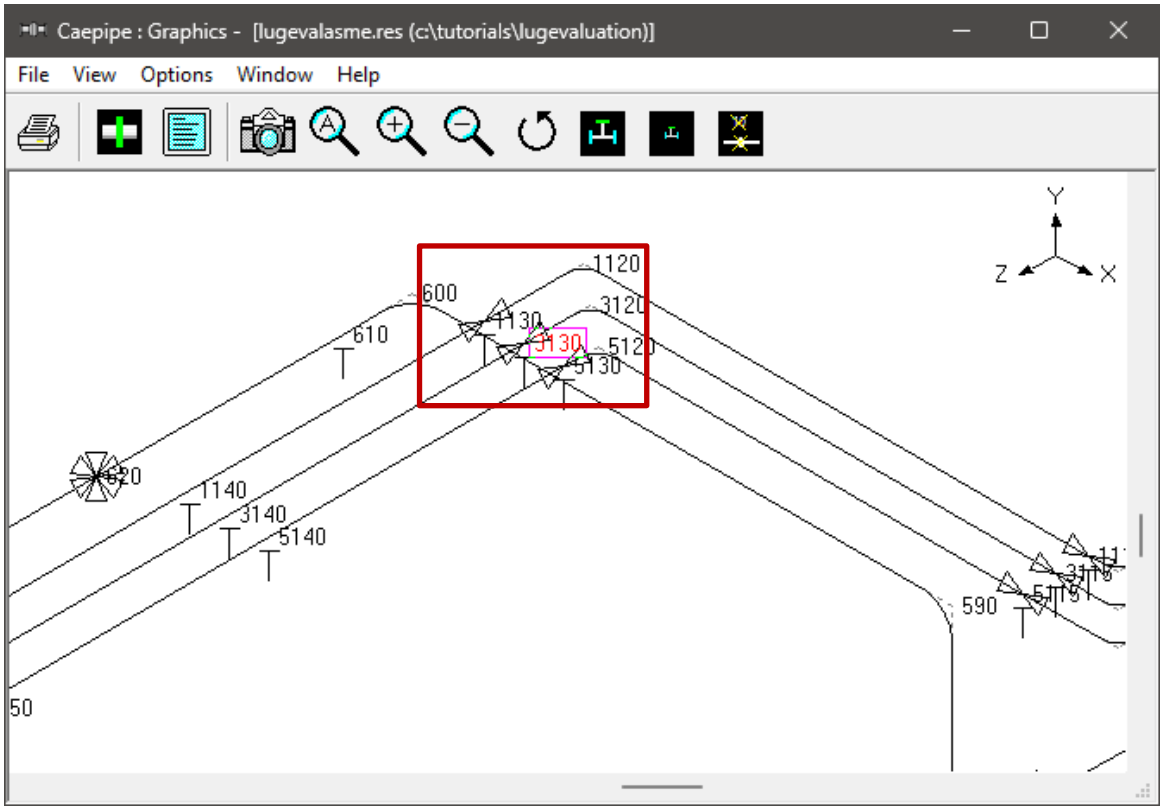
- ASME Section III, Division 1 (2010) – Appendix Y (NC Piping – Class 2)
- ASME Section III, Division 1 (2010) – Appendix Y (ND Piping – Class 3)
- EN 13480-3 (2017), Section 11

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

Caepipe : Pipe Sections (5) - [lugevalasme.mod (c:\tutorials\lugevaluation)]

File Edit View Options Misc Window Help

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Sc
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

Caepipe : B31.1 (2022) Code compliance (Sorted stresses) - [lugevalasme.res (C:\Tutorials\LugEvaluation)]

