Tutorial for Jacketed Piping Modeling and Analysis using CAEPIPE

The following are the Steps to perform Jacketed Piping Modeling and Analysis using CAEPIPE.

General

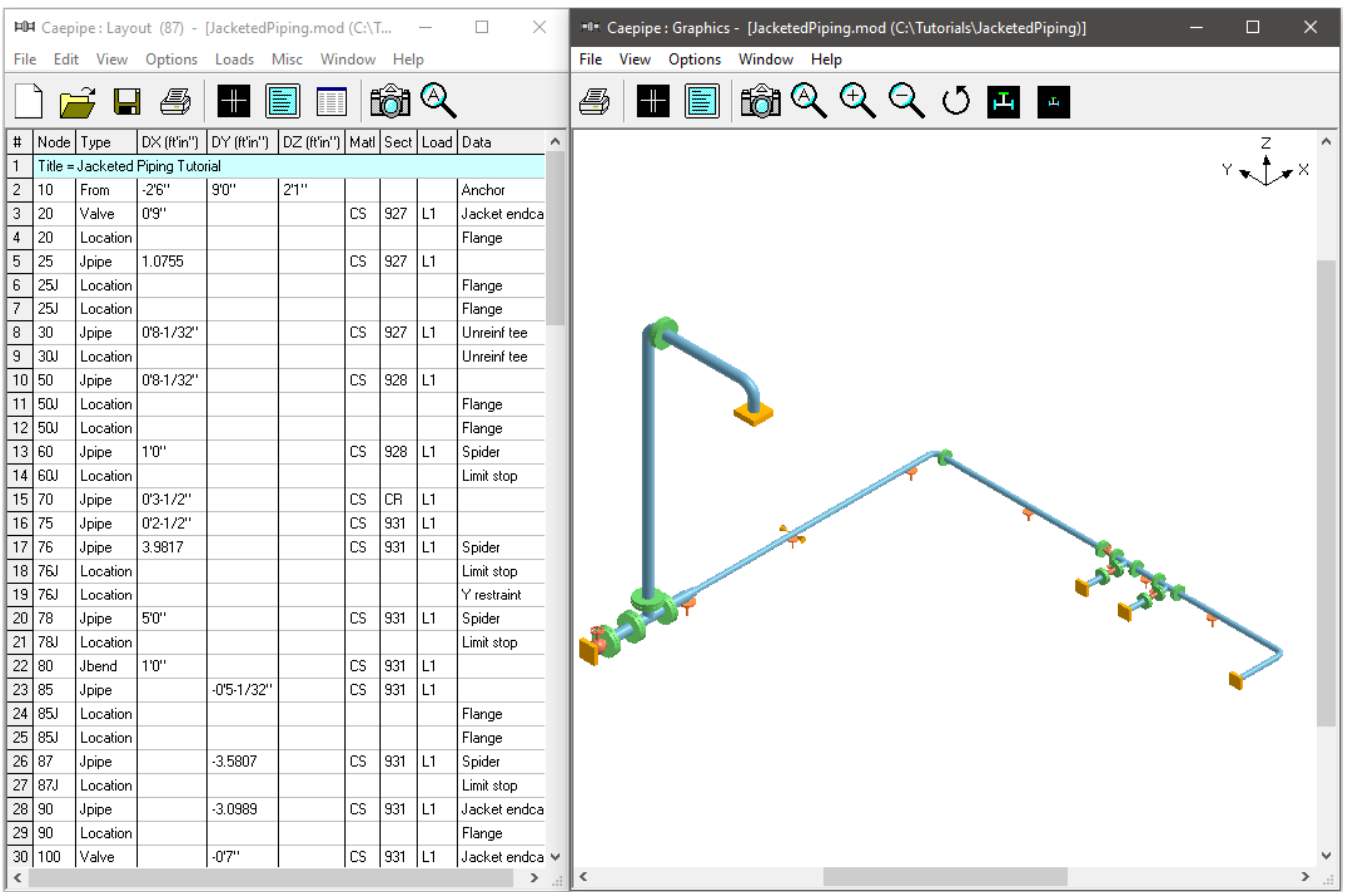
Jacketed piping is used when the primary state of the pipe contents (fuel, chemicals such as resins, etc.) needs to be maintained at a specific temperature during transport. An outer (jacket) pipe surrounds the inner (core) pipe that contains the operating fluid or the chemical. The jacket provides external heating or cooling as required along the length of the core pipe. The terminology used here is as follows:

- *Jacketed* piping refers to the entire assembly, i.e., a core pipe with a jacket on the outside.
- *Jacket* pipe refers only to the outside pipe.
- *Core* pipe refers only to the inside pipe that contains the operating fluid.

In CAEPIPE, jacketed piping need only be modeled once, not twice (as in some other programs). CAEPIPE models the outer jacket pipe along with the inner core pipe on the Layout window. Each row defines a jacketed piping element. The jacket and the core pipes may have different materials, sections and loads (pressures and temperatures).

