Tutorial on Analysis with Multiple Thermal Loads using CAEPIPE

General

The Reference Temperature (can be defined through Layout window > Options > Analysis" is "the ambient temperature at which the pipe is to be/was initially installed". In other words, when the whole piping system is at Reference Temperature, the piping system is "stress free" and the involved pipe supports are "loads free", as long as there are NO cold springs introduced during the installation of the system. There is no need to input Reference Pressure, as at installation the pressure is zero.

T1, T2 etc. (tuned ON through the "Layout window > Loads > Load cases") refer to the temperatures prevailing during different operational states of the piping system. Please note that the value of T1 for the first operational state could be different for different portions of the piping system. In other words, you could input multiple values for T1 (by having at least that many "Loads") corresponding to different portions of the piping. In addition, the same element in the piping system can experience different temperatures T1, T2, T3 etc. during different operational states.

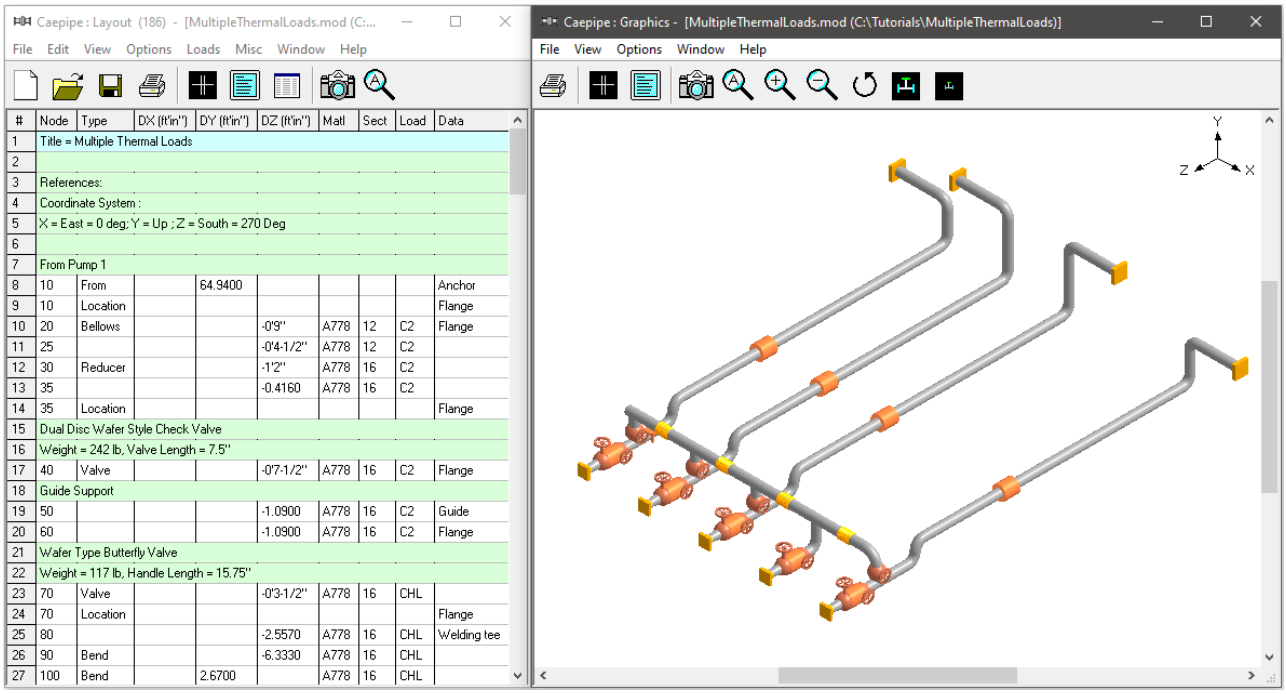
Hence, the Expansion (T1) case in the Results lists the "Range Solution" obtained for the temperature range from Reference Temperature to T1 [i.e., (T1 – Tref)], similarly for Expansion (T2), and so on. The Expansion (T1-T2) case in the Results lists the "Range Solution" obtained for the temperature range from T1 to T2, which is internally computed as [(T1 - Tref) – (T2 – Tref)], similarly for Expansion (T1-T3) and so on.

For the operating (W+P1+T1) case, CAEPIPE considers the weight, the pressure P1 corresponding to T1 and the expansion from Tref to T1.

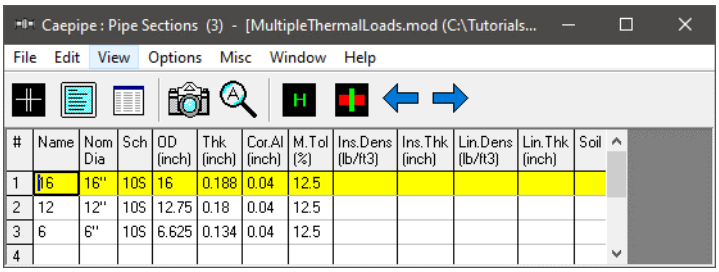
The following are the Steps for performing Analysis with Multiple Thermal loads in CAEPIPE.