File Results View Options Window Help

#	Sustained				Expansion				Occasional				Hydrotest Stress			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SO (psi)	1.2SH (psi)	SO/1.2SH	Node	SL (psi)	SLA (psi)	SL/SLA
114	5160	690	17100	0.04	640A	5236	42993	0.12	1670	2728	20520	0.13	1870	870	27000	0.03
115	1200	688	17100	0.04	3810	5289	43459	0.12	1870	2724	20520	0.13	3530	868	27000	0.03
116	670	686	17100	0.04	285	5023	42049	0.12	3600	2710	20520	0.13	5260	867	27000	0.03
117	1480	677	17100	0.04	520	4980	41719	0.12	1280	2694	20520	0.13	3180	867	27000	0.03
118	3370	677	17100	0.04	290	4856	42370	0.11	3340	2692	20520	0.13	3900	864	27000	0.03
119	3130	674	17100	0.04	1430	4833	42809	0.11	5100	2665	20520	0.13	3710	826	27000	0.03
120	3510	674	17100	0.04	1800	4804	42748	0.11	3900	2641	20520	0.13	3720	818	27000	0.03
121	3190	670	17100	0.04	590B	4825	42987	0.11	1640	2640	20520	0.13	5200	814	27000	0.03
122	1850	669	17100	0.04	3090B	4755	42471	0.11	3640	2635	20520	0.13	1190	814	27000	0.03
123	1340	668	17100	0.04	1620	4664	41818	0.11	5170B	2621	20520	0.13	1670	810	27000	0.03
124	3880	665	17100	0.04	530	4651	41909	0.11	5090A	2591	20520	0.13	3620A	802	27000	0.03
125	610	664	17100	0.04	3110B	4597	41775	0.11	1230B	2553	20520	0.12	3200	801	27000	0.03
126	1210	661	17100	0.04	3610	4722	43316	0.11	3260A	2552	20520	0.12	690	799	27000	0.03

Caepipe : B31.1 (2022) Code compliance (Sorted stresses) - [lugevalasme.res (C:\Tutorials\LugEvaluation)]

File Results View Options Window Help

#	Sustained				Expansion				Occasional				Hydrotest Stress			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SO (psi)	1.2SH (psi)	SO/1.2SH	Node	SL (psi)	SLA (psi)	SL/SLA
223	1750	282	17100	0.02	1805	518	42304	0.01	650	982	20520	0.05	1590	390	27000	0.01
224	3300	279	17100	0.02	1490	481	42764	0.01	5090B	980	20520	0.05	1790	387	27000	0.01
225	3570	276	17100	0.02	1860	478	42770	0.01	540	950	20520	0.05	3590	385	27000	0.01
226	1760	267	17100	0.02	3130	474	42970	0.01	1050	946	20520	0.05	3260A	382	27000	0.01
227	3220	266	17100	0.02	3835	460	42304	0.01	1460	943	20520	0.05	3030	380	27000	0.01
228	1410	264	17100	0.02	5060A	458	42719	0.01	3870	939	20520	0.05	3570	372	27000	0.01
229	1230A	264	17100	0.02	1020	445	43404	0.01	1210	879	20520	0.04	5220	370	27000	0.01
230	3440	263	17100	0.02	3490	434	43175	0.01	3490	869	20520	0.04	1750	370	27000	0.01
231	3170A	261	17100	0.02	3890	421	42775	0.01	1830	842	20520	0.04	1170A	369	27000	0.01
232	3070	260	17100	0.02	3500	417	43099	0.01	5190	830	20520	0.04	3300	366	27000	0.01
233	3360	259	17100	0.02	120	382	43613	0.01	610	828	20520	0.04	620	366	27000	0.01
234	1740	258	17100	0.02	3530	375	42862	0.01	3045	774	20520	0.04	3220	364	27000	0.01
235	3580	254	17100	0.01	1460	336	43173	0.01	3240	763	20520	0.04	5250	363	27000	0.01

Caepipe : B31.1 (2022) Code compliance (Sorted stresses) - [lugevalasme.res (C:\Tutorials\LugEvaluation)]