Tutorial

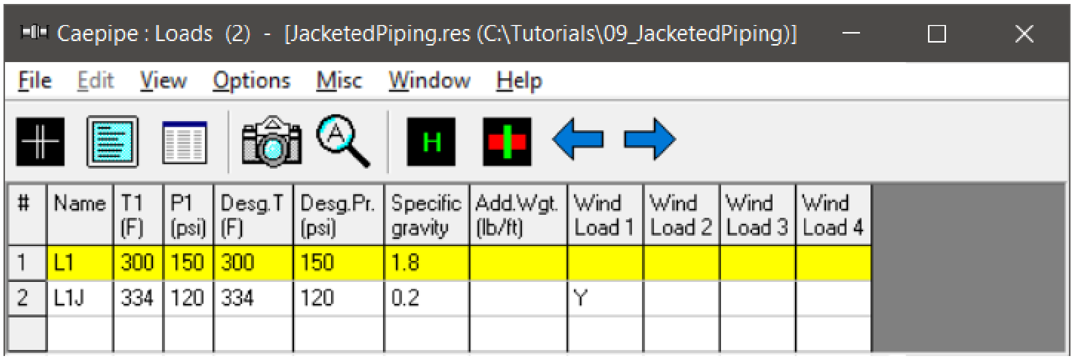
Snap shot shown below is a sample model for Jacketed Piping Modeling and Analysis. CAEPIPE model file (.mod) and results file (.res) are saved in the .zip file, which can be downloaded from this Tutorial.



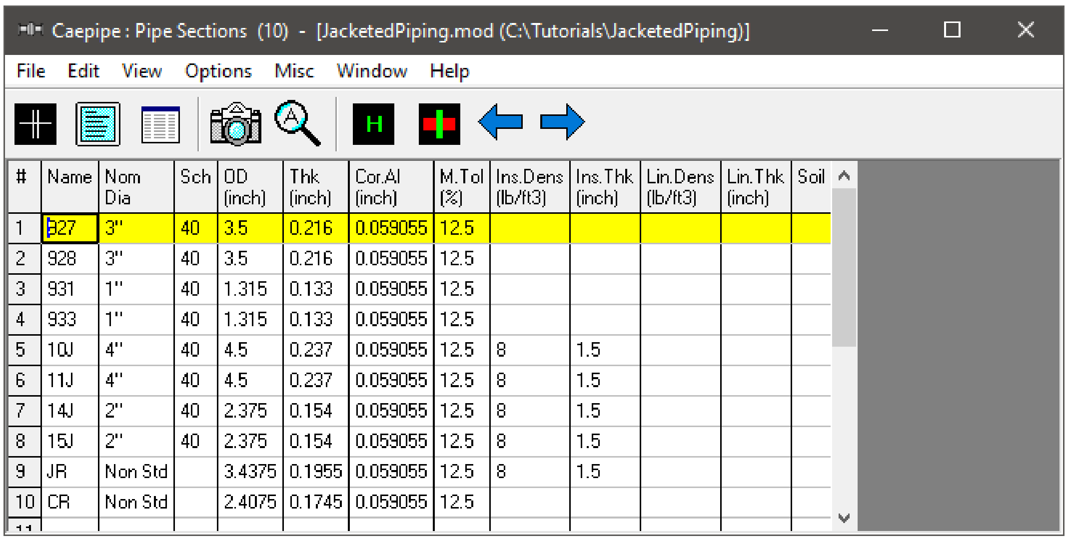
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Jacketed Piping Tutorial								
2	10	From	-2'6"	9'0"	2'1"				Anchor
3	20	Valve	0'9"			CS	927	L1	Jacket endca
4	20	Location							Flange
5	25	Jpipe	1.0755			CS	927	L1	
6	25J	Location							Flange
7	25J	Location							Flange
8	30	Jpipe	0'8-1/32"			CS	927	L1	Unreinf tee
9	30J	Location							Unreinf tee
10	50	Jpipe	0'8-1/32"			CS	928	L1	
11	50J	Location							Flange
12	50J	Location							Flange
13	60	Jpipe	1'0"			CS	928	L1	Spider
14	60J	Location							Limit stop
15	70	Jpipe	0'3-1/2"			CS	CR	L1	
16	75	Jpipe	0'2-1/2"			CS	931	L1	
17	76	Jpipe	3.9817			CS	931	L1	Spider
18	76J	Location							Limit stop
19	76J	Location							Y restraint
20	78	Jpipe	5'0"			CS	931	L1	Spider
21	78J	Location							Limit stop
22	80	Jbend	1'0"			CS	931	L1	
23	85	Jpipe		-0'5-1/32"		CS	931	L1	
24	85J	Location							Flange
25	85J	Location							Flange
26	87	Jpipe		-3.5807		CS	931	L1	Spider
27	87J	Location							Limit stop
28	90	Jpipe		-3.0989		CS	931	L1	Jacket endca
29	90	Location							Flange
30	100	Valve		-0'7"		CS	931	L1	Jacket endca

Step 1:

First, define materials, sections, and loads required for Jacket and Core elements through Layout window > Misc > Materials/Sections/Loads. Snapshots shown below for section and load names ending with "J" refer to the sections and loads defined for Jacket elements.



