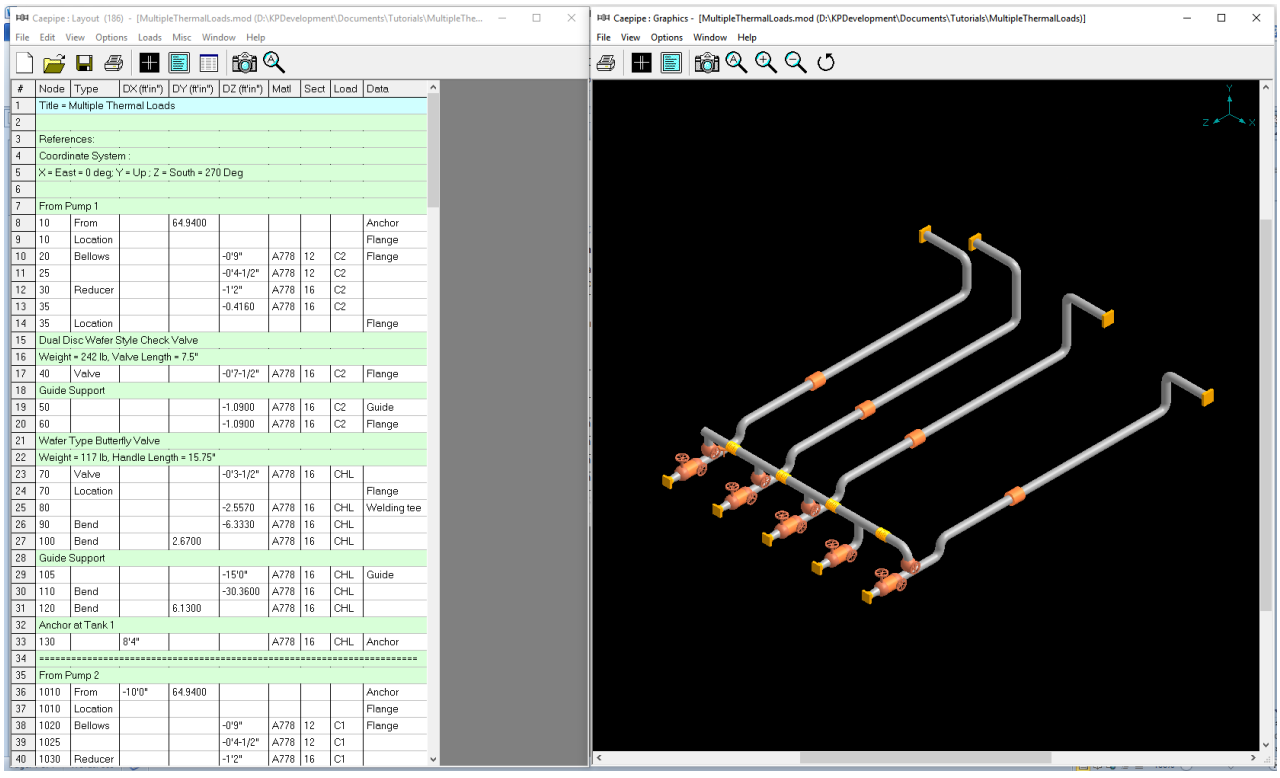
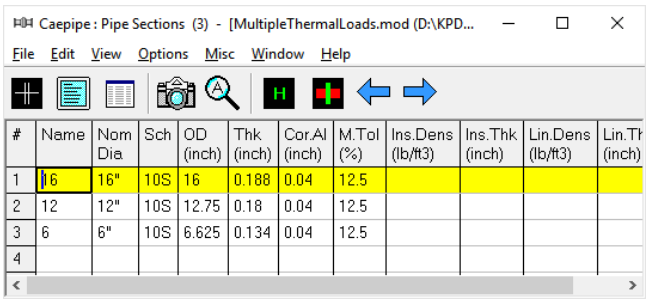
Tutorial on Analysis with Multiple Thermal Loads using CAEPIPE