File Results View Options Window Help

#	Sustained				Expansion				Occasional				Hydrotest Stress			
	Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA	Node	SO (psi)	1.2SH (psi)	SO / 1.2SH	Node	SL (psi)	SLA (psi)	SL / SLA
180	3140	420	17100	0.02	3190	1055	42974	0.02	3130	1470	20520	0.07	240	578	27000	0.02
181	5050	413	17100	0.02	1810	1046	42777	0.02	3180	1445	20520	0.07	3630B	563	27000	0.02
182	3170B	411	17100	0.02	1115	1048	42920	0.02	5180	1433	20520	0.07	1460	562	27000	0.02
183	1370	408	17100	0.02	3050	1050	43282	0.02	145	1427	20520	0.07	3490	560	27000	0.02
184	1510	408	17100	0.02	650	1041	43098	0.02	3090B	1418	20520	0.07	1040	558	27000	0.02
185	1880	407	17100	0.02	1080	983	43167	0.02	1420	1403	20520	0.07	3045	553	27000	0.02
186	5070	405	17100	0.02	3570	961	43377	0.02	675	1400	20520	0.07	1830	553	27000	0.02
187	3400	404	17100	0.02	1070	954	43223	0.02	1580	1374	20520	0.07	3860	550	27000	0.02
188	5120A	403	17100	0.02	3590	949	43352	0.02	1180	1362	20520	0.07	3170B	550	27000	0.02
189	3540	400	17100	0.02	3840	923	42776	0.02	5060A	1352	20520	0.07	3130	547	27000	0.02
190	3910	399	17100	0.02	3080	931	43329	0.02	1510	1329	20520	0.06	1570B	542	27000	0.02
191	570	399	17100	0.02	3115	917	42850	0.02	1045	1315	20520	0.06	3310	531	27000	0.02
192	5080	385	17100	0.02	1045	907	42610	0.02	690	1315	20520	0.06	1030	509	27000	0.02

