Tutorial for Jacketed Piping Modeling and Analysis using CAEPIPE

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

General

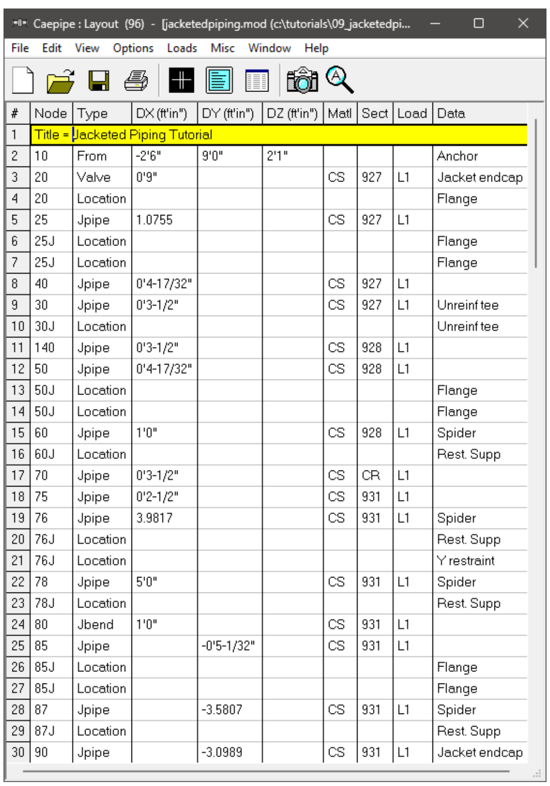
Jacketed piping is used when the primary state of the pipe contents (fuel, chemicals such as resins, etc.) needs to be maintained at a specific temperature during transport. An outer (jacket) pipe surrounds the inner (core) pipe that contains the operating fluid or the chemical. The jacket provides external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

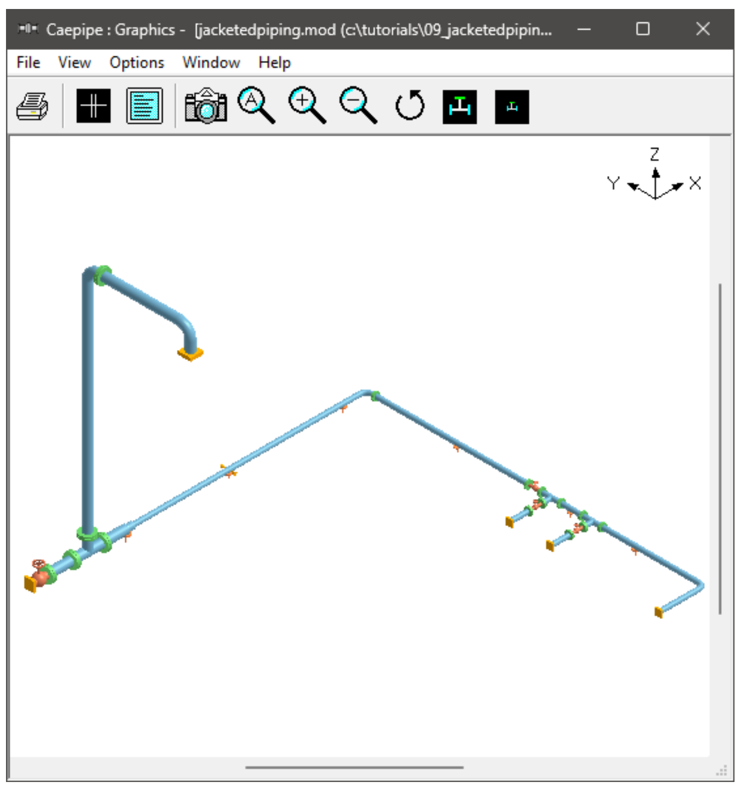
In CAEPIPE, jacketed piping need only be modeled once, not twice (as in some other programs). CAEPIPE models simultaneously the outer jacket pipe along with the inner core pipe on the Layout window. Each row defines a jacketed piping element. The jacket and the core pipes may have different materials,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