#	Name	T1 (F)	P1 (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	L1	300	150	300	150	1.8					
2	L1J	334	120	334	120	0.2		Y			



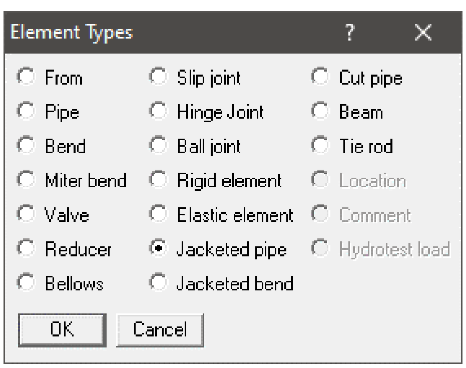
#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	927	3"	40	3.5	0.216	0.059055	12.5					
2	928	3"	40	3.5	0.216	0.059055	12.5					
3	931	1"	40	1.315	0.133	0.059055	12.5					
4	933	1"	40	1.315	0.133	0.059055	12.5					
5	10J	4"	40	4.5	0.237	0.059055	12.5	8	1.5			
6	11J	4"	40	4.5	0.237	0.059055	12.5	8	1.5			
7	14J	2"	40	2.375	0.154	0.059055	12.5	8	1.5			
8	15J	2"	40	2.375	0.154	0.059055	12.5	8	1.5			
9	JR	Non Std		3.4375	0.1955	0.059055	12.5	8	1.5			
10	CR	Non Std		2.4075	0.1745	0.059055	12.5					

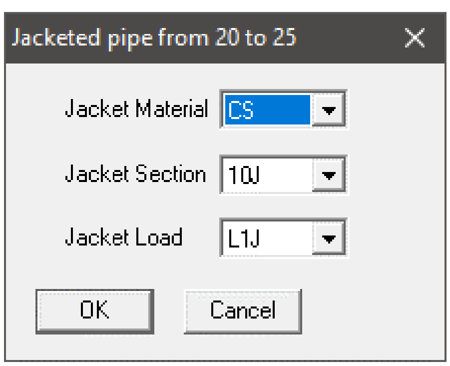
Step 2:

While modeling the stress system with jacketed piping, use the element types "JPIPE" and "JBEND" instead of PIPE and BEND. The details for Jacket Pipe and Jacket Bend are given below.

Jacket Pipe

A Jacketed pipe is input by typing "JP" under Type or selecting "Jacketed pipe" from the Element types dialog. The material, section and load specified in the Jacketed Pipe dialog apply to the jacket pipe, while the corresponding ones mentioned on the layout row (next to offsets) apply to the core pipe.





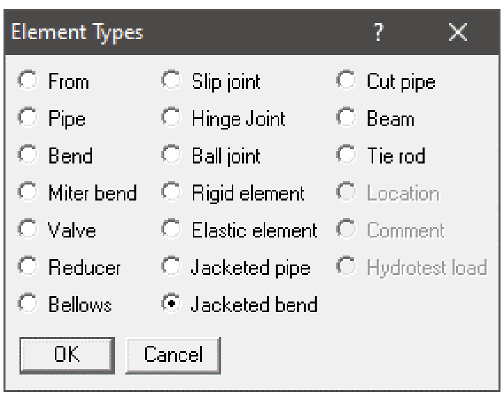
The jacket’s material, section, and load names are input here (CS, 10J and L1J as shown). CAEPIPE retains the properties of a jacket pipe until changed so there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

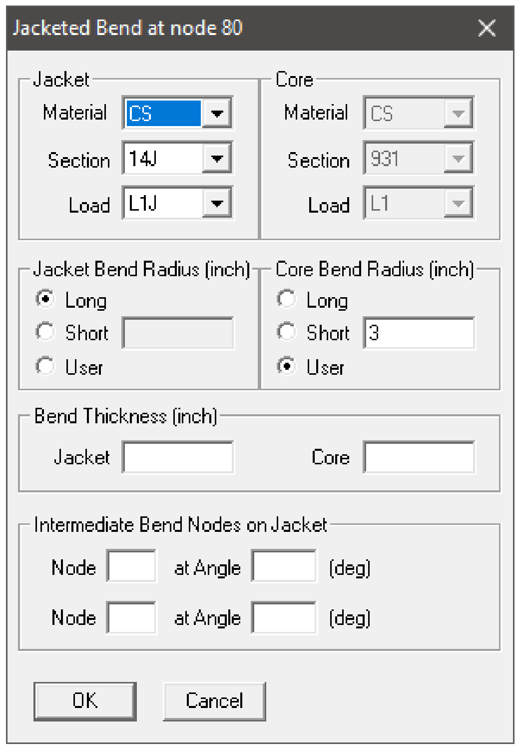
In case you are analyzing for wind, it may be more accurate to specify a different load for the core pipe alone that does not specify the Wind load since most of the core pipe is not exposed to Wind load. The same applies to the core pipe insulation if the core pipe does not have insulation.

