Tutorial for Modeling Victaulic Coupling in CAEPIPE

The following are the Steps for modeling and including Victaulic Coupling in CAEPIPE analysis.

General

- Victaulic is a developer and producer of mechanical pipe joining systems and is the originator of the grooved coupling pipe joining system.
- Victaulic Grooved Couplings are used to join mechanical pipes together. Grooved coupling pipe joining systems use a roll grooving technique to join pipes and pipe joining components. A groove is placed at the end of two pipes to prepare the pipes engagement with the coupling housing and gasket. The gasket creates a pressure responsive seal on the outside diameter of the pipe, unlike standard compression joints, where pressure acts to separate the seal. The gasket sealing is enhanced as the coupling housing is tightened onto the pipe end. "The economics of the grooved method derive from simplified assembly that involves three basic concepts: a pressure responsive gasket that creates a leak-tight seal; couplings that hold the pipes together; and fasteners that secure the couplings.

Mechanical piping joining systems are being used in HVAC, plumbing, fire protection and mining, water and waste water treatment, oilfield operations, power plants, military, marine systems and other industrial applications due to the time and labor-saving features associated with installation. Mechanical piping joining systems offer an alternative to welding, threading, and flanging for joining two pipe ends. See the figures given below for details.



- The steps provided in this tutorial are applicable for most of the Victaulic Couplings, including Styles 77 and 177. The properties for Style 77 are referred from the document available in the link <u>http://static.victaulic.com/assets/uploads/literature/06.04.pdf</u>. Dimensional details and mechanical properties of Victaulic Coupling are referred from the document given in the above link corresponding to 12" Victaulic Coupling. The same is presented below for quick reference.
- The following report gives a tutorial on modelling Rigid and Flexible Victaulic Couplings in CAEPIPE.

Part 1 - Tutorial for Modeling Rigid Victaulic Coupling

Rigid Victaulic Coupling Catalogue

The Manufacturer's Catalogue for Rigid Victaulic Coupling is shown below for your quick reference.

ictaulic.com												
4.0 DIMENSIONS												
tyle 77												
34 - 12'/20 - 300 mm sizes 14 - 24'/350 - 600 mm sizes Working Size Pipe End Pressure ³ End Load ³ Separation ⁴ Deflection from Centerline ⁴ Bolt/Nut ⁵ Dimensions Weight												
Nominal	Actual Outside Diameter	Maximum	Maximum	Allowable	Per Cplg.	Pipe	Qty.	Size	x	Y	z	Approx. (Each)
Inches DN	Inches	psi kPa	lb N	Inches	Degrees	inches/ft.		Inches	Inches	Inches	Inches mm	lb ka
DIA	5.250	1000	21,635	0-0.13	10-21'	0.28	2	20 x 108	7.63	10.38	2.13	10.0
DN125	5.500	1000	23,745	0-0.13	1°-18′	0.28	2	20 x 108	8.63	10.65	2.13	10.0
6 DN150	6.625	1000	34,470	0-0.13	1~-5'	0.23	2	¥4 x 4%	8.63	11.88	2.13	12.0
Diviso	6.250	1000	30,665	0-0.13	10-9'	0.24	2	20 x 108	8.63	11.50	2.13	13.2
	6.500	1000	33,185	0-0.13	1°-6'	0.23	2	¥4 x 4%	8.88	11.63	2.13	13.2
8 5 DN200	8.625	800 5500	46,740 207995	0-0.13 0-3.2	0°-50'	0.18	2	‰x5	11.00	14.75	2.50 63	20.8
10 ⁵	10.750	800	73,280	0-0.13	0°-40'	0.14	2	1x6	13.63	17.13	2.63	27.8
12.5 DN300	12.750	800	102,000	0-0.13	0°-34′	0.12	2	1 x 6%	15.63	19.25	2.63	31.1
14°	14.000	300	46,180	0-0.13	0=-31'	0.11	2	1x3%	16.75	20.25	3.00	39.2
DN350	355.6	2065 300	205500	0-3.2	0-31'	9	2	1x3%	425	514 20.96	2.80	17.8 48.8
166	377.0	2065 300	230,845 60,320	0-3.2	0=-27'	9	2	1x3%	442 18.75	531 22.25	71 3.00	22.1 45
DN400	406.4	2065 300	268425 66,245	0-3.2	0=27	9	2	1x3%	476	565 22.92	76 2.92	20.4
186	426.0 18.000	2065 300	294,795 76,340	0-3.2	0. 24	9	-	16.54	500 21.56	581 25.00	74 3.13	25.7 64.1
DN450	457.2 18.898	2065 300	339710 84,105	0-3.2 0-0.13	0=-24	7	2	116 x 4	548 22.38	635 25.86	80 3.04	29.1 77.2
2 Westing	480.0	2065	374,265	0-3.2	damal loads	7		Line A	569	655 standard m	77	35 ound in
 Allowable Pipe End Separation and Deflection figures show the maximum nominal range of movement available at each joint for standard roll grooved pipe. Figures for standard roll grooved pipe may be doubled. These figures are maximume; for design and installation purposes these figures should be reduced by: 50% for % – 3 W/20 – 90 mm, 25% for 4/100 mm and larger. Number of bolts required equals number of housing segments. Couplings 8, 10, 12/200, 250, 300 mm sizes available to JIS standards. Refer to Victaulic submittal <u>publication 06.17</u> for details. For 14 – 72/350 – 1800 mm Roll Groove systems Victaulic offers the Advanced Groove System (AGS) line of products. Refer to Victaulic submittal <u>publication 06.17</u> for details. Metric thread size bolts are available (color coded gold) for all coupling sizes upon request. Contact Victaulic for details. WARNING: FOR ONE TIME FIELD TEST ONLY, the Maximum Joint Working Pressure may be increased to 1½ times the figures shown. 												