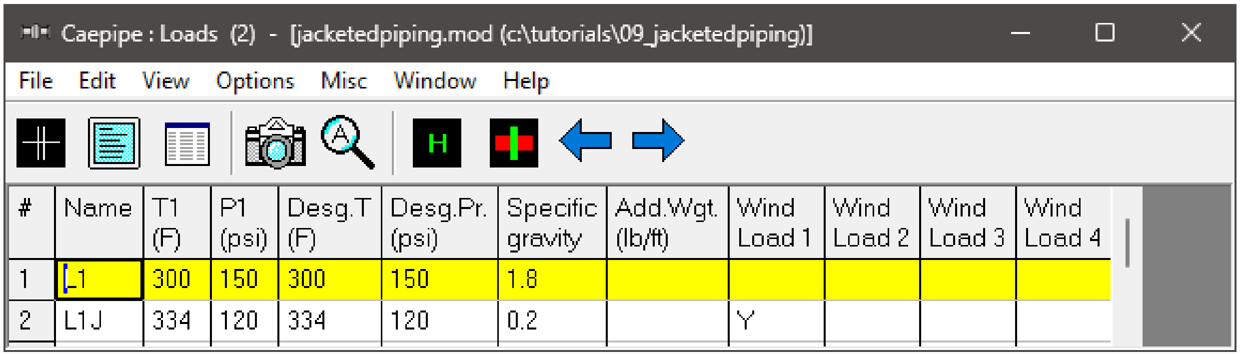


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Jacketed Piping Tutorial								
2	10	From	-2'6"	9'0"	2'1"				Anchor
3	20	Valve	0'9"			CS	927	L1	Jacket endcap
4	20	Location							Flange
5	25	Jpipe	1.0755			CS	927	L1	
6	25J	Location							Flange
7	25J	Location							Flange
8	40	Jpipe	0'4-17/32"			CS	927	L1	
9	30	Jpipe	0'3-1/2"			CS	927	L1	Unreinf tee
10	30J	Location							Unreinf tee
11	140	Jpipe	0'3-1/2"			CS	928	L1	
12	50	Jpipe	0'4-17/32"			CS	928	L1	
13	50J	Location							Flange
14	50J	Location							Flange
15	60	Jpipe	1'0"			CS	928	L1	Spider
16	60J	Location							Rest. Supp
17	70	Jpipe	0'3-1/2"			CS	CR	L1	
18	75	Jpipe	0'2-1/2"			CS	931	L1	
19	76	Jpipe	3.9817			CS	931	L1	Spider
20	76J	Location							Rest. Supp
21	76J	Location							Y restraint
22	78	Jpipe	5'0"			CS	931	L1	Spider
23	78J	Location							Rest. Supp
24	80	Jbend	1'0"			CS	931	L1	
25	85	Jpipe		-0'5-1/32"		CS	931	L1	
26	85J	Location							Flange
27	85J	Location							Flange
28	87	Jpipe		-3.5807		CS	931	L1	Spider
29	87J	Location							Rest. Supp
30	90	Jpipe		-3.0989		CS	931	L1	Jacket endcap

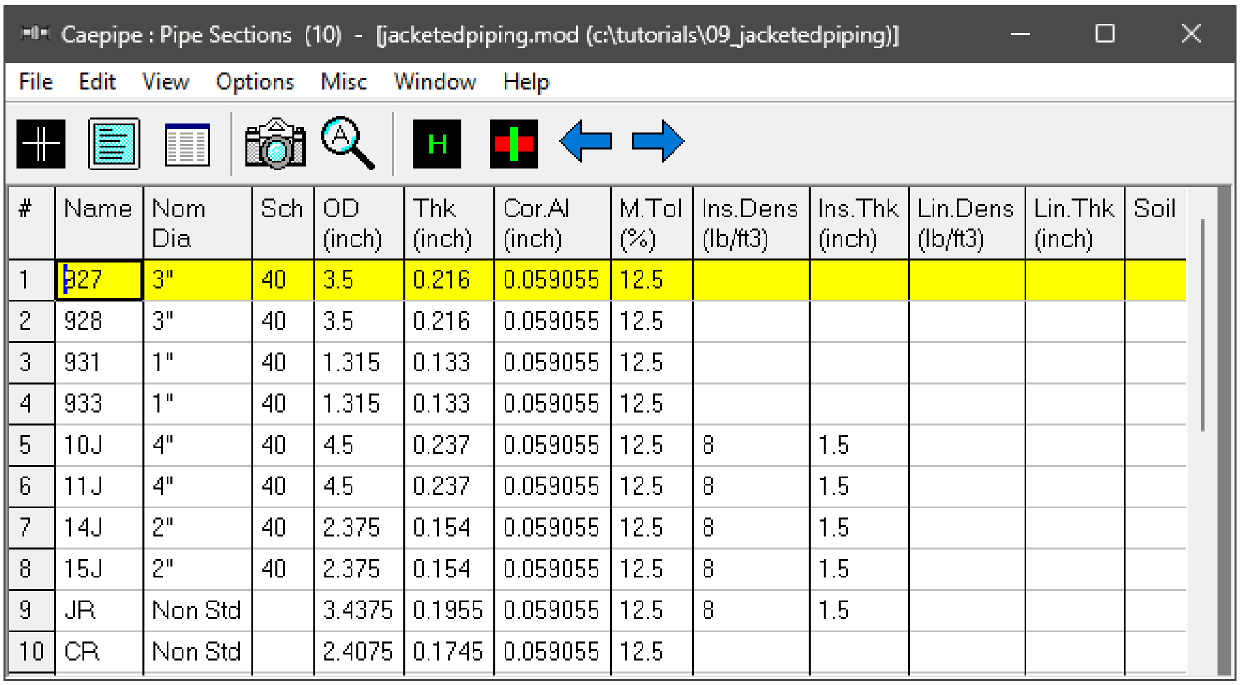


Step 1:

First, define materials, sections and loads required for Jacket and Core pipe/bend 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			



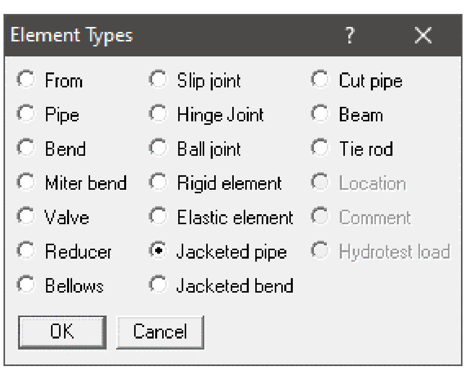
#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	927	3"	40	3.5	0.216	0.059055	12.5					
2	928	3"	40	3.5	0.216	0.059055	12.5					
3	931	1"	40	1.315	0.133	0.059055	12.5					
4	933	1"	40	1.315	0.133	0.059055	12.5					
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					

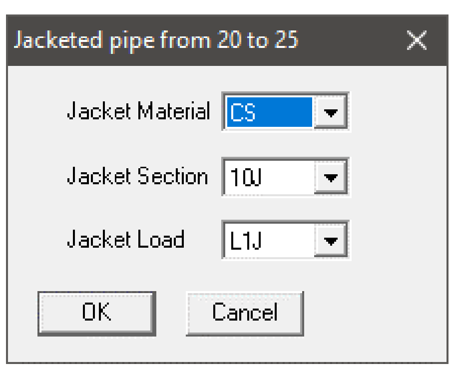
Step 2:

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.





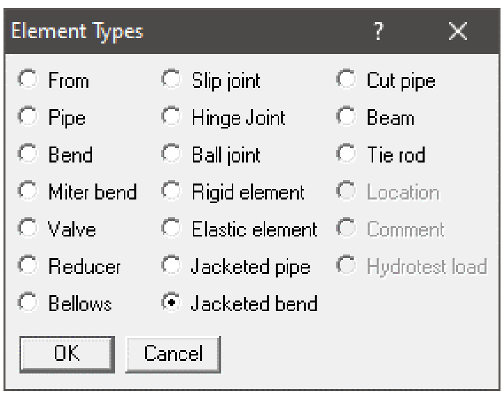
The jacket's material, section, and load names are input here (CS, 10J and L1J as shown). CAEPIPE retains the properties of a jacket pipe until changed so there is no need to retype the names of the jacket properties every time you input a jacketed pipe.

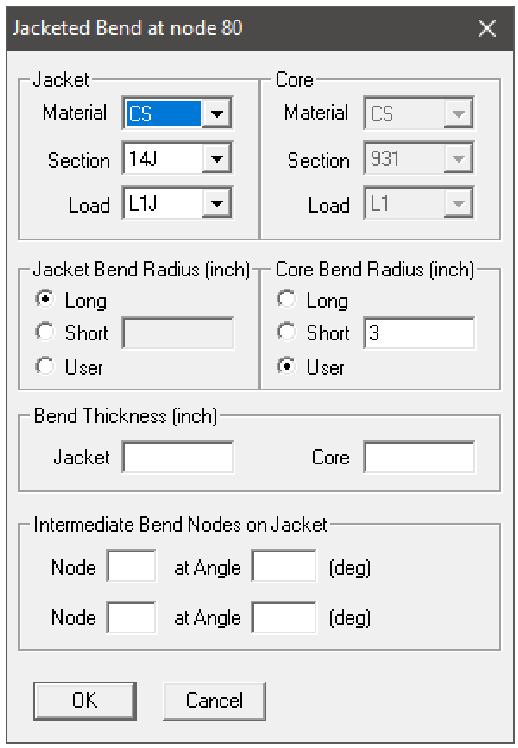
In case you are analyzing for wind, it may be more accurate to specify a different load for the core pipe alone that does not specify the Wind load since most of the core pipe is not exposed to Wind load. The same applies to the core pipe insulation if the core pipe does not have insulation.

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, internal nodes 80A and 80B (bend-end nodes on core bend), and internal nodes 80C and 80D (bend-end nodes on jacket bend) are automatically generated. Nodes (80A and 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.