Jacketed Bend

A Jacketed bend consists of a core bend (with a straight portion of core pipe) surrounded by a jacket bend (with a straight portion of jacket pipe).

A Jacketed bend is input by typing “JB” in the Type column or by selecting “Jacketed bend” from the Element types dialog.





Jacket (properties)

The jacket’s material, section, and load names are input here. The properties of a jacketed pipe are retained until changed. So, there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

Core (properties)

Presently these properties are disabled. You need to enter them on the layout row under Material, Section and Load.

Bend radius

Separate bend radii may be specified for the core and the jacket pipes. Note that CAEPIPE does not check for interference between the core and the jacket arising out of differently specified bend radii. The bend radius for the core pipe is generally the same as that of the jacket pipe since the two bends are generally concentric. Use the Render feature in the Graphics window to check visually for interference between the core and the jacket.

Bend thickness

Separate bend thicknesses may be specified for the core and the jacket bends, if they are not the same as the default jacket and core section thicknesses.

Intermediate nodes

You can define additional nodes on the outside jacket of a jacketed bend for locating supports. You may also use internal nodes generated by CAEPIPE to locate Data items such as supports, spiders, etc.

Internal nodes

CAEPIPE generates a "J" node for jacket pipes. For example, from node 20 to 25, CAEPIPE generates 20J and a 25J as (internal) jacket nodes (that may be referenced on the layout screen).

Similarly, CAEPIPE generates "C" and "D" nodes for the Jacketed bend on the jacket at the near and far ends of the bend. The core pipe bend has its own "A" and "B" nodes. Example: When you define a Jacketed bend from node 78 to the Tangent Intersection node 80, 80A, 80B (nodes on core bend), 80C and 80D (nodes on jacket) are automatically generated. Nodes (80A, 80C) and (80B and 80D) are coincident only if the core and the jacket pipes have the same bend radii.

The "C" and "D" nodes may be used to specify Data items such as supports, forces, etc. on the jacket.

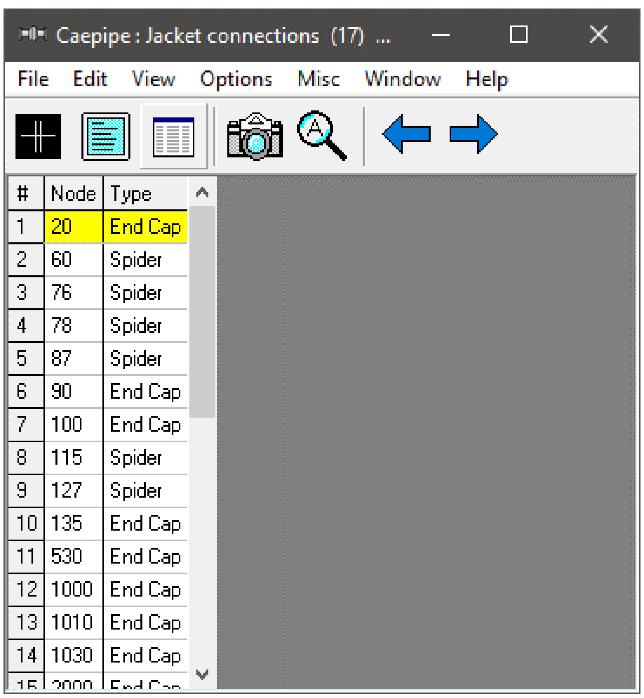
Step 3:

At nodes where the jacket terminates, the ends of the jacket and core pipes need to be rigidly connected using the "Jacket end cap" data type. See Node 530 as an example in the attached model.

By specifying "Jacket end cap" at a node, CAEPIPE only considers that the core pipe and the jacket are "tied" at that node and NOTHING more. Weld SIF at that node, if desired, should be explicitly added using "Location" type and the Data item "Weld". If your weld type is not listed there, you could specify the weld SIF for that node using the "User SIF" Data item. See Node 135 as an example in the attached model.

Also, "Spiders" need to be input at locations found in the physical assembly. You may have to break up the piping into smaller elements to insert spiders at appropriate locations. For example, see Nodes 76 and 78 from the attached model.

Locations where the "Jacket End Caps" and "Spiders" used in the stress system can be viewed through Layout window > View > List > Jacket connections.