The attached stress system shows the layout of four (4) pipelines. These pipelines are connected to five (5) centrifugal pumps at one end (with one of them being the Spare) and four (4) tanks at the other end. Out of those 5 centrifugal pumps, Pump 2 is the Spare and will turn into operation when one of the other 4 pumps fails. In other words, at any point in time, 4 pumps are operating with 1 pump either on standby or not operational. To represent these, the following thermal load cases are required (see the attached model).

Cases	Description
Case 1	Pump 2 (the Spare) is "OFF" and the remaining Pumps are "ON"
Case 2	Pump 1 is "OFF" and the remaining Pumps (including Spare) are "ON"
Case 3	Pump 3 is "OFF" and the remaining Pumps (including Spare) are "ON"
Case 4	Pump 4 is "OFF" and the remaining Pumps (including Spare) are "ON"
Case 5	Pump 5 is "OFF" and the remaining Pumps (including Spare) are "ON"



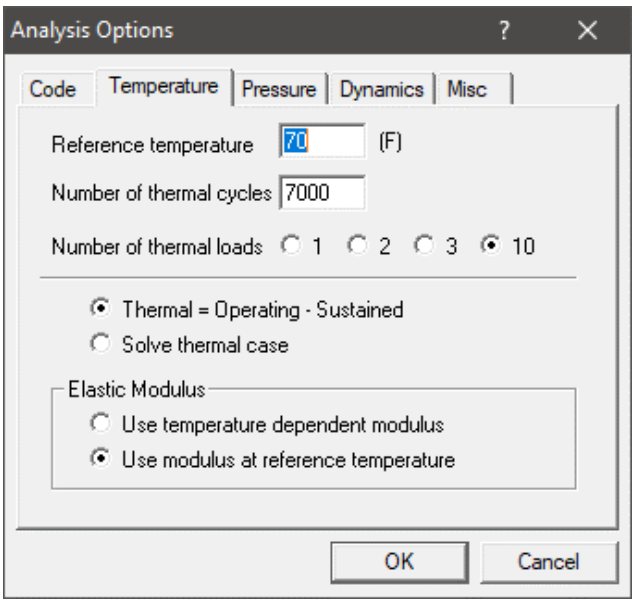
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Multiple Thermal Loads								
2									
3	References:								
4	Coordinate System :								
5	X = East = 0 deg; Y = Up ; Z = South = 270 Deg								
6									
7	From Pump 1								
8	10	From		64.9400					Anchor
9	10	Location							Flange
10	20	Bellows			-0'9"	A778	12	C2	Flange
11	25				-0'4-1/2"	A778	12	C2	
12	30	Reducer			-1'2"	A778	16	C2	
13	35				-0.4160	A778	16	C2	
14	35	Location							Flange
15	Dual Disc Wafer Style Check Valve								
16	Weight = 242 lb, Valve Length = 7.5"								
17	40	Valve			-0'7-1/2"	A778	16	C2	Flange
18	Guide Support								
19	50				-1.0900	A778	16	C2	Guide
20	60				-1.0900	A778	16	C2	Flange
21	Wafer Type Butterfly Valve								
22	Weight = 117 lb, Handle Length = 15.75"								
23	70	Valve			-0'3-1/2"	A778	16	CHL	
24	70	Location							Flange
25	80				-2.5570	A778	16	CHL	Welding tee
26	90	Bend			-6.3330	A778	16	CHL	
27	100	Bend		2.6700		A778	16	CHL	



#	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)	Soil
1	16	16"	10S	16	0.188	0.04	12.5					
2	12	12"	10S	12.75	0.18	0.04	12.5					
3	6	6"	10S	6.625	0.134	0.04	12.5					
4												

Step 1:

The above cases can be defined in CAEPIPE by defining the “Number of Thermal loads” as 10 through Layout window > Options > Analysis > Temperature.