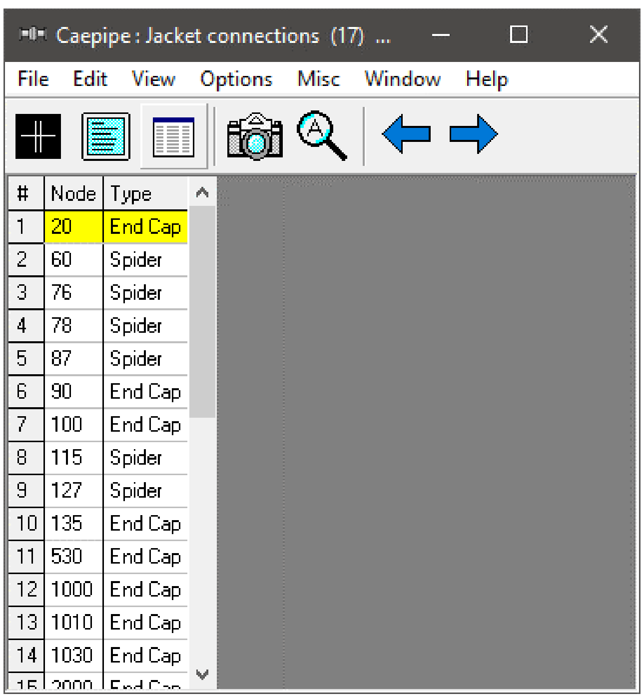
Step 3:

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” are used in the stress system can be viewed through Layout window > View > List > Jacket connections.



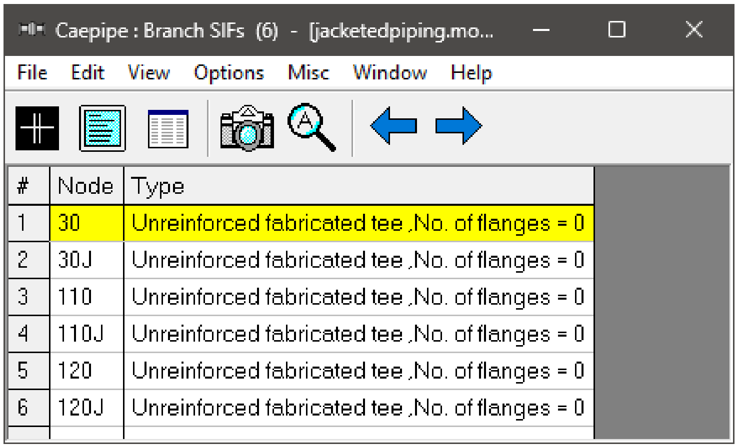
Step 4:

Specify Data items such as 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.

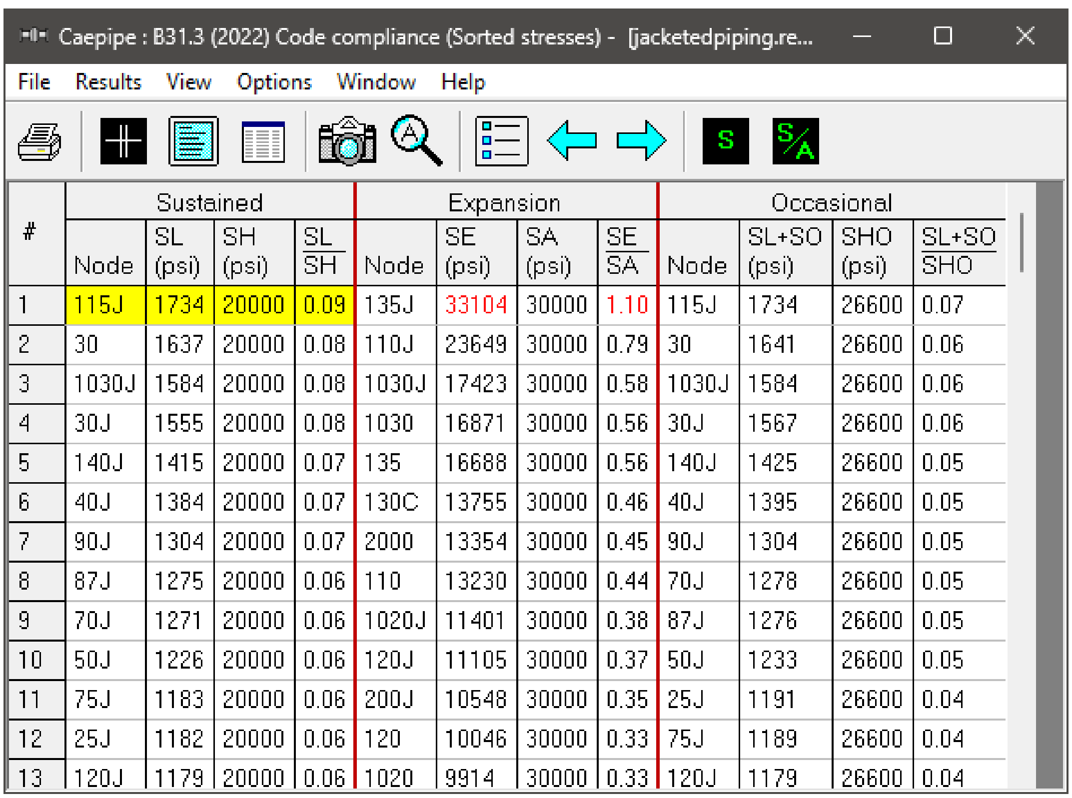
Any SIF value specified in the “User SIF” Data item will always overwrite any other SIF value calculated/determined at that node using any other method(s).