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

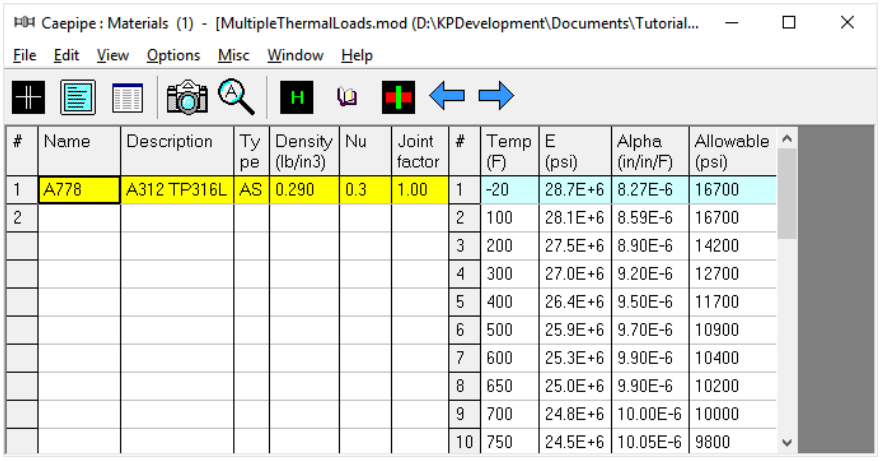
The attached stress system shows the layout of four (4) pipelines. These pipelines are connected to five (5) centrifugal pumps at one end (with one of them being the Spare) and four (4) tanks at the other end. Out of those 5 centrifugal pumps, Pump 2 is the Spare and will turn into operation when one 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”





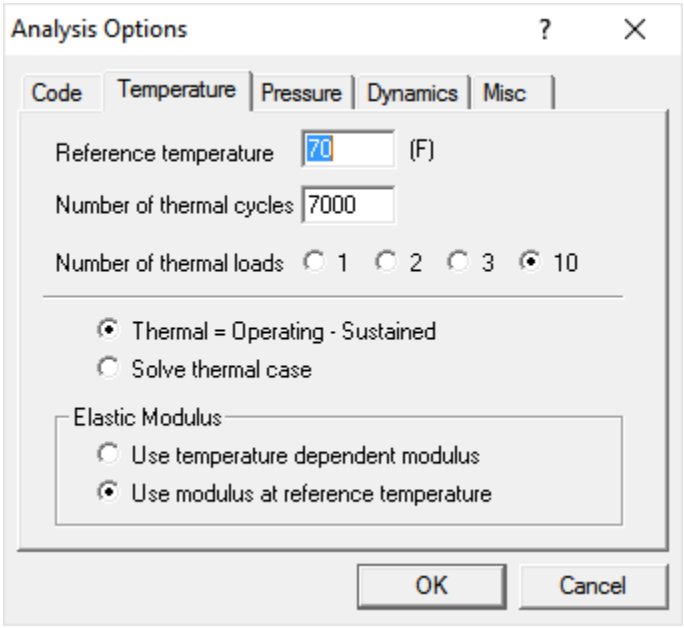
#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Th (inch)
1	16	16"	10S	16	0.188	0.04	12.5				
2	12	12"	10S	12.75	0.18	0.04	12.5				
3	6	6"	10S	6.625	0.134	0.04	12.5				
4											



#	Name	Description	Type	Density (lb/in3)	Nu	Joint factor	#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	A778	A312 TP316L	AS	0.290	0.3	1.00	1	-20	28.7E+6	8.27E-6	16700
2							2	100	28.1E+6	8.59E-6	16700
							3	200	27.5E+6	8.90E-6	14200
							4	300	27.0E+6	9.20E-6	12700
							5	400	26.4E+6	9.50E-6	11700
							6	500	25.9E+6	9.70E-6	10900
							7	600	25.3E+6	9.90E-6	10400
							8	650	25.0E+6	9.90E-6	10200
							9	700	24.8E+6	10.00E-6	10000
							10	750	24.5E+6	10.05E-6	9800

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.

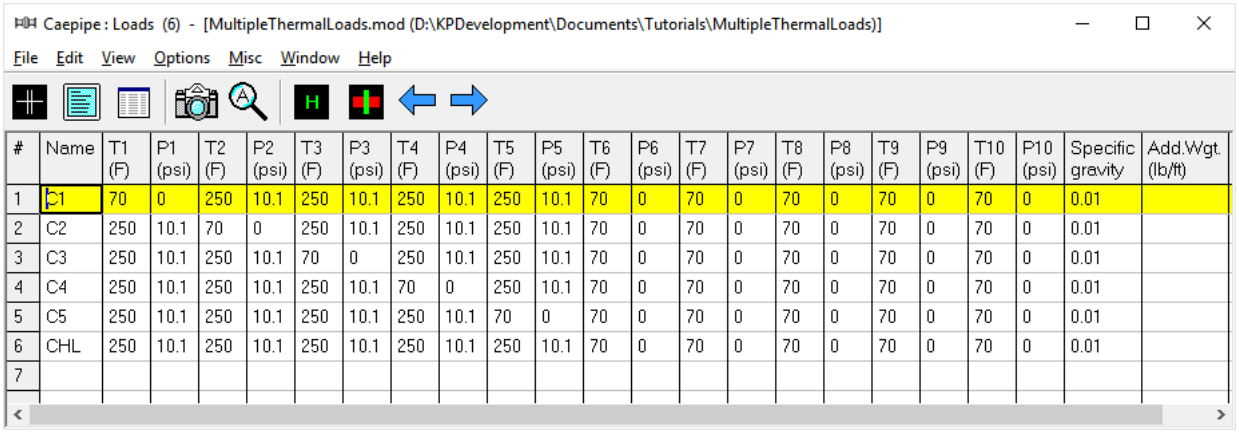


Step 2:

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.