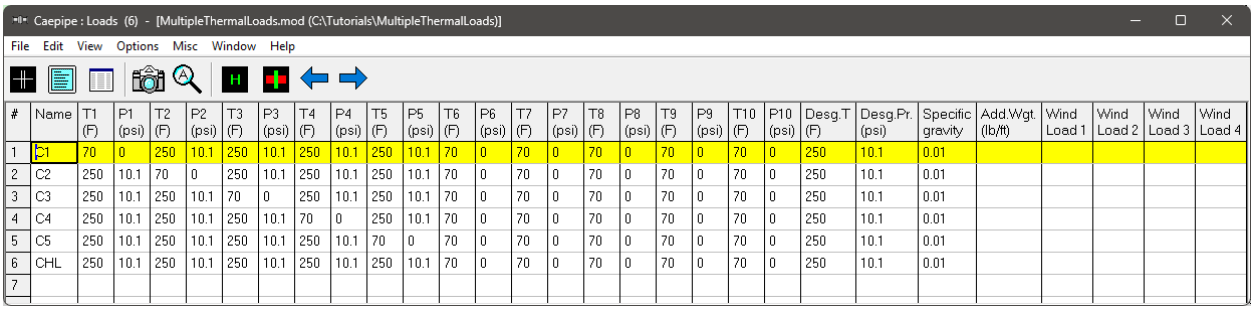


Step 2:

Define the Pressures and Temperatures for different operating cases described above through CAEPIPE Layout window > Misc > Loads. Description corresponding to Loads C1 through CHL is given in the table below for clarity.

Cases	Description	Pressures and Temperatures
Case 1	Spare Pump at Node 1010 is “OFF” and the remaining Pumps are “ON”	For C1, T1 = 70 degF; P1 = 0 psi. For others (C2 through C5), T1 = 250 degF and P1 = 10.1 psi
Case 2	Pump 1 at Node 10 is “OFF” and the remaining Pumps are “ON”	For C2, T2 = 70 degF; P2 = 0 psi. For others, T2 = 250 degF and P2 = 10.1 psi
Case 3	Pump 2 at Node 2010 is “OFF” and the remaining Pumps are “ON”	For C3, T3 = 70 degF; P3 = 0 psi. For others, T3 = 250 degF and P3 = 10.1 psi
Case 4	Pump 3 at Node 3010 is “OFF” and the remaining Pumps are “ON”	For C4, T4 = 70 degF; P4 = 0 psi. For others, T4 = 250 degF and P4 = 10.1 psi
Case 5	Pump 4 at Node 4010 is “OFF” and the remaining Pumps are “ON”	For C5, T5 = 70 degF; P5 = 0 psi. For others, T5 = 250 degF and P5 = 10.1 psi
Load with name “CHL” is defined to represent the portion of the piping that are always HOT irrespective of which pump is OFF. Hence, the T1 through T5 is 250 deg F and P1 through P5 is 10.1 psi. The Load cases and Load combinations defined in the model can be seen using Layout window > Misc > Loads and Layout Window > Loads > Load cases respectively.		

Define the loads C1 through CHL as shown in the snap shot below.