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

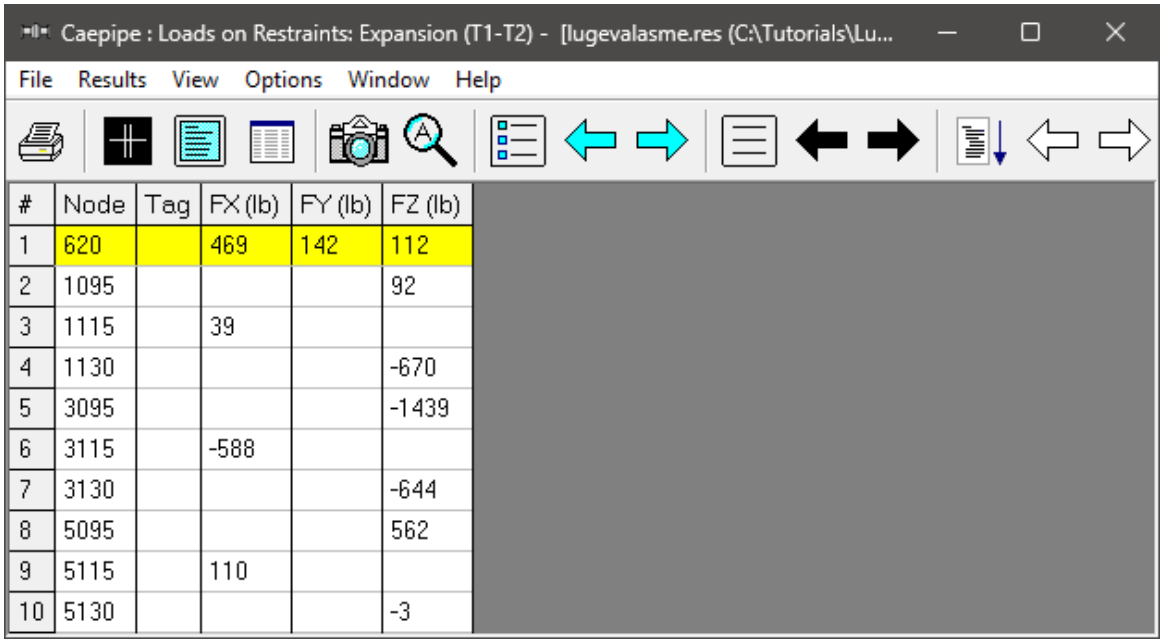
OK Cancel Properties Library

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

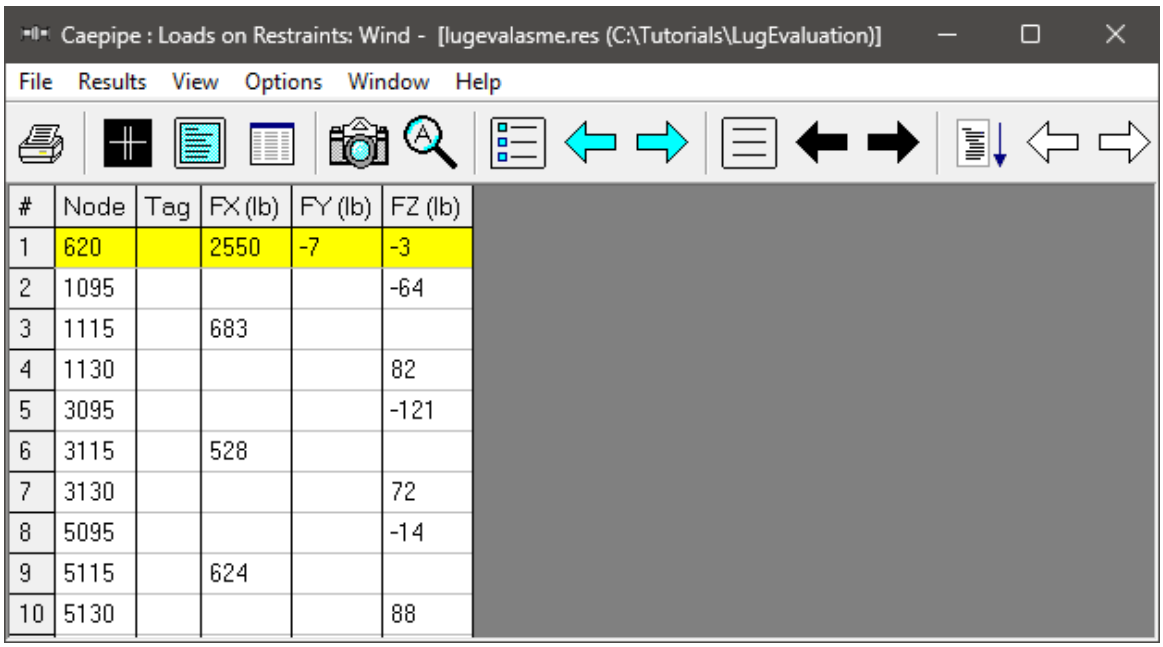
Caepipe : Loads on Restraints: Sustained (W+P) - [lugevalasme.res (C:\Tutorials\Lug...