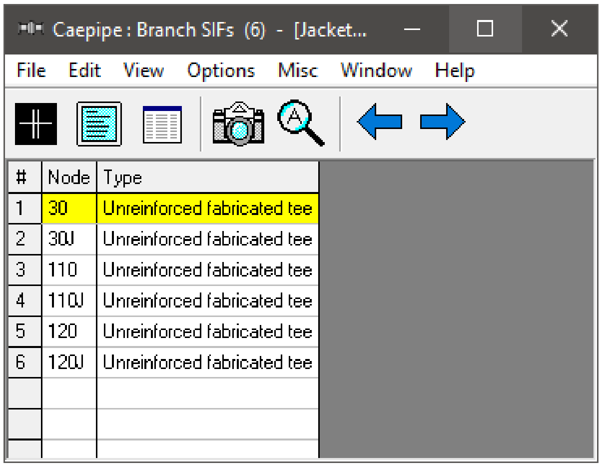
Step 4:

Specify Data items such as a Limit Stops, Flanges, Restraints, etc. on the jacket/core at appropriate locations as required.

Step 5:

At the Branch Nodes 30, 110 and 120, both core pipe and jacket are having an "Unreinforced fabricated tee". Then, the "Unreinforced fabricated tees" on core pipe are to be input at Nodes 30, 110 and 120 using the Data item "Branch SIF", while the jacket "Unreinforced fabricated tees" have to be specified at Nodes 30J, 110J and 120J using "Location" type and the Data item "Branch SIF". At all these nodes (30, 30J, 110, 110J, 120 and 120J), you can also add the weld SIFs, again using the "Location" type and the Data item "Weld" or "User SIF". Please note that CAEPIPE will consider only the higher of the two SIF values (first SIF due to branch and the second SIF due to weld) at these nodes in computing stresses.

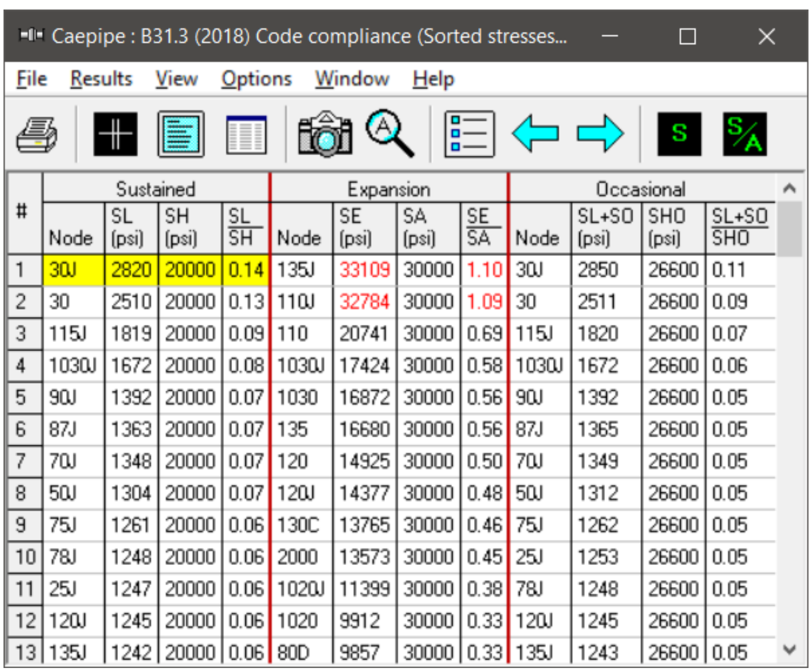
Any SIF value specified in the "User SIF" Data item will always overwrite any other SIF value calculated/determined at that node using any other method(s).