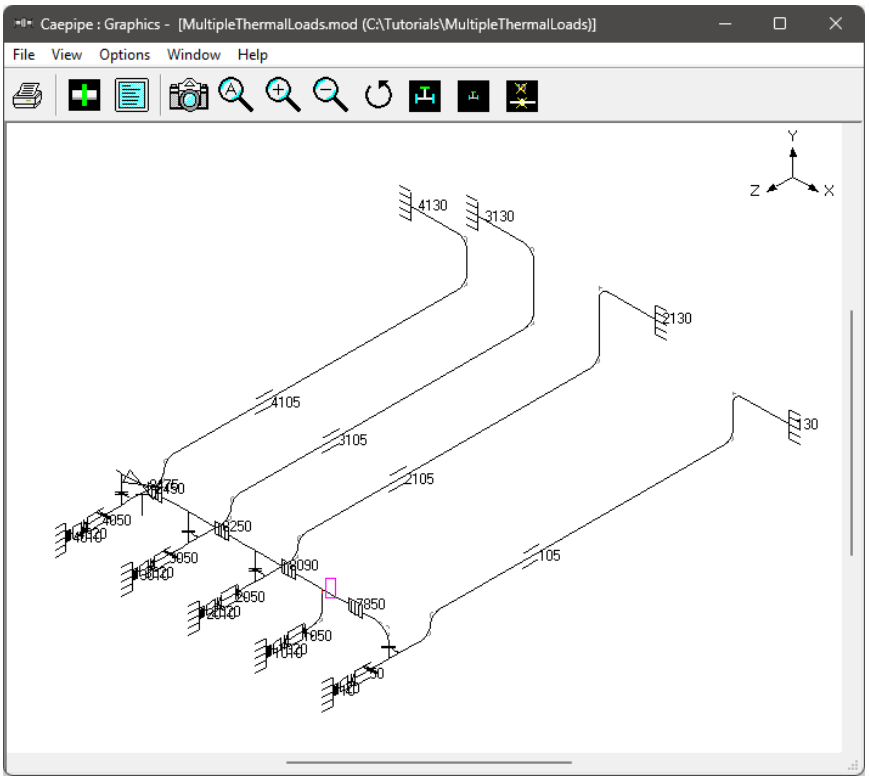


#	Name	T1 (F)	P1 (psi)	T2 (F)	P2 (psi)	T3 (F)	P3 (psi)	T4 (F)	P4 (psi)	T5 (F)	P5 (psi)	T6 (F)	P6 (psi)	T7 (F)	P7 (psi)	T8 (F)	P8 (psi)	T9 (F)	P9 (psi)	T10 (F)	P10 (psi)	Desg.T (F)	Desg.Pr. (psi)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load 1	Wind Load 2	Wind Load 3	Wind Load 4
1	C1	70	0	250	10.1	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
2	C2	250	10.1	70	0	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
3	C3	250	10.1	250	10.1	70	0	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
4	C4	250	10.1	250	10.1	250	10.1	70	0	250	10.1	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
5	C5	250	10.1	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
6	CHL	250	10.1	250	10.1	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	250	10.1	0.01					
7																													

Step 3:

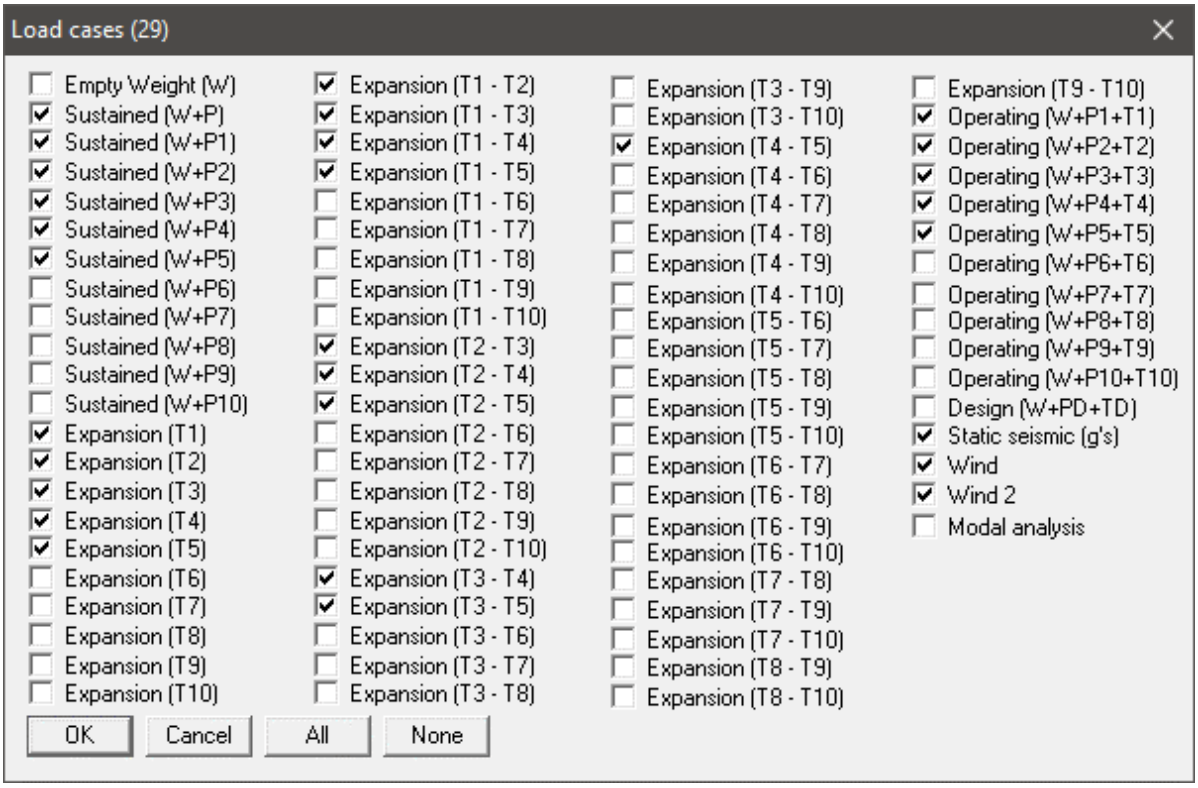
Assign the Loads C1 through CHL to different portions of stress system as required while creating the stress layout. After modeling the stress system, one can review the loads assigned to different portions using the Highlight feature through “Loads List window”.

From the attached model, to review the loads assigned, place the highlight on each load (C1 through CHL) and press “Ctrl+H” or select option “Highlight” under List window >View to highlight only that portion of the model that is using that specific load. The snap shot below highlight only that portion of the model that is using the Load C1.