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

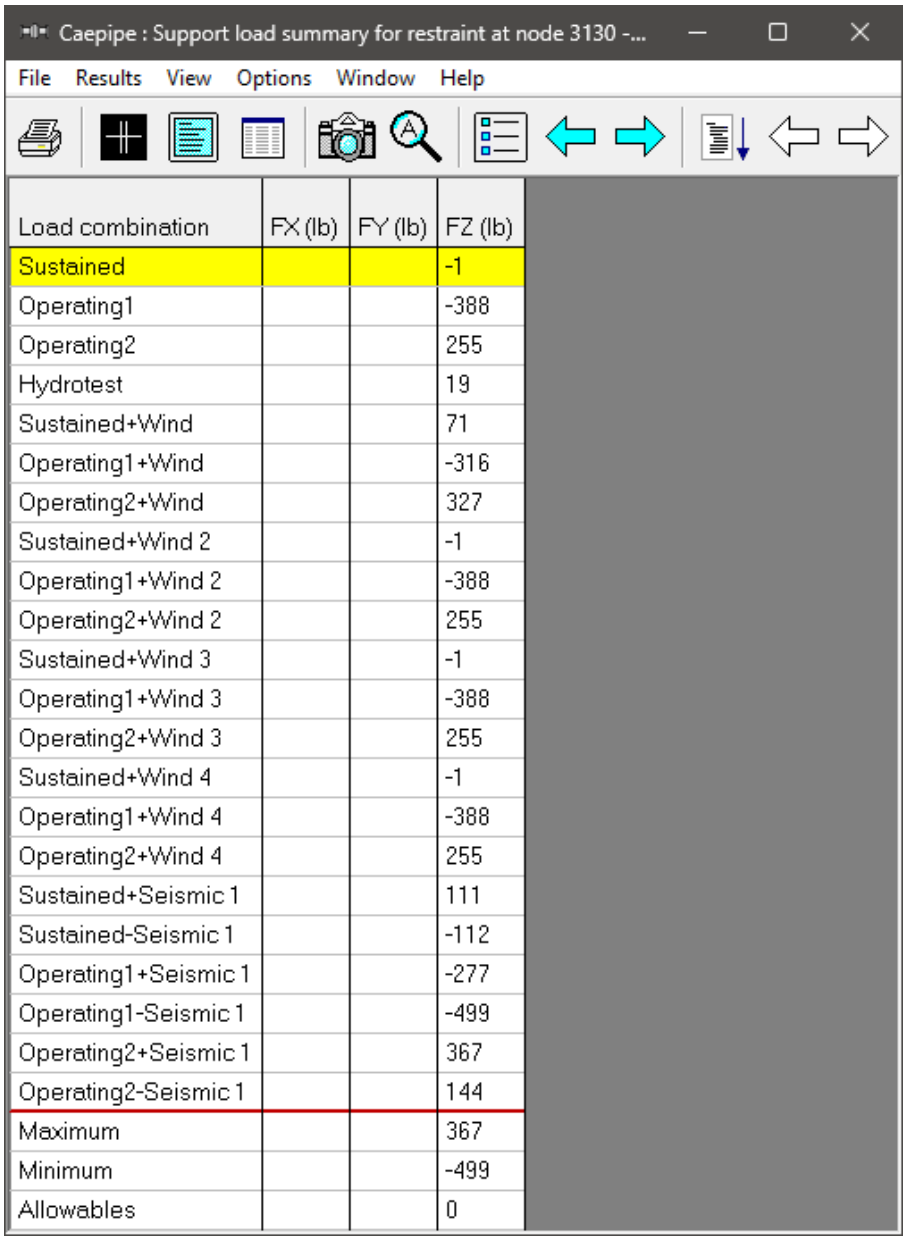


#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)
1	620		469	142	112
2	1095				92
3	1115		39		
4	1130				-670
5	3095				-1439
6	3115		-588		
7	3130				-644
8	5095				562
9	5115		110		
10	5130				-3



#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)
1	620		2550	-7	-3
2	1095				-64
3	1115		683		
4	1130				82
5	3095				-121
6	3115		528		
7	3130				72
8	5095				-14
9	5115		624		
10	5130				88

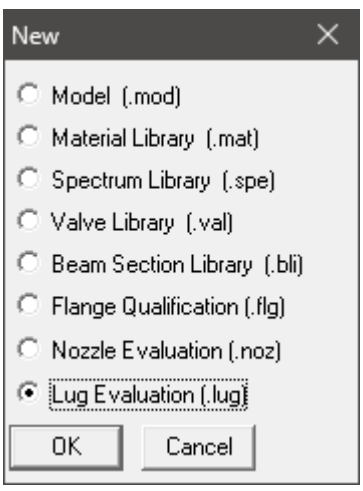
Support Load Summary for Node 3130



Load combination	FX (lb)	FY (lb)	FZ (lb)
Sustained			-1
Operating1			-388
Operating2			255
Hydrotest			19
Sustained+Wind			71
Operating1+Wind			-316
Operating2+Wind			327
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 1			111
Sustained-Seismic 1			-112
Operating1+Seismic 1			-277
Operating1-Seismic 1			-499
Operating2+Seismic 1			367
Operating2-Seismic 1			144
Maximum			367
Minimum			-499
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.