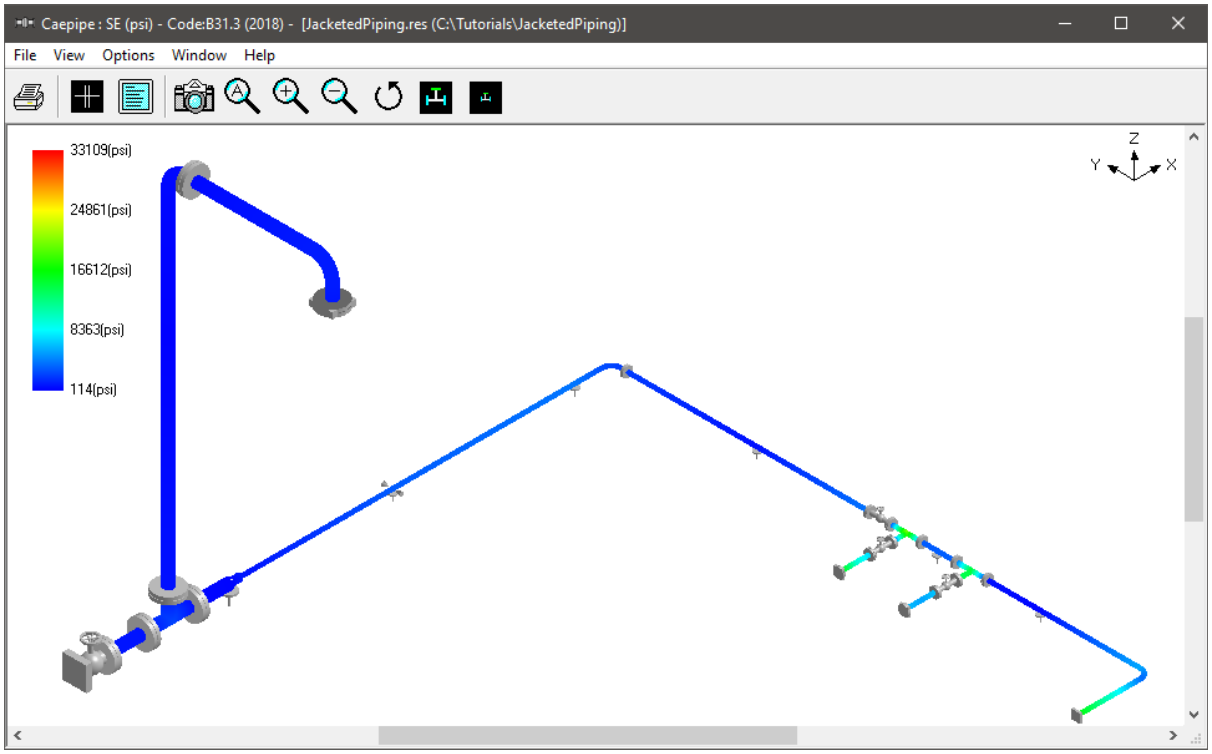
#	Node	Type
1	30	Unreinforced fabricated tee
2	30J	Unreinforced fabricated tee
3	110	Unreinforced fabricated tee
4	110J	Unreinforced fabricated tee
5	120	Unreinforced fabricated tee
6	120J	Unreinforced fabricated tee

Step 6:

Save and Analyze the model through File > Analyze. Upon successful analysis, CAEPIPE display Stresses, Displacements, Element forces, Support loads and Support load summary.

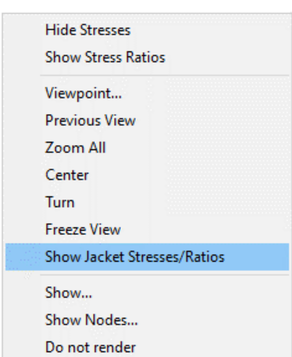


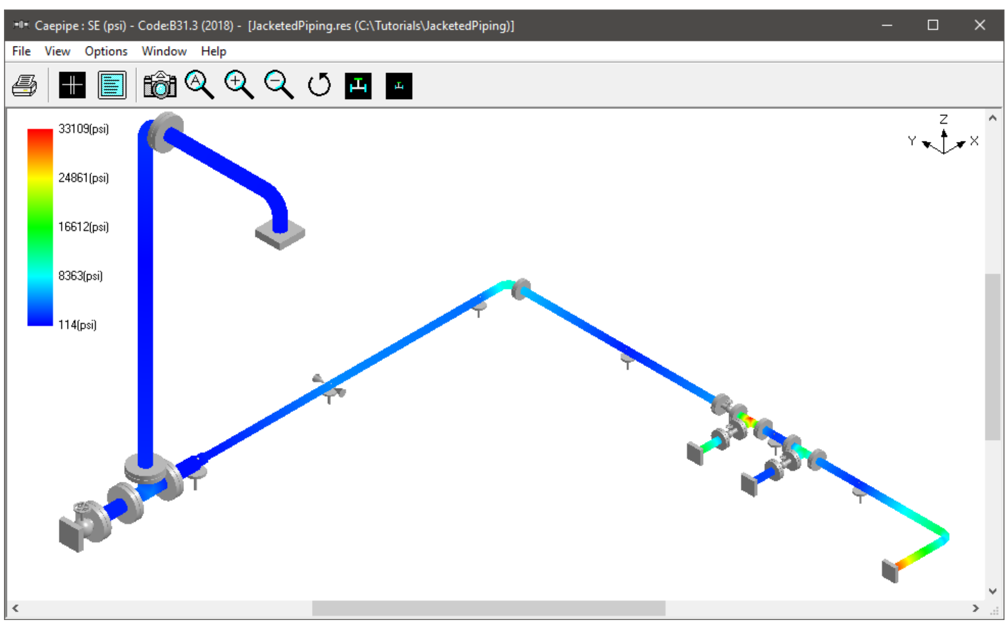
#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SL+SO (psi)	SHO (psi)	SL+SO/SHO
1	30J	2820	20000	0.14	135J	33109	30000	1.10	30J	2850	26600	0.11
2	30	2510	20000	0.13	110J	32784	30000	1.09	30	2511	26600	0.09
3	115J	1819	20000	0.09	110	20741	30000	0.69	115J	1820	26600	0.07
4	1030J	1672	20000	0.08	1030J	17424	30000	0.58	1030J	1672	26600	0.06
5	90J	1392	20000	0.07	1030	16872	30000	0.56	90J	1392	26600	0.05
6	87J	1363	20000	0.07	135	16680	30000	0.56	87J	1365	26600	0.05
7	70J	1348	20000	0.07	120	14925	30000	0.50	70J	1349	26600	0.05
8	50J	1304	20000	0.07	120J	14377	30000	0.48	50J	1312	26600	0.05
9	75J	1261	20000	0.06	130C	13765	30000	0.46	75J	1262	26600	0.05
10	78J	1248	20000	0.06	2000	13573	30000	0.45	25J	1253	26600	0.05
11	25J	1247	20000	0.06	1020J	11399	30000	0.38	78J	1248	26600	0.05
12	120J	1245	20000	0.06	1020	9912	30000	0.33	120J	1245	26600	0.05
13	135J	1242	20000	0.06	80D	9857	30000	0.33	135J	1243	26600	0.05