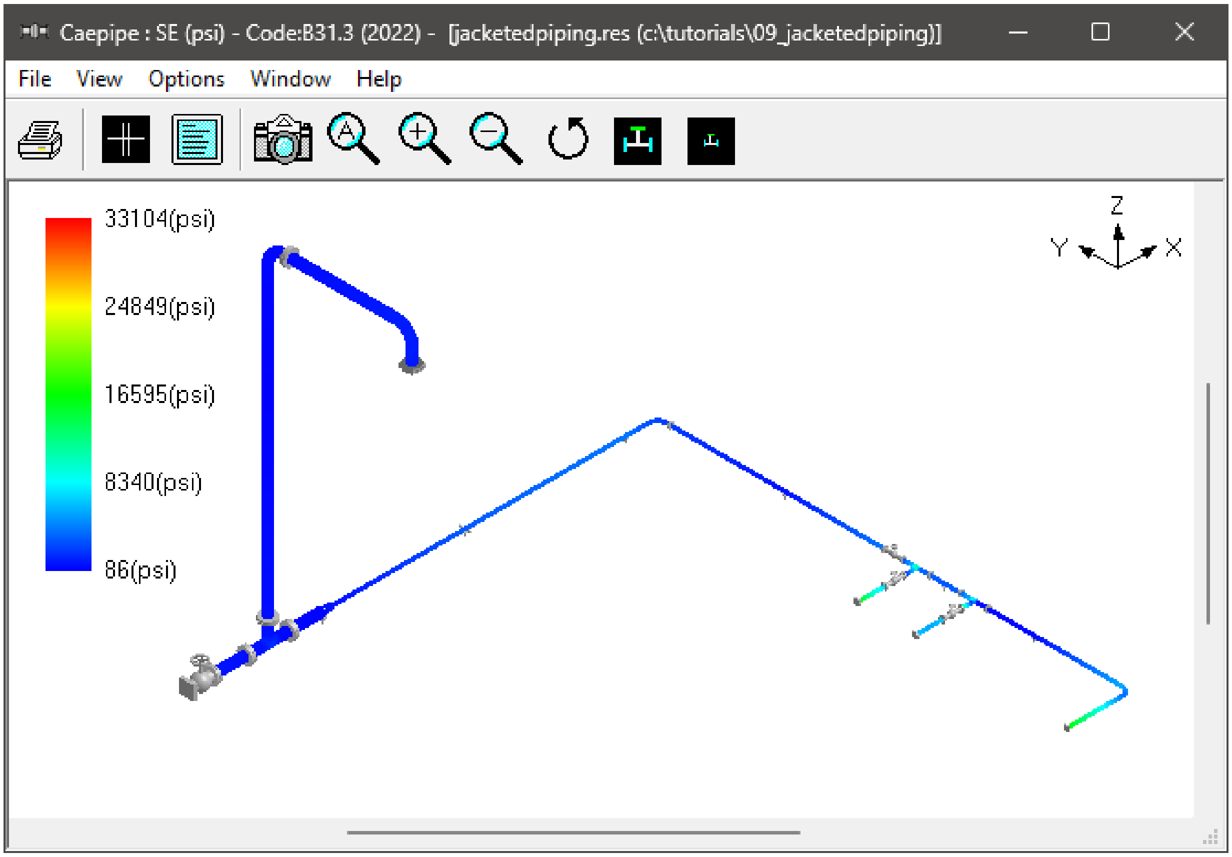
#	Node	Type
1	30	Unreinforced fabricated tee ,No. of flanges = 0
2	30J	Unreinforced fabricated tee ,No. of flanges = 0
3	110	Unreinforced fabricated tee ,No. of flanges = 0
4	110J	Unreinforced fabricated tee ,No. of flanges = 0
5	120	Unreinforced fabricated tee ,No. of flanges = 0
6	120J	Unreinforced fabricated tee ,No. of flanges = 0

Step 6:

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

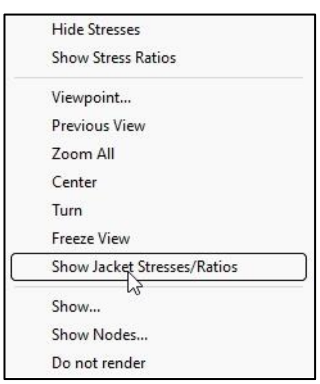


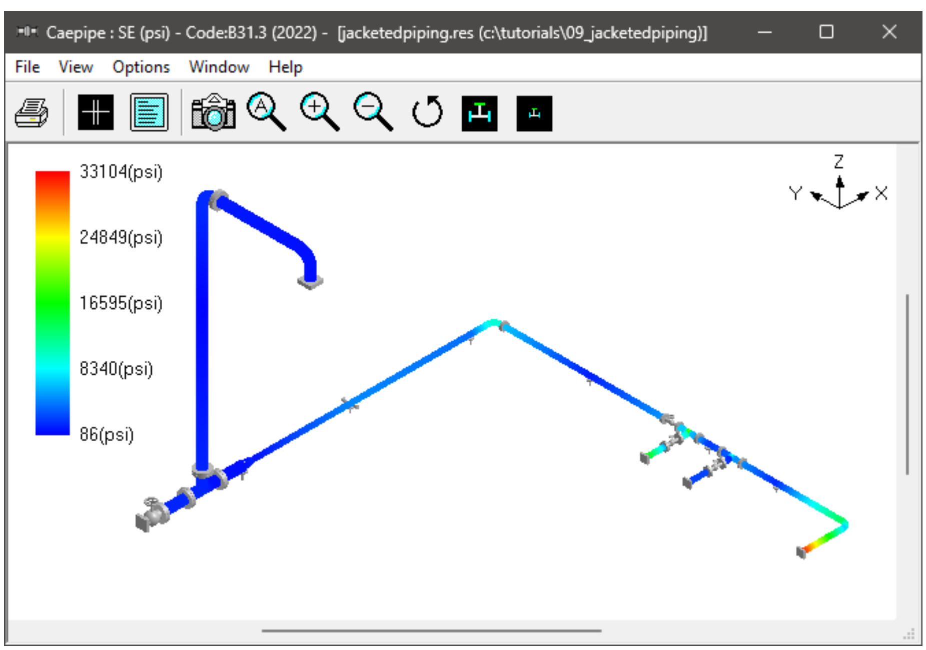
#	Sustained				Expansion				Occasional			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA	Node	SL+SO (psi)	SHO (psi)	SL+SO/SHO
1	115J	1734	20000	0.09	135J	33104	30000	1.10	115J	1734	26600	0.07
2	30	1637	20000	0.08	110J	23649	30000	0.79	30	1641	26600	0.06
3	1030J	1584	20000	0.08	1030J	17423	30000	0.58	1030J	1584	26600	0.06
4	30J	1555	20000	0.08	1030	16871	30000	0.56	30J	1567	26600	0.06
5	140J	1415	20000	0.07	135	16688	30000	0.56	140J	1425	26600	0.05
6	40J	1384	20000	0.07	130C	13755	30000	0.46	40J	1395	26600	0.05
7	90J	1304	20000	0.07	2000	13354	30000	0.45	90J	1304	26600	0.05
8	87J	1275	20000	0.06	110	13230	30000	0.44	70J	1278	26600	0.05
9	70J	1271	20000	0.06	1020J	11401	30000	0.38	87J	1276	26600	0.05
10	50J	1226	20000	0.06	120J	11105	30000	0.37	50J	1233	26600	0.05
11	75J	1183	20000	0.06	200J	10548	30000	0.35	25J	1191	26600	0.04
12	25J	1182	20000	0.06	120	10046	30000	0.33	75J	1189	26600	0.04
13	120J	1179	20000	0.06	1020	9914	30000	0.33	120J	1179	26600	0.04