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The .pdf file of the details of Style 77 Victaulic Couplings downloaded from the link mentioned above is attached herewith for convenience.

Rigid Victaulic Grooved Couplings provide a permanent pipe connection which can withstand full pressure thrust loads at their maximum rated working pressure. Victaulic rigid couplings positively clamp the pipe to create a rigid joint, so axial movement and angular deflection are eliminated. They are particularly useful on risers, mechanical rooms, horizontal runs with numerous branches and other areas where flexibility is not required. Proper rigid coupling installation provides system behavior characteristics similar to those of other rigid systems, in that all piping remains strictly aligned and is not subject to axial or angular movement during operation. For this reason, systems installed with Victaulic rigid couplings utilize support techniques identical to those used in welded systems. **This Rigid Victaulic Coupling can be best represented in CAEPIPE using an element called "Ball joint" with its Rotational and Torsional stiffnesses as 'Rigid' and its Rotational and Torsional limits as NONE.**

Tutorial

Step 1:

Attached is a sample CAEPIPE Stress layout with Rigid Victaulic Couplings (see the "vicsty77_rigid.mod" file). Snapshots of the piping layout along with its details are shown below.

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#	Node	Туре	DX (fi	'in'')	DY	(ft'in'')	DZ (ft'in'')	Matl	Sect	Load	Data			
1	Title =													
2	10	From									Anchor			
3	15		10'0''					A53	12	L1				
4	20		10'0''					A53	12	L1				
5	21	Ball												
6	25		10'0''					A53	12	L1	Y restraint			
7	30		10'0''					A53	12	L1				
8	31	Ball												
9	35		16'0''					A53	12	L1	Y restraint			
10	40		4'0''					A53	12	L1				
11	41	Ball												
12	50	Bend	1'8''					A53	12	L1				
13	60				-1'8			A53	12	L1				
14	61	Ball												
15	70				-20	0''		A53	12	L1		1		
16	71	Ball												
17	80	Bend			-1'8			A53	12	L1				
18	90						1'8''	A53	12	L1				
19	91	Ball												
20	94						4'0''	A53	12	L1	Y restraint			
21	98						12'0''	A53	12	L1	Y restraint			
22	100						4'0''	A53	12	L1				
23	101	Ball												
24	110	Bend					1'8''	A53	12	L1				
25	120		1'8''					A53	12	L1				
26	121	Ball												
27	125		4'0''					A53	12	L1	Y restraint			
28	130		16'0''					A53	12	L1				
29	131	Ball						A53	12	L1				
30	135		10'0''					A53	12	L1	YZ restraint			
31	140		10'0''					A53	12	L1				
32	141	Ball												
33	145		16'0''					A53	12	L1	Y restraint			
34	150		4'0''					A53	12	L1				
(ne	4.004													