Jacketed Piping Stresses/Ratios

The default stress contour is for the core piping. CAEPIPE provides an option for you to display the color-coded stress/ratio contour for jacketed piping in the graphics window context menu. Upon selecting the command, Jacket stresses can be seen as shown below:





Caepipe : B31.3 (2018) Code Compliance - [JacketedPipi...

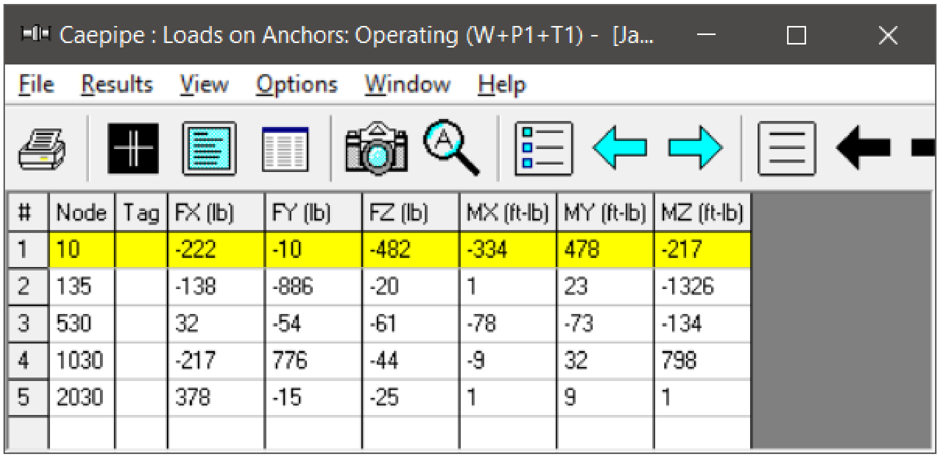
File Results View Options Window Help

#	Node	Press. Allow. (psi)	Sustained SL (psi)	SH (psi)	SL / SH	Expansion SE (psi)	SA (psi)	SE / SA	Occasional SL+SO (psi)	SHO (psi)	SL+SO / SHO
1	20	150	866	20000	0.04	809	30000	0.03	867	26600	0.03
	25	1531	616	20000	0.03	690	30000	0.02	617	26600	0.02
2	20J	120	1041	20000	0.05	1122	30000	0.04	1043	26600	0.04
	25J	1354	1247	20000	0.06	1221	30000	0.04	1253	26600	0.05
3	25	150	616	20000	0.03	690	30000	0.02	617	26600	0.02
	30	1531	2508	20000	0.13	1444	30000	0.05	2509	26600	0.09
4	25J	120	1247	20000	0.06	1221	30000	0.04	1253	26600	0.05
	30J	1354	2776	20000	0.14	2898	30000	0.10	2804	26600	0.11
5	30	150	2510	20000	0.13	1436	30000	0.05	2511	26600	0.09
	50	1531	836	20000	0.04	295	30000	0.01	837	26600	0.03
6	30J	120	2820	20000	0.14	2297	30000	0.08	2850	26600	0.11
	50J	1354	1304	20000	0.07	571	30000	0.02	1312	26600	0.05
7	50	150	836	20000	0.04	295	30000	0.01	837	26600	0.03
	60	1531	232	20000	0.01	93	30000	0.00	232	26600	0.01
8	50J	120	1304	20000	0.07	571	30000	0.02	1312	26600	0.05
	60J	1354	868	20000	0.04	298	30000	0.01	868	26600	0.03
9	60	150	344	20000	0.02	250	30000	0.01	344	26600	0.01
	70	1606	296	20000	0.01	193	30000	0.01	296	26600	0.01
10	60J	120	1000	20000	0.05	559	30000	0.02	1000	26600	0.04
	70J	1338	954	20000	0.05	421	30000	0.01	955	26600	0.04