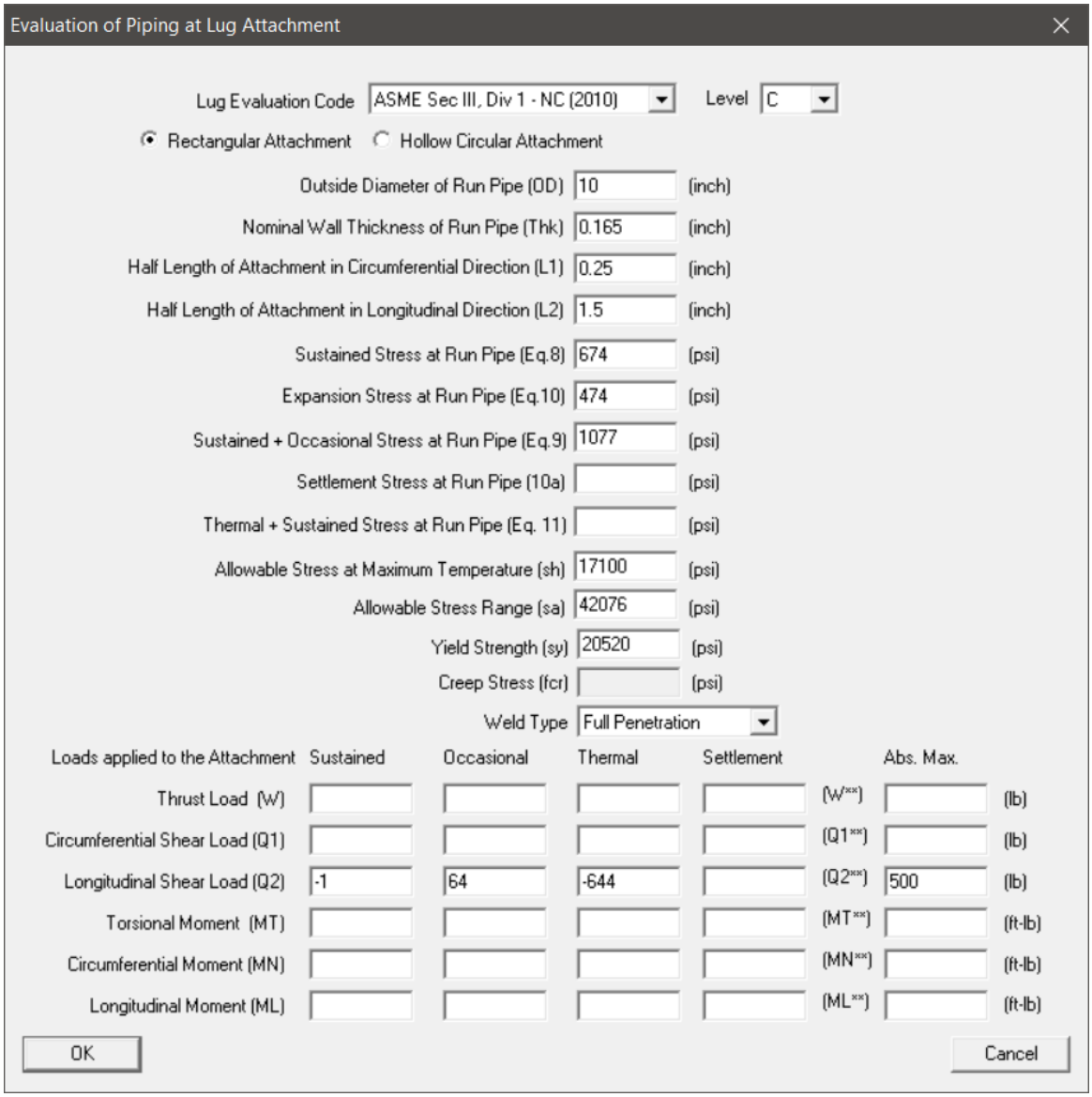


Step 3:

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.