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#	Name	Description	Ty pe	Density (Ib/in3)	Nu	Joint factor	Yield (psi)	Tensile (psi)	Fatigue Curve Name	#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)	
1	A53	A53 GRADE A (SEAMLESS)	CS	0.283	0.3	1.00	30000	48000		1	20	29.7E+6	6.32E-6	13700	
2										2	70	29.4E+6	6.40E-6	13700	
										3	100	29.3E+6	6.47E-6	13700	
										4	200	28.8E+6	6.70E-6	13700	
										5	300	28.3E+6	6.90E-6	13700	
										6	400	27.4E+6	7.10E-6	13700	1
										7	500	27.3E+6	7.30E-6	13700	
										8	600	26.5E+6	7.40E-6	13700	
										9	650	26.0E+6	7.50E-6	13700	
										10	700	25.5E+6	7.60E-6	12500	
										11	750	24.9E+6	7.70E-6	10700	
										12	800	24.2E+6	7.80E-6	9000	

1-0-1	Caepip	e 3D+ :	Loads (1) - [vics	.y77_rigio	l.mod (c:∖	users\put	blic\06_v	victaulio	:c	-		\times
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1	<mark>_1</mark> _2	20 400	220	450	1.0								
2													
-0-	Caep	ipe 3D	+ : Pipe	Section	s (1) -	[vicsty77	7_rigid.n	nod (c:	\us	—	C	כ	×
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			w <u>O</u> p	ions <u>N</u>		H	Help		➡				
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Step 2:

You may observe that all of the Victaulic Couplings are modeled using "Ball joints" in CAEPIPE. As an example, the dialogue box corresponding to the Victaulic Coupling (Ball joint) between nodes 20 and 21 is shown below.

Ball joint from 20 to 21 X										
Rotational stiffness	Bending Rigid	Torsional Rigid	(in-lb/deg)							
Rotation limit	None	None	(deg)							
Friction torque			(ft-lb)							
Weight		(Њ)								
ОК	Cancel									

Step 3:

Select the required Load Cases through 'Layout Window > Loads > Load cases'. Save the model and perform the analysis through 'Layout window > File > Analyze'.

Load cases (4)	×
🔽 Sustained (W+P)	🔽 Operating (W+P1+T1)
🔽 Empty Weight (W)	🔲 Design (W+PD+TD)
🔽 Expansion (T1)	🔲 Modal analysis
OK Cancel	All None

Step 4:

The sorted stress, displacments, and support loads of the results are shown below.

⊓∎ Cae	pipe 3D+	: B31.1 (20)22) Code	e compliar	nce (Sort	ted stre	sses) - [v	vicsty77_rigi	d —		\times	
<u>F</u> ile <u>R</u> e	esults <u>V</u> i	ew <u>O</u> ptio	ons <u>W</u> ir	ndow <u>H</u> e	elp							
4	+) 🔍				s S	Á			
	Sustain	ed	E	xpansion								
# Node	SL S	H <u>SL</u> ਗੀ SH	SE Node (n	E SA	SE SA							
1 200	9345 1:	3700 0.68	94 52	263 20550	0.26							
2 181	6262 1:	3700 0.46	50B 46	686 20550	0.23							
3 180	6262 1	3700 0.46	160A 45	547 20550	0.22							
4 175	5794 1	3700 0.42	160B 45	515 20550	0.22							
5 135	5716 1	3700 0.42	35 42	221 20550	0.21							
6 10	5629 1	3700 0.41	110B 34	120 20550	0.17							
7 35	5441 1:	3700 0.40	110A 31	199 20550	0.16							
8 94	5247 1	3700 0.38	200 26	33 20550	0.13							
9 25	4570 1	3700 0.37	808 25	571 20550 Mail 20550	0.13							
10 141	4578 1	3700 0.33	80A 21	142 20550	0.10							
12 145	4539 1	3700 0.33	61 20	150 20550 150 20550	0.10							
13 160E	3 4522 1	3700 0.33	191 17	768 20550	0.09							
14 125	4390 1	3700 0.32	190 17	768 20550	0.09							
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HII Cae	pipe 3D+	: Displacer	ments: O	perating (\	W+P1+	[1) - [vi	csty77_r	igid.res (c:\u	s —		×	
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#			Displaceme	ents (global)		<u> </u>					
1 10	e X (inch)	Y (inch)	∠ (inch)	XX (deg)	YY (deg)		:g) \					
2 15	0.000	-0.027	-0.028	-0.0132	0.0000	1-0.000	2					
3 20	0.253	-0.018	-0.099	-0.0265	0.0412	0.0164						
4 21	0.253	-0.018	-0.099	-0.0265	0.0412	0.0164						
5 25	0.380	0.000	-0.195	-0.0397	0.0488	-0.019	3					
6 30	0.506	-0.087	-0.297	-0.0529	0.0476	-0.037	0					
7 31	0.506	-0.087	-0.297	-0.0529	0.0476	-0.037	0					
8 35	0.709	0.000	-0.430	-0.0741	0.0276	0.0971						
9 40	0.760	0.091	-0.449	-0.0794	0.0191	0.1102	2					
10 41	0.760	0.091	-0.449	-0.0794	0.0191	0.1102	2					
11 5UA	0.762	0.095	-0.450	-0.0796	0.0187	0.1100) 					
12 508	0.800	0.104	-0.421	-0.1056	-0.0151	0.024	2					
14 61	0.800	0.102	-0.417	-0.1058	-0.0156	0.0230	, ;					
15 70	0.763	-0.150	0.099	-0.1465	-0.0792	-0.020	7					
	1	1				,						SI
⊫l∎ Ca	epipe 30	D+ : Load	ls on An	chors in	Global	Coord	inates:	Operating	(W+P1+	T1) - [vics	sty77_r	igid.res (— 🗆 🗙
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4				6	A] 🗲					I () (-
# No	de Tao	EX (b)	EX (Ib)	EZ (Ib)	M×	(ft-lb)	MY (ft-Jb	MZ (ft-lb)				
1 10	109		()		1003	(0. 10) 10		et 20				
		-305	1-1351	- 87	1.111	1.5	/ 7/ 1	1.01.20				
2 200	ן ז ו ו	-305 305	-1351 -2551	-87	-10	738	2321 .9205	11/15				
2 200)	-305 305	-1351 -2551	-87 269	-10	738	9205	1145				