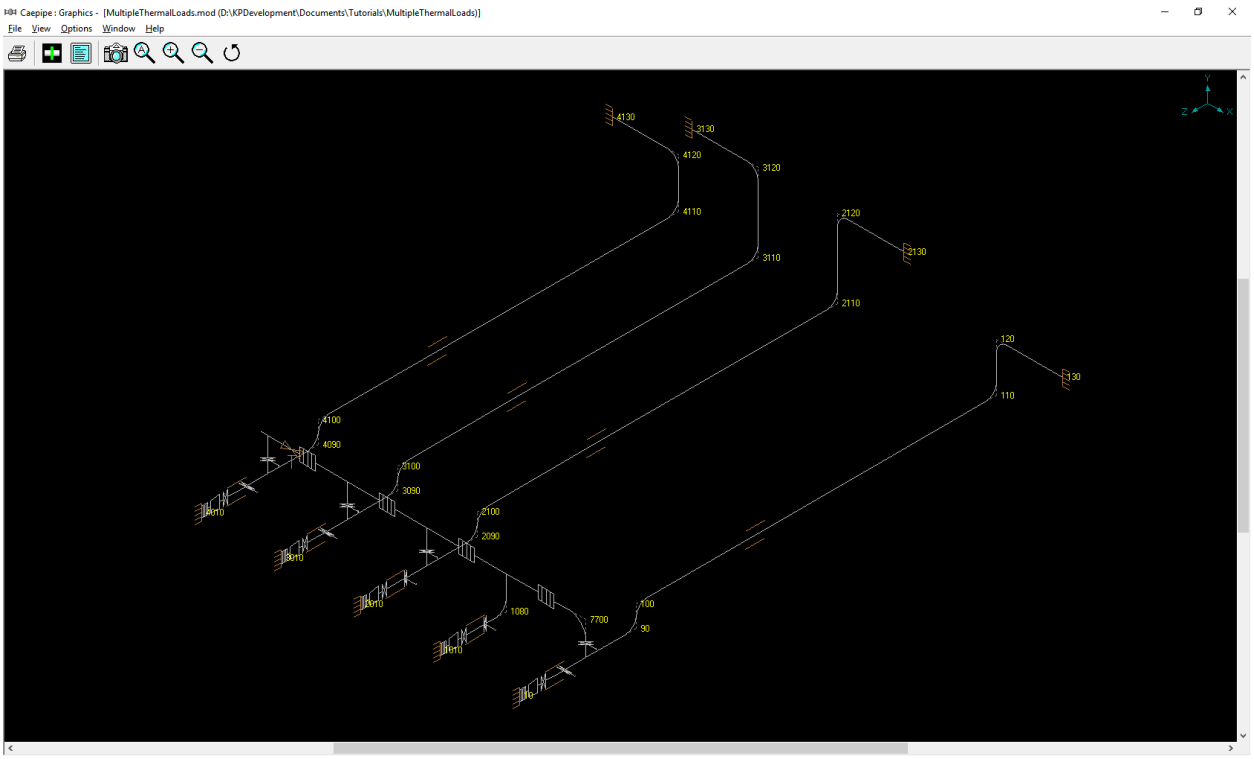


#	Name	T1 (F)	P1 (psi)	T2 (F)	P2 (psi)	T3 (F)	P3 (psi)	T4 (F)	P4 (psi)	T5 (F)	P5 (psi)	T6 (F)	P6 (psi)	T7 (F)	P7 (psi)	T8 (F)	P8 (psi)	T9 (F)	P9 (psi)	T10 (F)	P10 (psi)	Specific gravity	Add.Wgt. (lb/ft)
1	C1	70	0	250	10.1	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	0.01	
2	C2	250	10.1	70	0	250	10.1	250	10.1	250	10.1	70	0	70	0	70	0	70	0	70	0	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	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	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	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	0.01	
7																							

Step 3:

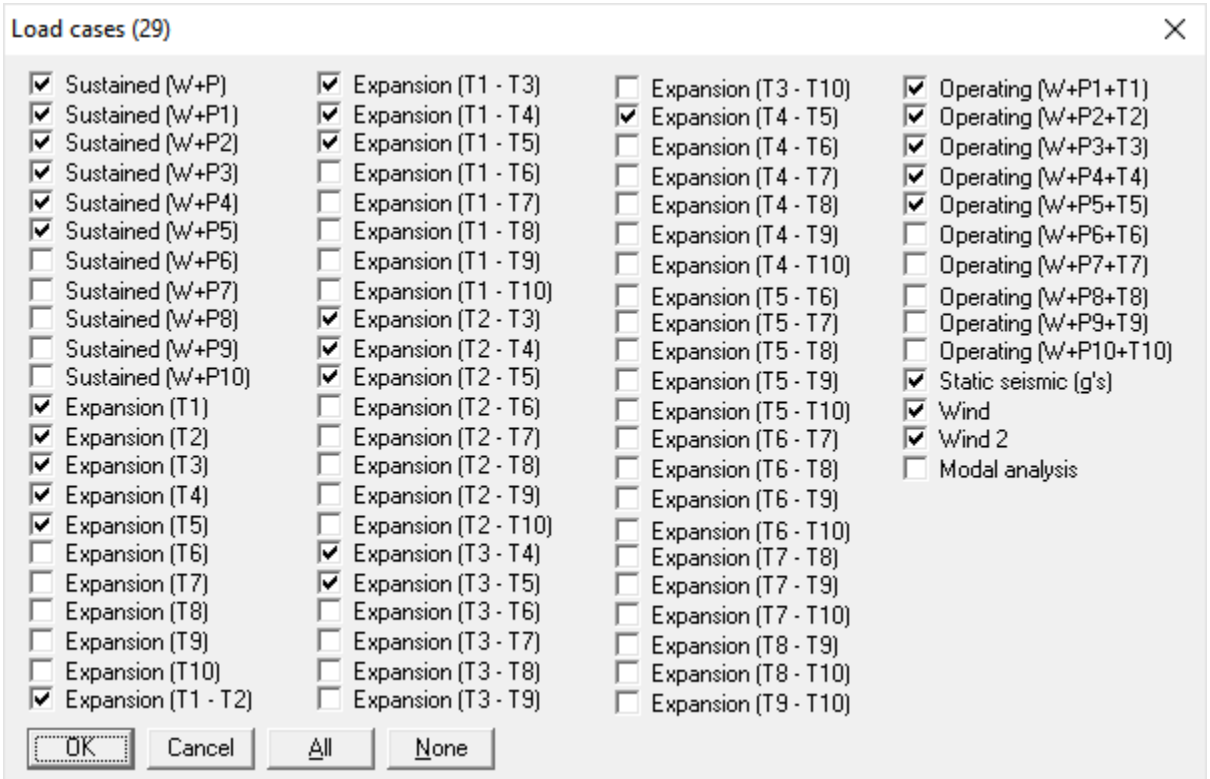
Assign the Loads C1 through CHL to different portions of stress system as required while creating the stress layout. After modeling the stress system, one can review the loads assigned to different portions using the Highlight feature through "Loads List window".

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:

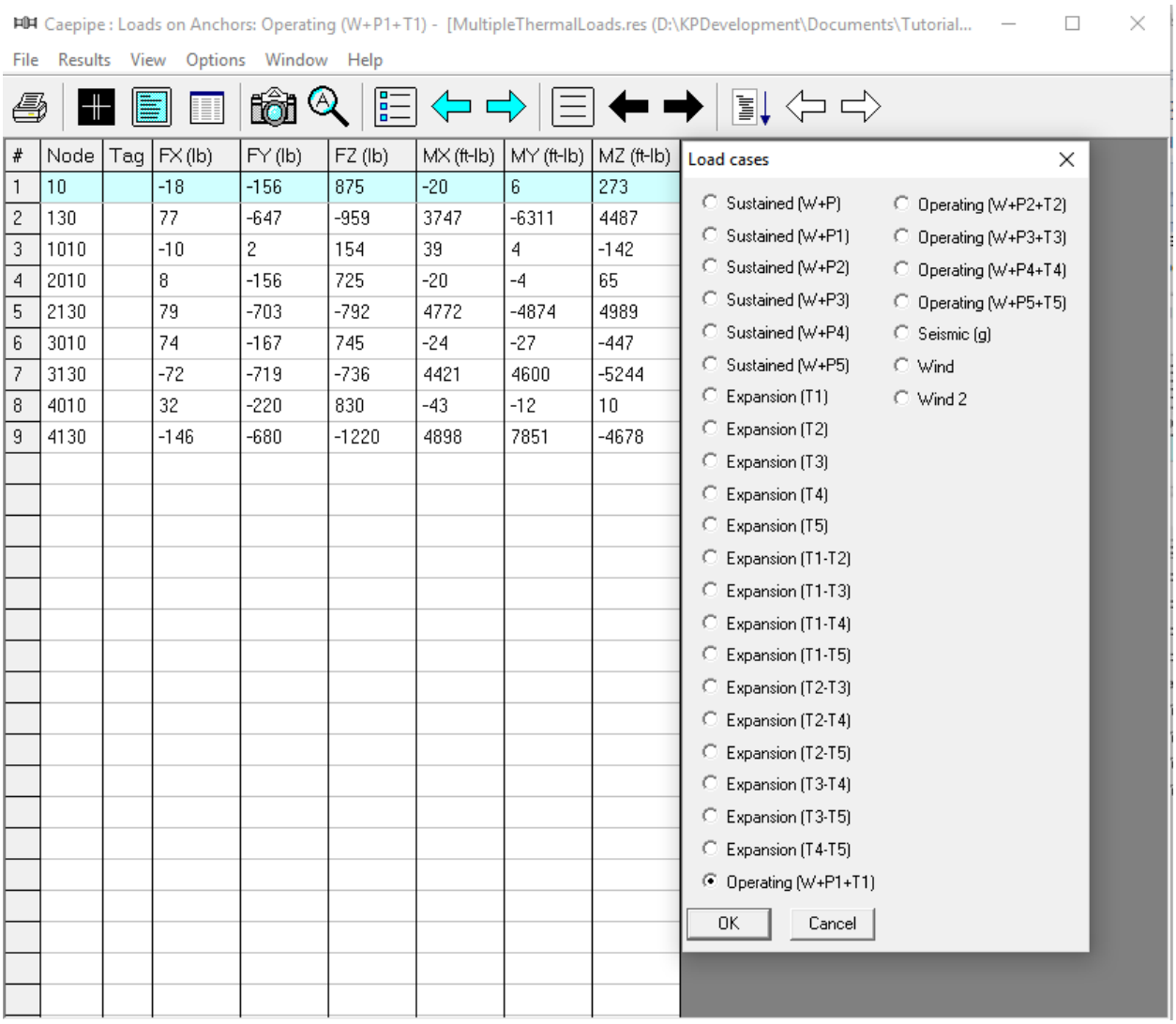
Select the load cases and load combinations required for analysis through Layout window > Loads > Load cases.