Step 4:

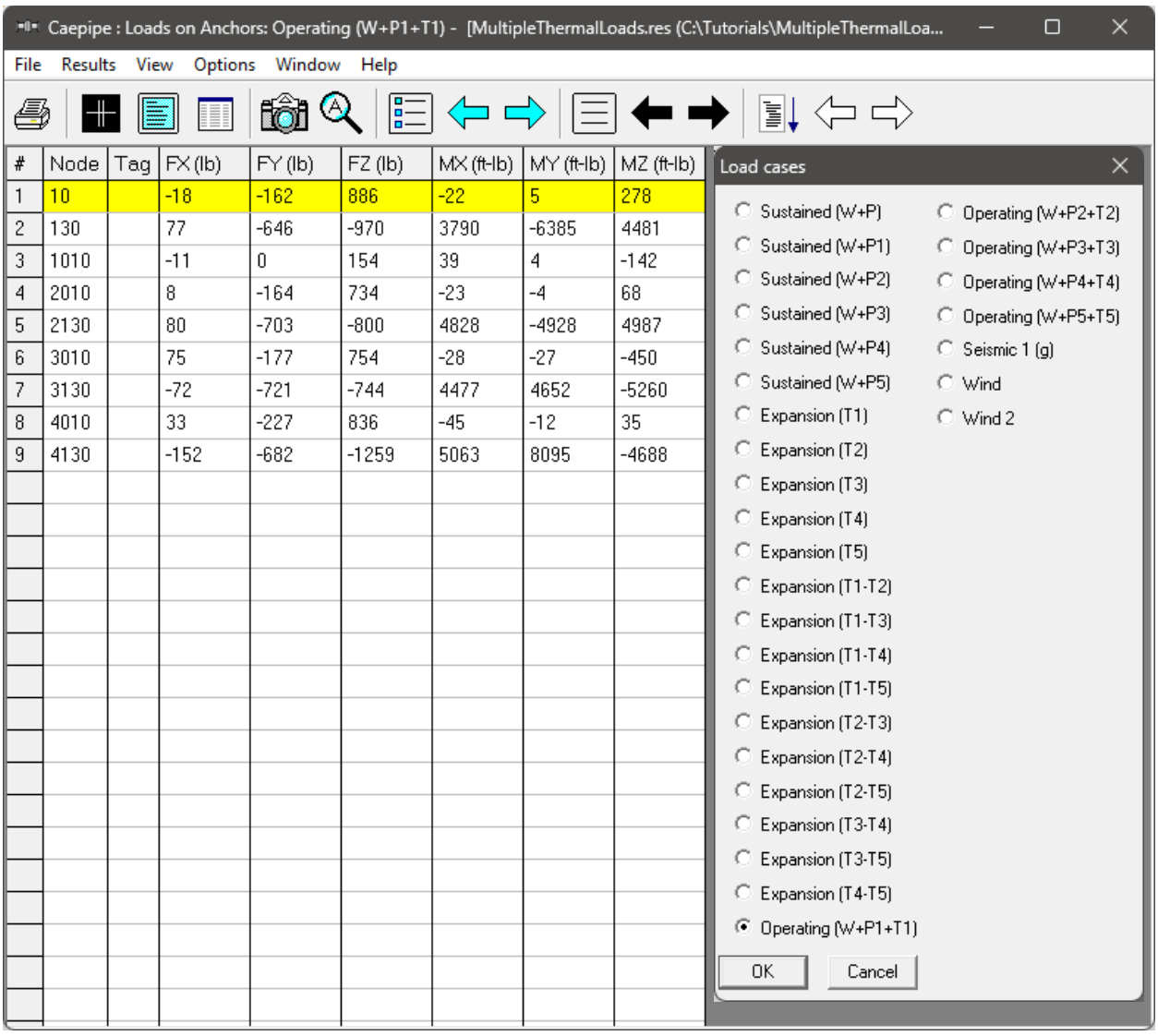
Select the load cases and load combinations required for analysis through Layout window > Loads > Load cases.