Step 5:

Loads computed at the Ball joints (Victaulic Couplings) can be seen through "Results Window> Results > Element forces" and then, "Results Menu > Results > Other forces > Other". The forces shown below for operating load case 1 (W+P1+T1) results can then be compared against the 'End Loads' provided in the Victaulic Coupling Manufacturer's Catalogue (shown above).

For example, for the considered 12" Victaulic Couplings in the model, the 'End Load' provided in the Victaulic Coupling catalogue is 102,000 lbs which is greater than the maximum of all the Ball joint forces (fx, fy & fz).

-11-	Caep	ipe 30)+:Oth	er force	s in loca	I coordi	inates: C	Operatin	g (W+P 1	I+T1) -	[vicsty7	7_rigid.r	es (c	-	D	×
<u>F</u> il	e <u>R</u> es	ults	<u>V</u> iew	Option:	s <u>W</u> ind	low <u>H</u>	<u>l</u> elp									
4	3				Î	Q			⇒	\equiv	-	⇒	Ī	$\langle \neg$	$\Rightarrow $	[†] G
#	Node	Туре	fx (lb)	fy (Ib)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)								
1	20 21	Ball	-305 -305	619 619	-87 -87	-1013 -1013	1184 1184	1190 1190								
2	30 31	Ball	-305 -305	-975 -975	-87 -87	-1013 -1013	-552 -552	4747 4747								
3	40 41	Ball	-305 -305	2496 2496	-87 -87	-1013 -1013	-2289 -2289	-1458 -1458								
4	60 61	Ball	-2761 -2761	305 305	87 87	2434 2434	1158 1158	5261 5261								
5	70 71	Ball	-4731 -4731	305 305	87 87	2434 2434	2894 2894	-848 -848								
6	90 91	Ball	-87 -87	4995 4995	305 305	1357 1357	-1925 -1925	-5134 -5134								
7	100 101	Ball	-87 -87	855 855	305 305	1357 1357	4184 4184	986 986								
8	120 121	Ball	-305 -305	1119 1119	-87 -87	591 591	4548 4548	-356 -356								
9	130 131	Ball	-305 -305	384 384	-87 -87	591 591	2812 2812	844 844								
10	140 141	Ball	-305 -305	-757 -757	-269 -269	591 591	-747 -747	4580 4580								
11	150 151	Ball	-305 -305	1036 1036	-269 -269	591 591	-6127 -6127	734 734								
12	170 171	Ball	-269 -269	1301 1301	305 305	-1145 -1145	-6066 -6066	-2607 -2607								
13	180 181	Ball	-269 -269	-404 -404	305 305	-1145 -1145	43 43	10469 10469								
14	190 191	Ball	-269 -269	1566 1566	305 305	-1145 -1145	6151 6151	-1153 -1153								

Summary

From the above exercise, it is noted that the loads (fx, fy &fz) at all Victaulic coupling locations (ball joints) computed by CAEPIPE for Operating Load Case 1 are less than the respective Maximum Permissible End Load (102000 lb) provided in the Catalog thereby meeting the criteria.