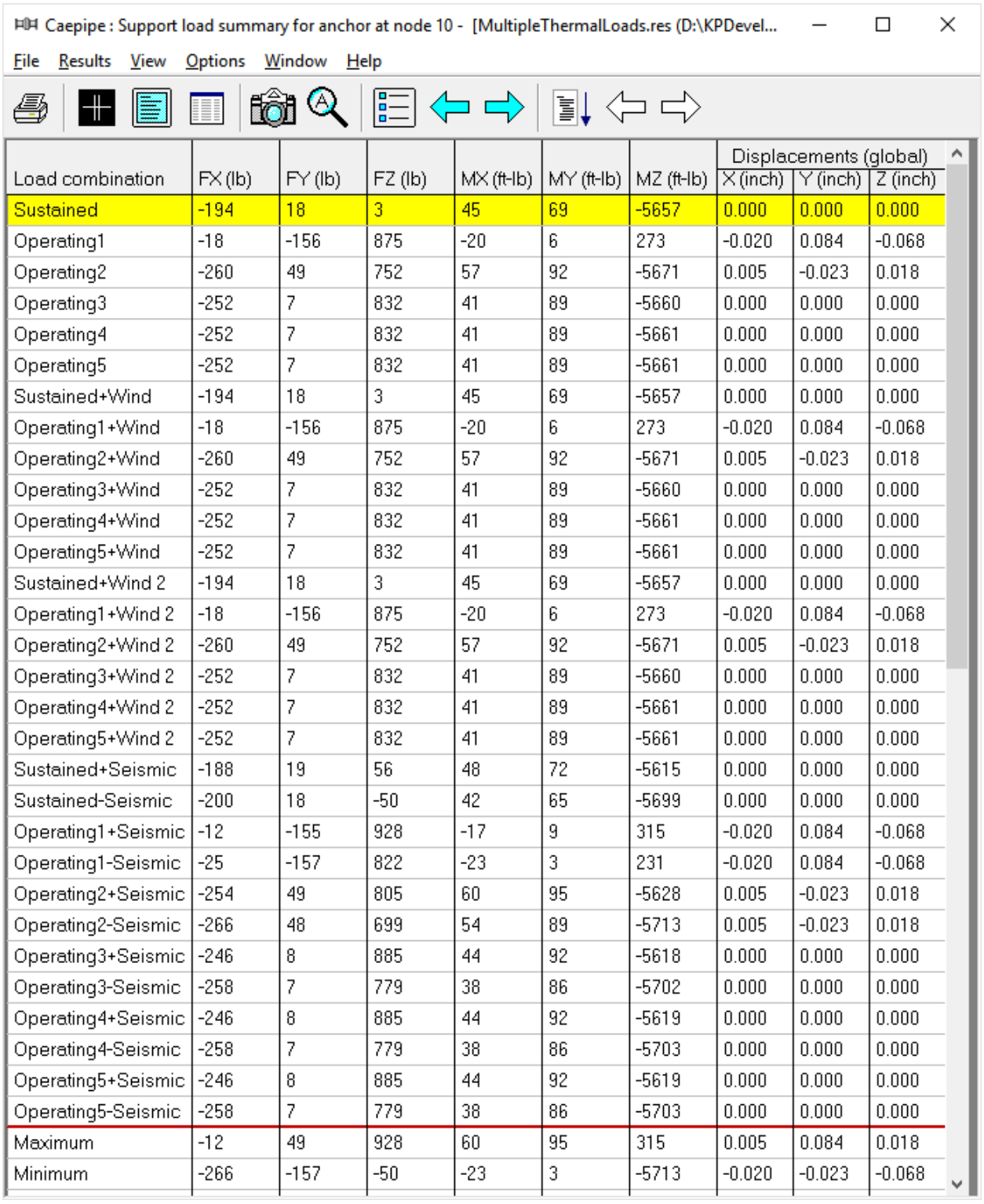


Step 5:

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

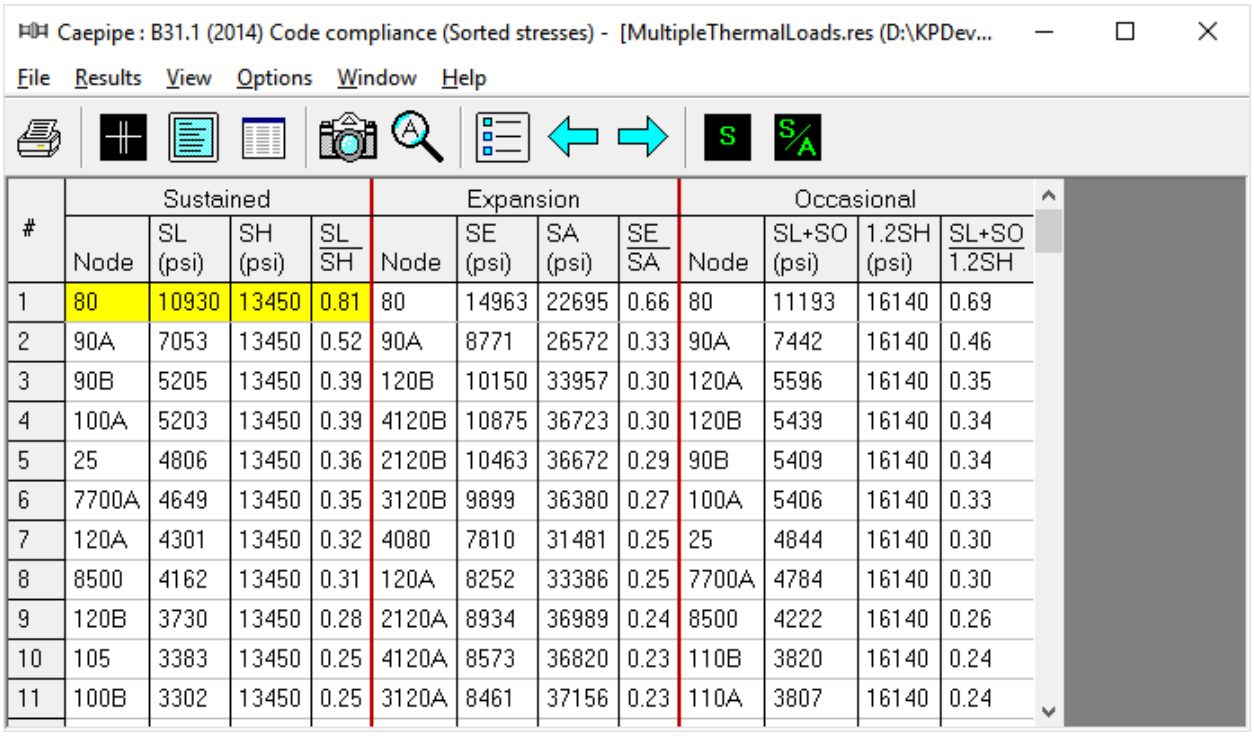
In order to understand the loads and load combinations used for analysis, review the CAEPIPE results file for Support Loads (loads acting on the supports by the piping for each load case), Element Forces & Moments (local/global forces and moments on each element for each load case) and Support Load Summary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