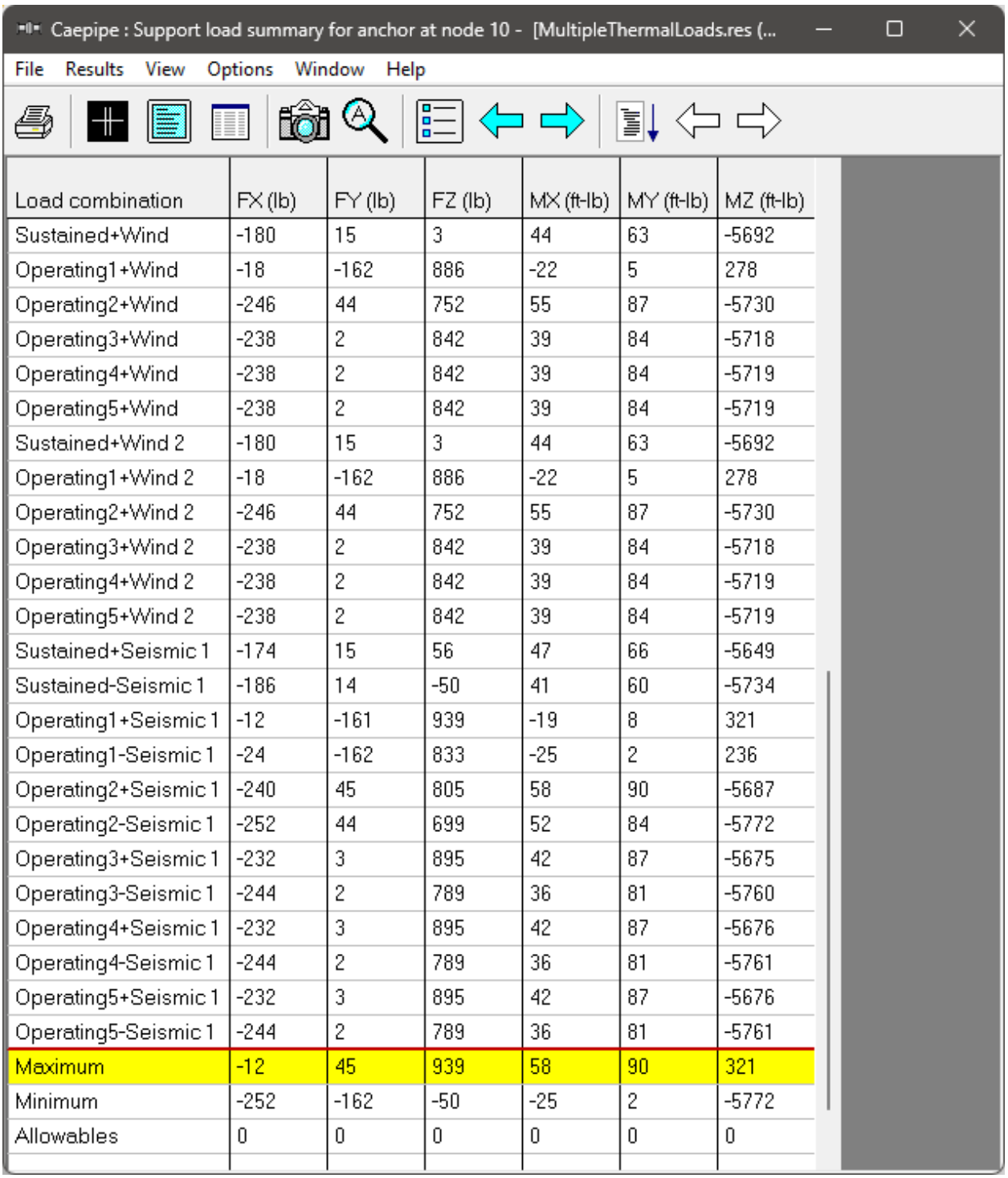


Step 5:

Save the model and perform analysis through Layout window > File > Analyze.

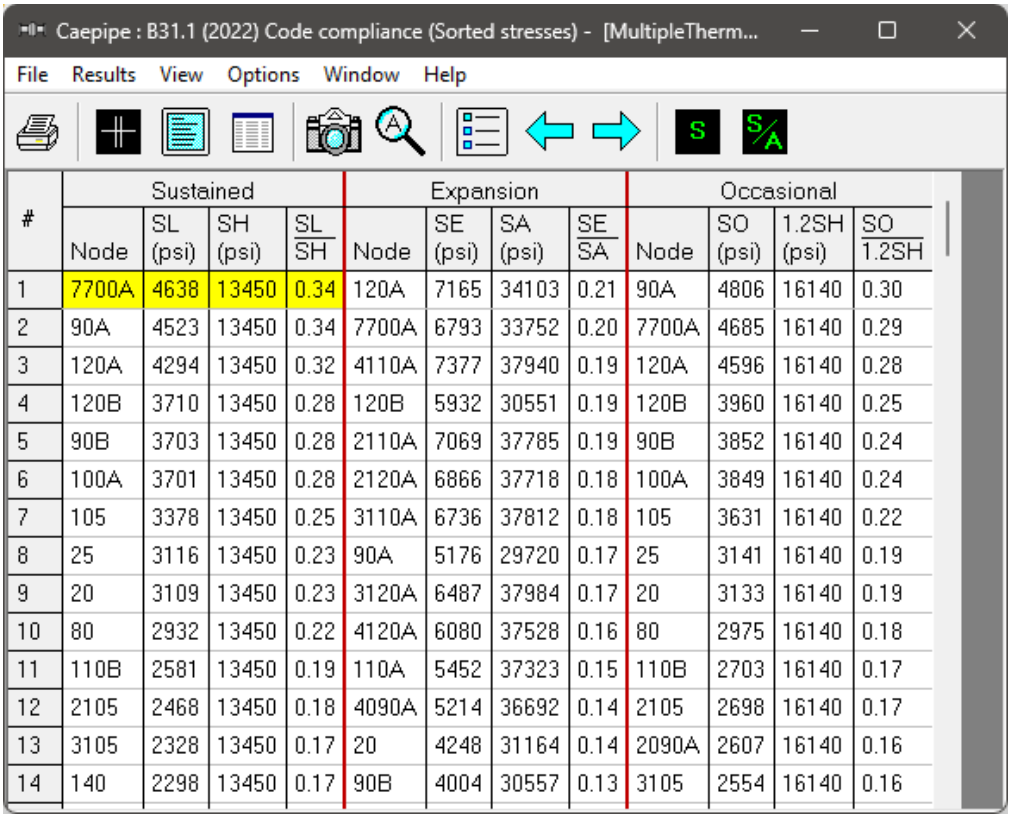
In order to understand the loads and load combinations used for analysis, review the CAEPIPE results file for Support Loads (loads acting on the supports by the piping for each load case), Element Forces & Moments (local/global forces and moments on each element for each load case) and Support Load Summary (listing support loads at particular support for all relevant load cases and load combinations).





Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained+Wind	-180	15	3	44	63	-5692
Operating1+Wind	-18	-162	886	-22	5	278
Operating2+Wind	-246	44	752	55	87	-5730
Operating3+Wind	-238	2	842	39	84	-5718
Operating4+Wind	-238	2	842	39	84	-5719
Operating5+Wind	-238	2	842	39	84	-5719
Sustained+Wind 2	-180	15	3	44	63	-5692
Operating1+Wind 2	-18	-162	886	-22	5	278
Operating2+Wind 2	-246	44	752	55	87	-5730
Operating3+Wind 2	-238	2	842	39	84	-5718
Operating4+Wind 2	-238	2	842	39	84	-5719
Operating5+Wind 2	-238	2	842	39	84	-5719
Sustained+Seismic 1	-174	15	56	47	66	-5649
Sustained-Seismic 1	-186	14	-50	41	60	-5734
Operating1+Seismic 1	-12	-161	939	-19	8	321
Operating1-Seismic 1	-24	-162	833	-25	2	236
Operating2+Seismic 1	-240	45	805	58	90	-5687
Operating2-Seismic 1	-252	44	699	52	84	-5772
Operating3+Seismic 1	-232	3	895	42	87	-5675
Operating3-Seismic 1	-244	2	789	36	81	-5760
Operating4+Seismic 1	-232	3	895	42	87	-5676
Operating4-Seismic 1	-244	2	789	36	81	-5761
Operating5+Seismic 1	-232	3	895	42	87	-5676
Operating5-Seismic 1	-244	2	789	36	81	-5761
Maximum	-12	45	939	58	90	321
Minimum	-252	-162	-50	-25	2	-5772
Allowables	0	0	0	0	0	0

The Sorted Stresses in CAEPIPE lists the maximum of Expansion stresses for all thermal range cases at each node as well as the maximum of Sustained + Occasional stresses for all Occasional cases at each node. On the other hand, for the Sustained case, it always uses the maximum pressure among the input pressures (P1 through P10) while computing Sustained Stress at each node.



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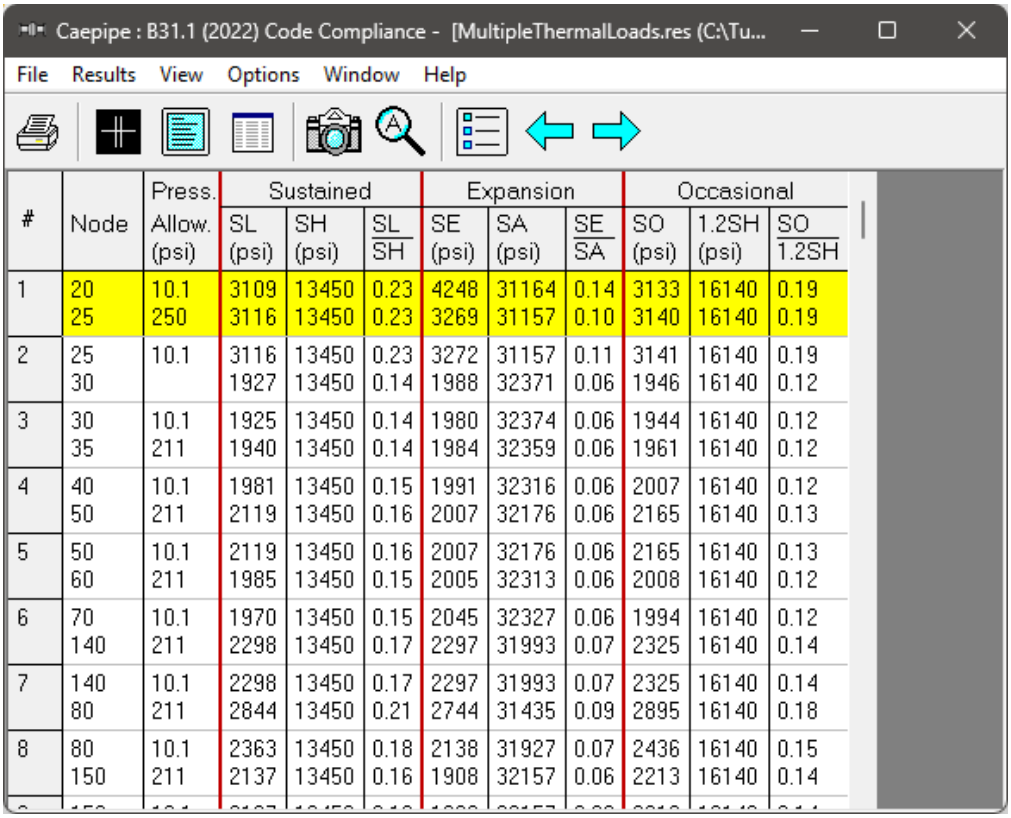
File Results View Options Window Help