Part 2 - Tutorial for Modeling Flexible Victaulic Coupling

Flexible Victaulic Couplings permit controlled pipe movement within the couplings while they maintain a positive seal and self-restrained joint. This is achieved because the coupling key section engages but "floats" in the groove. The design allows for expansion, contraction and angular deflection generated by thermal changes, building or ground settlement, and seismic activity. Pipe movement accommodation by Victaulic flexible couplings will minimize the stresses that can be generated by this movement. Victaulic flexible couplings also have superior vibration attenuation characteristics.



This Flexible Victaulic Coupling can be simulated in CAEPIPE using "Bellow and a Tie Rod" as shown in part 2 of this tutorial titled "Tutorial for Modelling Rigid Victaulic Coupling". Flexible Victaulic Coupling Stiffnesses can be obtained from the manufacturer or else, they can be hand calculated using the dimensional properties provided in the Victaulic Coupling Catalogue as shown in the sample calculations provided below.

Axial, lateral, and torsional Stiffnesses of Victaulic AGS Flexible Coupling, Style W77 are not available in the manufacturer's catalog. Hence, these values are calculated manually using the dimensions X, Z, and outer diameter of pipe (=ID of coupling) provided in the Victaulic Coupling Catalogue given above and entered in the stress model.

The properties of NS 12" Victaulic Coupling thus computed are shown below.

Flexible Victaulic Coupling Stiffness Calculation



¾ – 12"/20 – 300 mm sizes

14 – 24"/350 – 600 mm sizes

	Flexible Victaulic Coupling Stiffness Calculations										
										Torsional	
Pipe		Pipe		Moment of		'			Lateral	Stiffness =	
Nominal		Outer	Area (A) =	Inertia (I) =	Elastic	'	Axial	Bending	Stiffness	GJ/L =	
Diamete	1	Diamete	(PI/4)x(X^	(PI/64).(X^4-	Modulus	Length	Stiffness	Stiffness	=	(E/(2.(1+nu))	
r	х	r=0D	2-OD^2)	OD^4)	(E)	(Z)	= AE/L	= 4EI/L	12EI/L^3	.(2I))/L	
(in)	(in)	(in)	(in2)	(in4)	(psi)	(in)	(lb/in)	(in-lb/deg	(lb/in)	(n-lb/deg)	
12	15.63	12.75	64.19	1632.37	3.00E+07	2.63	7.32E+08	7.45E+10	3.23E+10	1.43E+10	

Tutorial

Step 1:

Shown below is a sample CAEPIPE model with Flexible Victaulic Coupling (see the "flexvc_m1_positivetemp.mod" file). As stated above, Flexible Victaulic Coupling is modeled using a combination of Bellow and a Tie Rod between nodes 20 and 30.



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#	Name	Desc	ription	Ty pe	Densi (Ib/in3	ty 3]	Nu	Joint factor	Fatig Curve	ue e Name	#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	A106	A106	Grade A	CS	0.283		0.3	1.00			1	-20	29.9E+6	6.50E-6	30000
2											2	70	29.5E+6	6.50E-6	30000
											3	100	29.3E+6	6.50E-6	30000
											4	150	29.1E+6	6.50E-6	30000
											5	200	28.8E+6	6.50E-6	30000
											6	300	28.6E+6	6.50E-6	30000
											7				
+0- File #	Caepipe Edit	3D+:L View	oads (1) Options) - [1 Mi] (psi) 400	flexvc_r sc W , Pr. Sp gr.	m1_po: indow H becific avity	sitiveter Help Add.Wg (lb/ft)	t. Wind	(c:\us	nd W ad 2 Lo	ind ad 3	Wind Load 4	Snow Ic	e pad	
2		70 400	170	400											
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			tô	9 (2 ا	н			⇒						
#	Name N D	om Sch ia	OD (inch) (Thk jinch)	Cor.Al (inch)	M.Tol (%)	Ins.Der (Ib/ft3)	is Ins.T (inch	ihk Lir i) (Ib	n.Dens /ft3)	Lin.T (inch	hk Soil)			
1	12 1:	2" 105	12.75 (0.18											