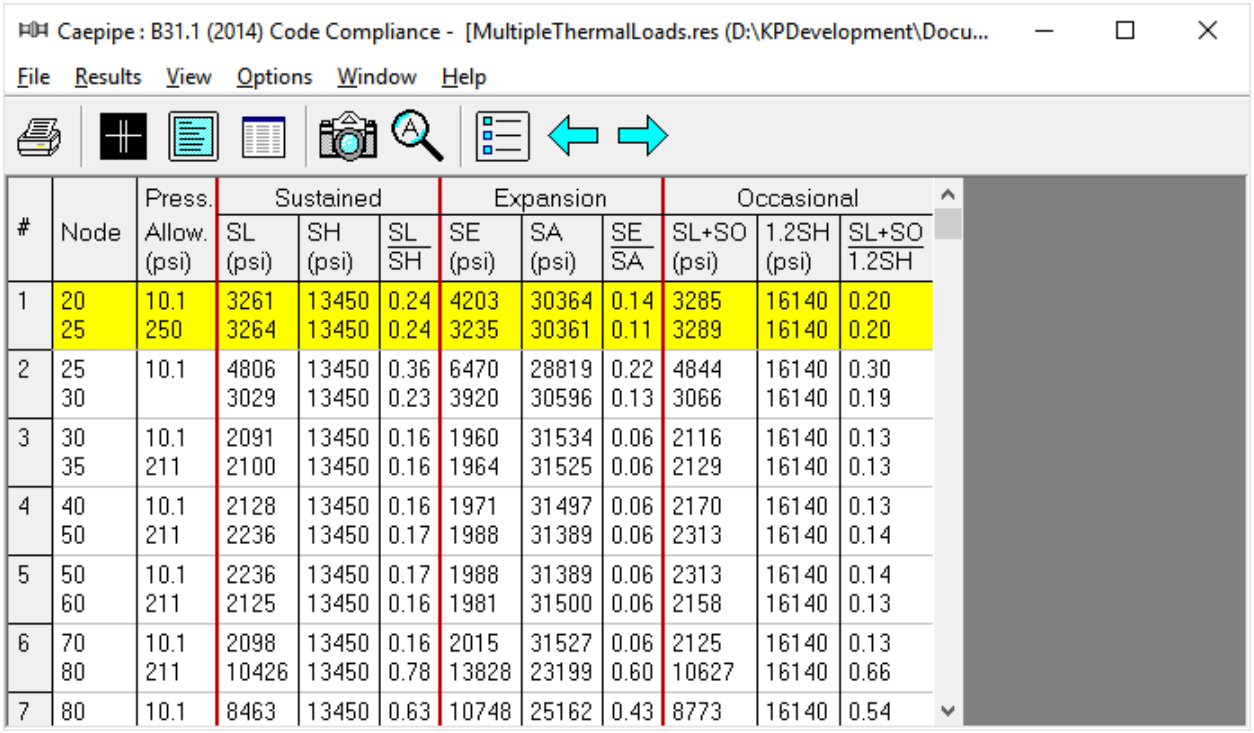
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Sustained	-194	18	3	45	69	-5657	0.000	0.000	0.000
Operating1	-18	-156	875	-20	6	273	-0.020	0.084	-0.068
Operating2	-260	49	752	57	92	-5671	0.005	-0.023	0.018
Operating3	-252	7	832	41	89	-5660	0.000	0.000	0.000
Operating4	-252	7	832	41	89	-5661	0.000	0.000	0.000
Operating5	-252	7	832	41	89	-5661	0.000	0.000	0.000
Sustained+Wind	-194	18	3	45	69	-5657	0.000	0.000	0.000
Operating1+Wind	-18	-156	875	-20	6	273	-0.020	0.084	-0.068
Operating2+Wind	-260	49	752	57	92	-5671	0.005	-0.023	0.018
Operating3+Wind	-252	7	832	41	89	-5660	0.000	0.000	0.000
Operating4+Wind	-252	7	832	41	89	-5661	0.000	0.000	0.000
Operating5+Wind	-252	7	832	41	89	-5661	0.000	0.000	0.000
Sustained+Wind 2	-194	18	3	45	69	-5657	0.000	0.000	0.000
Operating1+Wind 2	-18	-156	875	-20	6	273	-0.020	0.084	-0.068
Operating2+Wind 2	-260	49	752	57	92	-5671	0.005	-0.023	0.018
Operating3+Wind 2	-252	7	832	41	89	-5660	0.000	0.000	0.000
Operating4+Wind 2	-252	7	832	41	89	-5661	0.000	0.000	0.000
Operating5+Wind 2	-252	7	832	41	89	-5661	0.000	0.000	0.000
Sustained+Seismic	-188	19	56	48	72	-5615	0.000	0.000	0.000
Sustained-Seismic	-200	18	-50	42	65	-5699	0.000	0.000	0.000
Operating1+Seismic	-12	-155	928	-17	9	315	-0.020	0.084	-0.068
Operating1-Seismic	-25	-157	822	-23	3	231	-0.020	0.084	-0.068
Operating2+Seismic	-254	49	805	60	95	-5628	0.005	-0.023	0.018
Operating2-Seismic	-266	48	699	54	89	-5713	0.005	-0.023	0.018
Operating3+Seismic	-246	8	885	44	92	-5618	0.000	0.000	0.000
Operating3-Seismic	-258	7	779	38	86	-5702	0.000	0.000	0.000
Operating4+Seismic	-246	8	885	44	92	-5619	0.000	0.000	0.000
Operating4-Seismic	-258	7	779	38	86	-5703	0.000	0.000	0.000
Operating5+Seismic	-246	8	885	44	92	-5619	0.000	0.000	0.000
Operating5-Seismic	-258	7	779	38	86	-5703	0.000	0.000	0.000
Maximum	-12	49	928	60	95	315	0.005	0.084	0.018
Minimum	-266	-157	-50	-23	3	-5713	-0.020	-0.023	-0.068