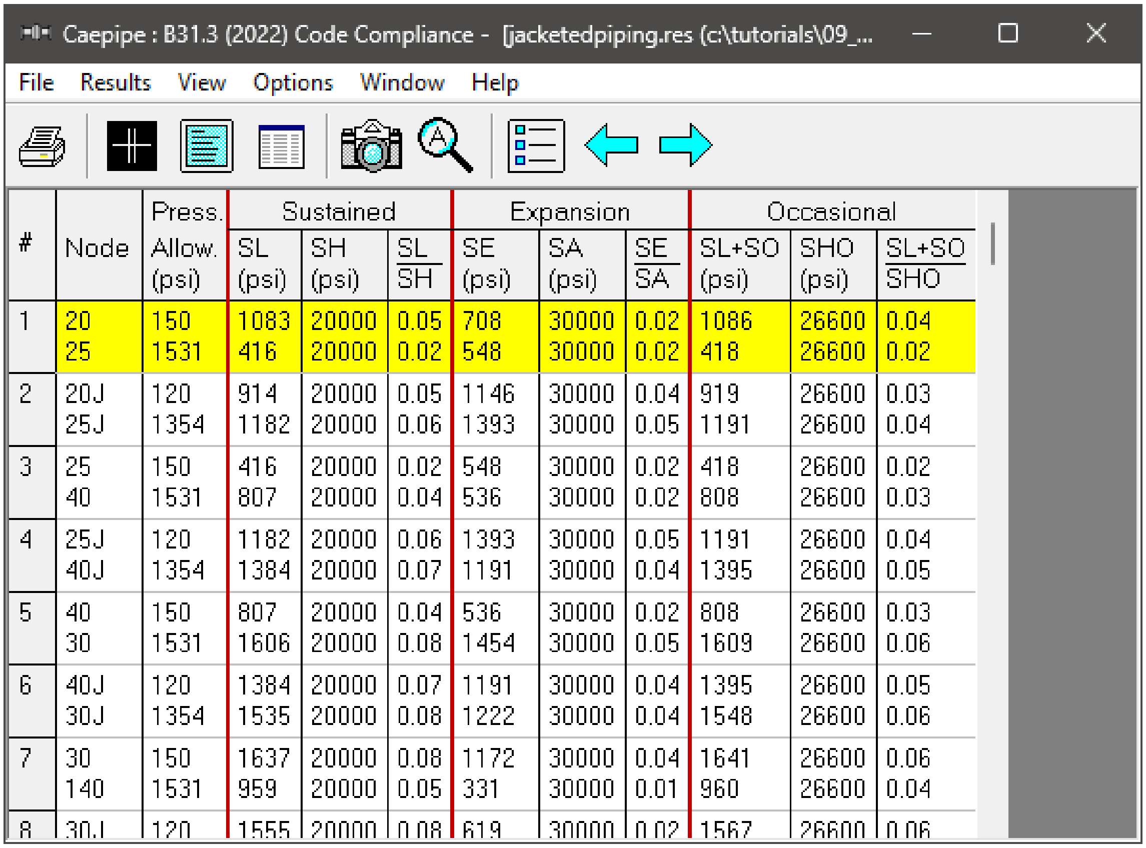


Jacketed Piping Stresses/Ratios

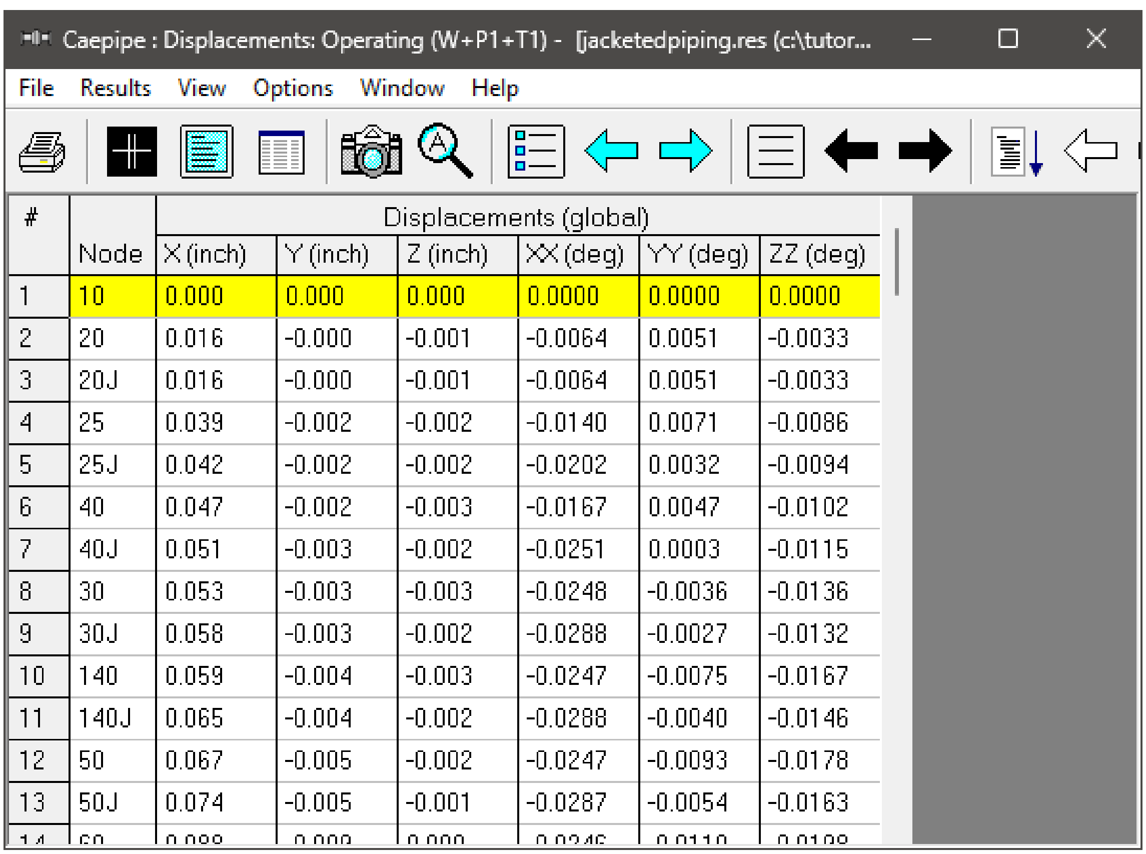
The default color-coded stress / stress ratio contour plots are for the core piping. CAEPIPE provides an option for you to display the color-coded stress / stress ratio contour plots for jacket piping in the graphics window context menu. Upon selecting the command, Jacket stresses can be seen as shown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