Step 2:

- Axial Stiffness of the Tie Rod in Compression and Tension = AE/L = **7.32E+8 lb/inch** (as shown in the table above)
- Gap in Tension = 0.13" (= Maximum Separation for Roll Groove Minimum Separation for Roll Groove = 0.13" 0.0")
- Gap in Compression = **0**" (as the coupler cannot compress any further beyond Minimum Separation)

The above parameters are entered for Tie Rod between Node 20 and 30, as shown in the snapshot below.

Tie rod from 20 to 30 $$? $$ $ imes$									
Stiffness	Tension 7.320E+8	Compressi 7.320E+8	on (lb/inch)						
Gap	0.13	0	(inch)						
ОК	Cance								

Lateral, bending and torsional stiffnesses of the flexible Victaulic Coupling are entered in Bellow's Input Dialogue as shown below. Since the axial stiffness fo the flexible Victaluic Coupling is already input in Tie Rod, the same is entered as 1 (Very Small Non-Zero Number) in Bellow's dialogue.

Bellows from 20 to 30	×
Axial stiffness 1	(lb/inch)
Bending stiffness 7.45E+10	(in-lb/deg)
Torsional stiffness 1.43E+10	(in-lb/deg)
Lateral stiffness 3.23E+10	(lb/inch)
Pressure thrust area	(in2)
Weight 31.1	(lb)
Mean diameter 0	(inch)
OK Cancel	

Step 3:

Select the Load Cases shown below for analysis through Layout Window > Loads > Load cases. Save the model and perform the analysis through Layout window > File > Analyze.

Load cases (3)	×						
☑ Sustained (W+P)	✓ Operating (W+P1+T1)						
Empty Weight (W)	🔲 Design (W+PD+TD)						
🔽 Expansion (T1)	🔲 Modal analysis						
OK Cancel	All None						

Step 4:

From the Displacements and Element forces results of CAEPIPE for "Operating (W+P1+T1)" Load case for the model with temperature Increase, note the following.



-0-	-III Caepipe 3D+ : Pipe forces in local coordinates: Operating (W+P1+T1) - [flexvc_m1_positivetemp.r — 🛛 🗙														
<u>F</u> ile	<u>File R</u> esults <u>V</u> iew <u>O</u> ptions <u>W</u> indow <u>H</u> elp														
$ \blacksquare \blacksquare \blacksquare \blacksquare \land \land \land \models \rightarrow \blacksquare \leftarrow \rightarrow \blacksquare \land \neg \land \land \models \land \land$															
#	Node	Node Axial y Shear z		z Shear	Torsio	n(ft-lb)	-lb) Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			Sopr	
		(lb)	(lb)	(Њ)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)	
1	10 20	-4598 -4598	717 911	0 0	0 0		5526 -986		0 0					9149 6675	
2	30 40A	-4598 -4598	942 1002	0 0	0 0		-1189 -3619		0 0					6786 8109	
3	40A 40B	-4598 -1059	-1002 4598	0 0	0 0		3619 -1745	2.91 2.91	0 0	2.42 2.42	13.77 13.77	13.77 13.77		11868 9399	
4	40B 50	-1059 -1168	4598 4598	0 0	0 0		-1745 -22437		0 0					7586 18844	

- The <u>differential Axial displacement</u> between Nodes 20 and 30 = abs[0.069 (0.069)] = 0.0" < 0.13" (Pipe End Separation specified in the catalog 0.13").
- The <u>differential Angular Deflection</u> = abs[0.0382 0.0382)] = 0 deg < 0.58 deg (Allowable Deflection specified in the catalog).
- Axial Load at Tie Rod = -4598 lb < 102000 lb (End Load specified in the catalog).

Summary

From the above exercise, it is noted that the differential Axial displacement, differential Angular rotation and Axial load at Tie Rod computed by CAEPIPE for Operating Load Case 1 for Coupling modeled between Nodes 20 and 30 for Temperature Increase are less than the respective Allowable Linear Movement (0.13"), Angular Deflection (0.58 deg) and Maximum Permissible End Load (102000 lb) provided in the Catalog, thereby meeting the criteria.