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 Sustained case, it always uses the maximum pressure among the input pressures (P1 through P10) while computing Sustained Stress at each node.



#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SL+SO (psi)	1.2SH (psi)	SL+SO/1.2SH
1	80	10930	13450	0.81	80	14963	22695	0.66	80	11193	16140	0.69
2	90A	7053	13450	0.52	90A	8771	26572	0.33	90A	7442	16140	0.46
3	90B	5205	13450	0.39	120B	10150	33957	0.30	120A	5596	16140	0.35
4	100A	5203	13450	0.39	4120B	10875	36723	0.30	120B	5439	16140	0.34
5	25	4806	13450	0.36	2120B	10463	36672	0.29	90B	5409	16140	0.34
6	7700A	4649	13450	0.35	3120B	9899	36380	0.27	100A	5406	16140	0.33
7	120A	4301	13450	0.32	4080	7810	31481	0.25	25	4844	16140	0.30
8	8500	4162	13450	0.31	120A	8252	33386	0.25	7700A	4784	16140	0.30
9	120B	3730	13450	0.28	2120A	8934	36989	0.24	8500	4222	16140	0.26
10	105	3383	13450	0.25	4120A	8573	36820	0.23	110B	3820	16140	0.24
11	100B	3302	13450	0.25	3120A	8461	37156	0.23	110A	3807	16140	0.24

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



#	Node	Press. Allow. (psi)	Sustained			Expansion			Occasional		
			SL (psi)	SH (psi)	SL/SH	SE (psi)	SA (psi)	SE/SA	SL+SO (psi)	1.2SH (psi)	SL+SO/1.2SH
1	20 25	10.1 250	3261 3264	13450 13450	0.24 0.24	4203 3235	30364 30361	0.14 0.11	3285 3289	16140 16140	0.20 0.20
2	25 30	10.1	4806 3029	13450 13450	0.36 0.23	6470 3920	28819 30596	0.22 0.13	4844 3066	16140 16140	0.30 0.19
3	30 35	10.1 211	2091 2100	13450 13450	0.16 0.16	1960 1964	31534 31525	0.06 0.06	2116 2129	16140 16140	0.13 0.13
4	40 50	10.1 211	2128 2236	13450 13450	0.16 0.17	1971 1988	31497 31389	0.06 0.06	2170 2313	16140 16140	0.13 0.14
5	50 60	10.1 211	2236 2125	13450 13450	0.17 0.16	1988 1981	31389 31500	0.06 0.06	2313 2158	16140 16140	0.14 0.13
6	70 80	10.1 211	2098 10426	13450 13450	0.16 0.78	2015 13828	31527 23199	0.06 0.60	2125 10627	16140 16140	0.13 0.66
7	80	10.1	8463	13450	0.63	10748	25162	0.43	8773	16140	0.54