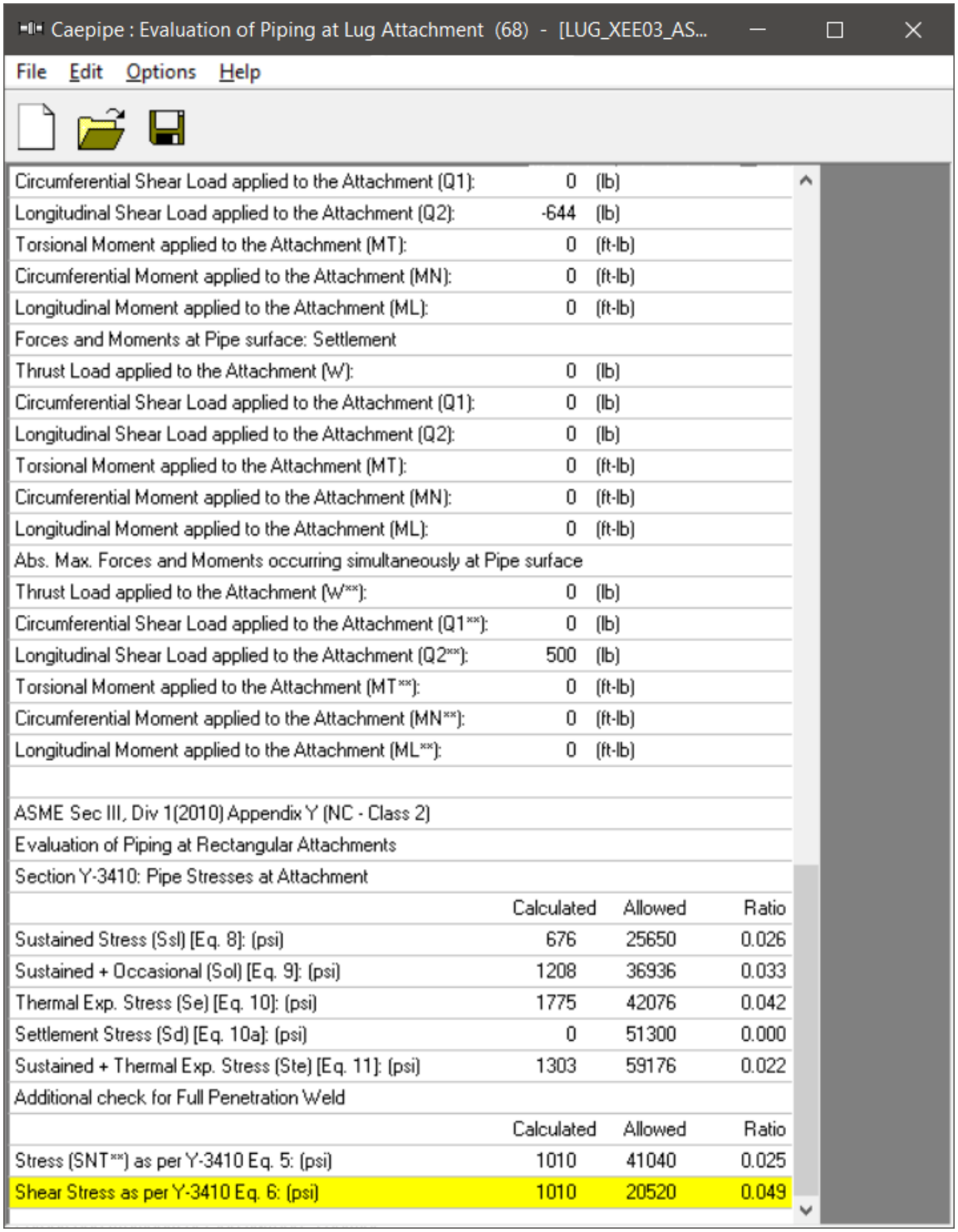
L1 = 0.25 inch (see the picture in page 1 for L1 and L2)

L2 = 1.50 inch



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.



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)
Evaluation of Piping at Rectangular Attachments
Section Y-3410: Pipe Stresses at Attachment

	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**) as per Y-3410 Eq. 5: (psi)	1010	41040	0.025
Shear Stress as per Y-3410 Eq. 6: (psi)	1010	20520	0.049

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.

Title:

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)

Evaluation of Piping at Rectangular Attachments

Section Y-3410: Pipe Stresses at Attachment			
	Calculated (psi)	Allowed (psi)	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 (psi)	Allowed (psi)	Ratio
Stress (SNT**) as per Y-3410 Eq. 5: (psi)	1010	41040	0.025
Shear Stress as per Y-3410 Eq. 6: (psi)	1010	20520	0.049