#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA	Node	SO (psi)	1.2SH (psi)	SO / 1.2SH
1	7700A	4638	13450	0.34	120A	7165	34103	0.21	90A	4806	16140	0.30
2	90A	4523	13450	0.34	7700A	6793	33752	0.20	7700A	4685	16140	0.29
3	120A	4294	13450	0.32	4110A	7377	37940	0.19	120A	4596	16140	0.28
4	120B	3710	13450	0.28	120B	5932	30551	0.19	120B	3960	16140	0.25
5	90B	3703	13450	0.28	2110A	7069	37785	0.19	90B	3852	16140	0.24
6	100A	3701	13450	0.28	2120A	6866	37718	0.18	100A	3849	16140	0.24
7	105	3378	13450	0.25	3110A	6736	37812	0.18	105	3631	16140	0.22
8	25	3116	13450	0.23	90A	5176	29720	0.17	25	3141	16140	0.19
9	20	3109	13450	0.23	3120A	6487	37984	0.17	20	3133	16140	0.19
10	80	2932	13450	0.22	4120A	6080	37528	0.16	80	2975	16140	0.18
11	110B	2581	13450	0.19	110A	5452	37323	0.15	110B	2703	16140	0.17
12	2105	2468	13450	0.18	4090A	5214	36692	0.14	2105	2698	16140	0.17
13	3105	2328	13450	0.17	20	4248	31164	0.14	2090A	2607	16140	0.16
14	140	2298	13450	0.17	90B	4004	30557	0.13	3105	2554	16140	0.16

Similarly, Code Compliance report lists the Stresses element-wise following the same procedure as done for Sorted Stresses.



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File Results View Options Window Help

#	Node	Press. Allow. (psi)	Sustained			Expansion			Occasional		
			SL (psi)	SH (psi)	SL / SH	SE (psi)	SA (psi)	SE / SA	SO (psi)	1.2SH (psi)	SO / 1.2SH
1	20 25	10.1 250	3109 3116	13450 13450	0.23 0.23	4248 3269	31164 31157	0.14 0.10	3133 3140	16140 16140	0.19 0.19
2	25 30	10.1	3116 1927	13450 13450	0.23 0.14	3272 1988	31157 32371	0.11 0.06	3141 1946	16140 16140	0.19 0.12
3	30 35	10.1 211	1925 1940	13450 13450	0.14 0.14	1980 1984	32374 32359	0.06 0.06	1944 1961	16140 16140	0.12 0.12
4	40 50	10.1 211	1981 2119	13450 13450	0.15 0.16	1991 2007	32316 32176	0.06 0.06	2007 2165	16140 16140	0.12 0.13
5	50 60	10.1 211	2119 1985	13450 13450	0.16 0.15	2007 2005	32176 32313	0.06 0.06	2165 2008	16140 16140	0.13 0.12
6	70 140	10.1 211	1970 2298	13450 13450	0.15 0.17	2045 2297	32327 31993	0.06 0.07	1994 2325	16140 16140	0.12 0.14
7	140 80	10.1 211	2298 2844	13450 13450	0.17 0.21	2297 2744	31993 31435	0.07 0.09	2325 2895	16140 16140	0.14 0.18
8	80 150	10.1 211	2363 2137	13450 13450	0.18 0.16	2138 1908	31927 32157	0.07 0.06	2436 2213	16140 16140	0.15 0.14