#	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 25	150 1531	1083 416	20000 20000	0.05 0.02	708 548	30000 30000	0.02 0.02	1086 418	26600 26600	0.04 0.02
2	20J 25J	120 1354	914 1182	20000 20000	0.05 0.06	1146 1393	30000 30000	0.04 0.05	919 1191	26600 26600	0.03 0.04
3	25 40	150 1531	416 807	20000 20000	0.02 0.04	548 536	30000 30000	0.02 0.02	418 808	26600 26600	0.02 0.03
4	25J 40J	120 1354	1182 1384	20000 20000	0.06 0.07	1393 1191	30000 30000	0.05 0.04	1191 1395	26600 26600	0.04 0.05
5	40 30	150 1531	807 1606	20000 20000	0.04 0.08	536 1454	30000 30000	0.02 0.05	808 1609	26600 26600	0.03 0.06
6	40J 30J	120 1354	1384 1535	20000 20000	0.07 0.08	1191 1222	30000 30000	0.04 0.04	1395 1548	26600 26600	0.05 0.06
7	30 140	150 1531	1637 959	20000 20000	0.08 0.05	1172 331	30000 30000	0.04 0.01	1641 960	26600 26600	0.06 0.04
8	30J	120	1555	20000	0.08	619	30000	0.02	1567	26600	0.06



#	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	-0.0064	0.0051	-0.0033
3	20J	0.016	-0.000	-0.001	-0.0064	0.0051	-0.0033
4	25	0.039	-0.002	-0.002	-0.0140	0.0071	-0.0086
5	25J	0.042	-0.002	-0.002	-0.0202	0.0032	-0.0094
6	40	0.047	-0.002	-0.003	-0.0167	0.0047	-0.0102
7	40J	0.051	-0.003	-0.002	-0.0251	0.0003	-0.0115
8	30	0.053	-0.003	-0.003	-0.0248	-0.0036	-0.0136
9	30J	0.058	-0.003	-0.002	-0.0288	-0.0027	-0.0132
10	140	0.059	-0.004	-0.003	-0.0247	-0.0075	-0.0167
11	140J	0.065	-0.004	-0.002	-0.0288	-0.0040	-0.0146
12	50	0.067	-0.005	-0.002	-0.0247	-0.0093	-0.0178
13	50J	0.074	-0.005	-0.001	-0.0287	-0.0054	-0.0163

Caepipe : Loads on Anchors: Operating (W+P1+T1) - [jacketedpiping.res (c:\tu...

File Results View Options Window Help

#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10		-219	-11	-483	-317	496	-216
2	135		-138	-886	-20	1	23	-1326
3	530		31	-52	-63	-84	-72	-130
4	1030		-217	776	-44	-9	32	798
5	2030		377	-14	-25	1	9	1

Caepipe : Support load summary for anchor at node 10 - [jacketedpiping.res (...

File Results View Options Window Help

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	0	0	-394	-1	411	0
Operating1	-219	-11	-483	-317	496	-216
Sustained+Wind	2	0	-392	-1	410	-1
Operating1+Wind	-218	-11	-481	-317	495	-217
Sustained+Wind 2	0	0	-394	-1	411	0
Operating1+Wind 2	-219	-11	-483	-317	496	-216
Sustained+Wind 3	0	0	-394	-1	411	0
Operating1+Wind 3	-219	-11	-483	-317	496	-216
Sustained+Wind 4	0	0	-394	-1	411	0
Operating1+Wind 4	-219	-11	-483	-317	496	-216
Maximum	2	0	-392	-1	496	0
Minimum	-219	-11	-483	-317	410	-217
Allowables	0	0	0	0	0	0