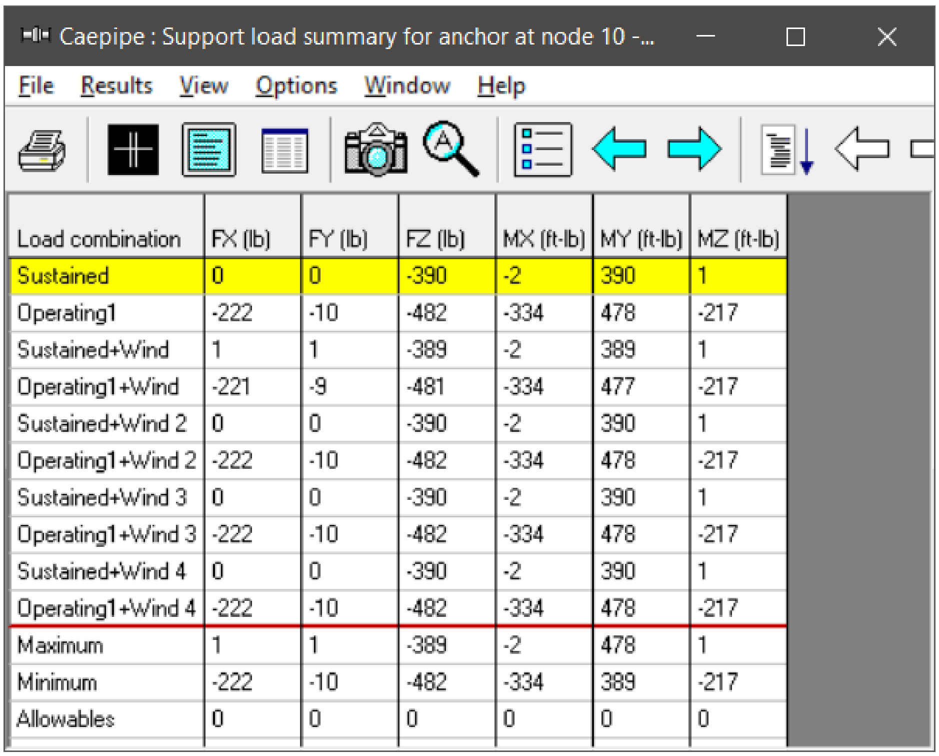
Caepipe : Displacements: Operating (W+P1+T1) - [Jacke...

File Results View Options Window Help

#	Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
1	10	0.000	0.000	0.000	0.0000	0.0000	0.0000
2	20	0.016	-0.000	-0.001	-0.0067	0.0048	-0.0033
3	20J	0.016	-0.000	-0.001	-0.0067	0.0048	-0.0033
4	25	0.039	-0.002	-0.002	-0.0168	0.0046	-0.0097
5	25J	0.042	-0.002	-0.002	-0.0205	0.0032	-0.0091
6	30	0.053	-0.003	-0.002	-0.0231	-0.0021	-0.0130
7	30J	0.058	-0.003	-0.002	-0.0290	-0.0027	-0.0128
8	50	0.067	-0.005	-0.002	-0.0230	-0.0061	-0.0156
9	50J	0.074	-0.005	-0.001	-0.0289	-0.0053	-0.0159
10	60	0.088	-0.009	0.000	-0.0229	-0.0082	-0.0178
11	60J	0.099	-0.009	0.000	-0.0286	-0.0064	-0.0192
12	70	0.095	-0.010	0.000	-0.0228	-0.0076	-0.0190
13	70J	0.106	-0.010	0.000	-0.0284	-0.0057	-0.0209



#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10		-222	-10	-482	-334	478	-217
2	135		-138	-886	-20	1	23	-1326
3	530		32	-54	-61	-78	-73	-134
4	1030		-217	776	-44	-9	32	798
5	2030		378	-15	-25	1	9	1



Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	0	0	-390	-2	390	1
Operating1	-222	-10	-482	-334	478	-217
Sustained+Wind	1	1	-389	-2	389	1
Operating1+Wind	-221	-9	-481	-334	477	-217
Sustained+Wind 2	0	0	-390	-2	390	1
Operating1+Wind 2	-222	-10	-482	-334	478	-217
Sustained+Wind 3	0	0	-390	-2	390	1
Operating1+Wind 3	-222	-10	-482	-334	478	-217
Sustained+Wind 4	0	0	-390	-2	390	1
Operating1+Wind 4	-222	-10	-482	-334	478	-217
Maximum	1	1	-389	-2	478	1
Minimum	-222	-10	-482	-334	389	-217
Allowables	0	0	0	0	0	0