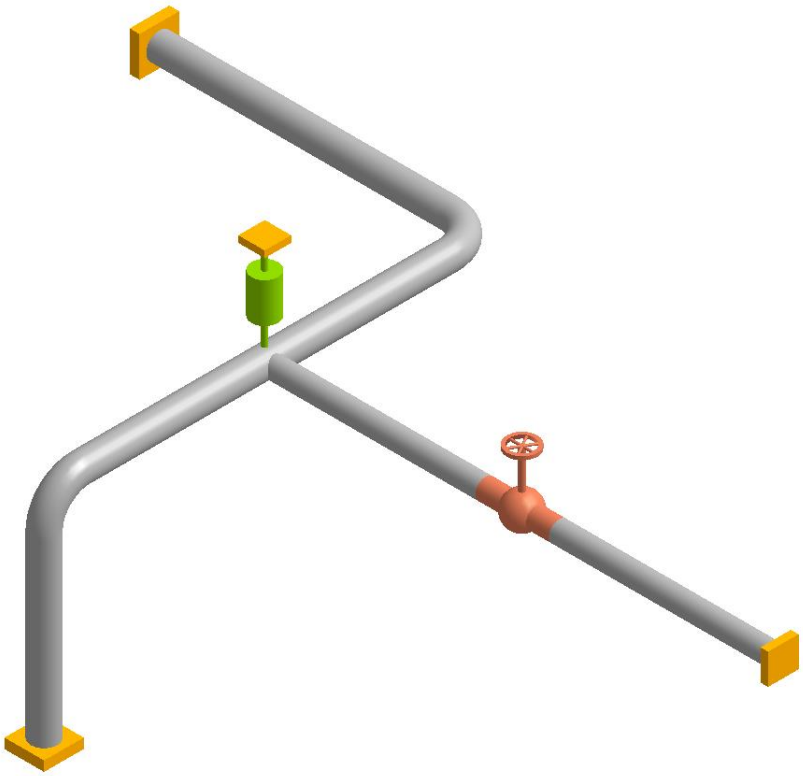
CAEPIPE™

Tutorial for Modeling and Results Review

Problem 1



SST SYSTEMS, INC.

The ***FASTEST*** Solutions for Piping Design and Analysis

Disclaimer

Please read the following carefully:

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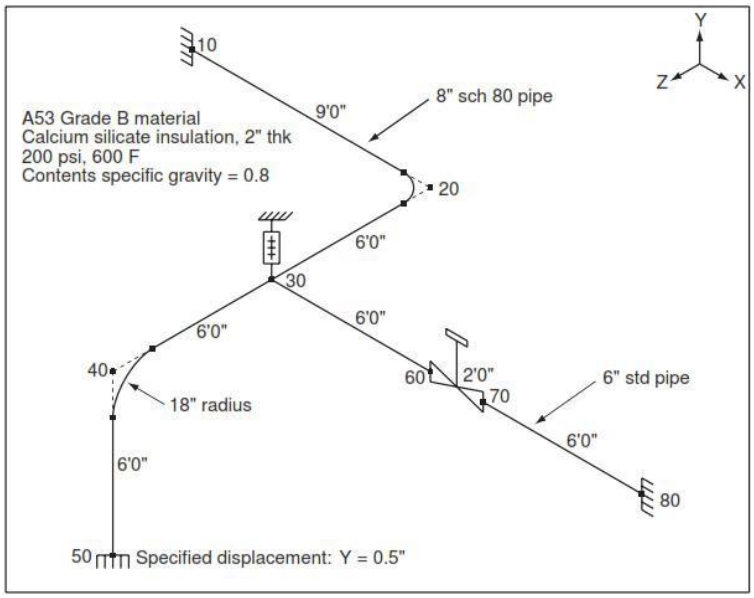
Tutorial for Modeling and Results Review – Problem 1

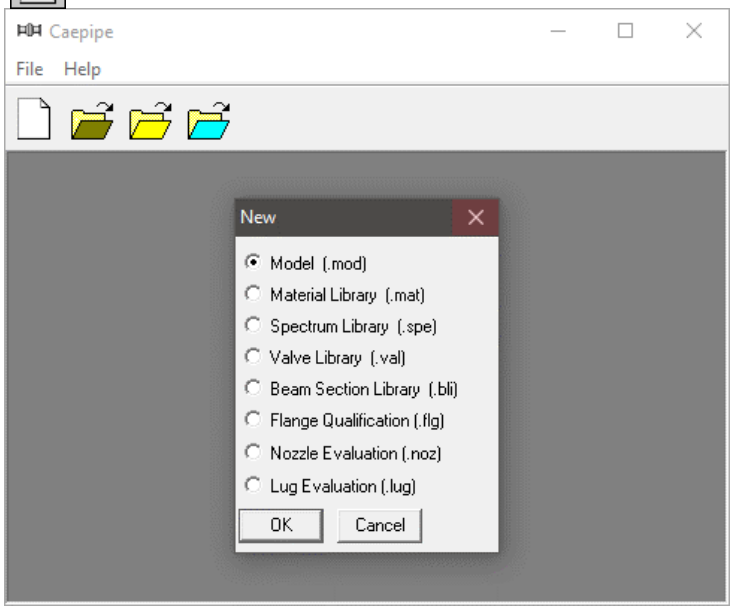
The best way to learn CAEPIPE is to try it yourself. In this tutorial we will create a simple model to help you understand the use of CAEPIPE. The details of the model are shown below:



You will learn how to:

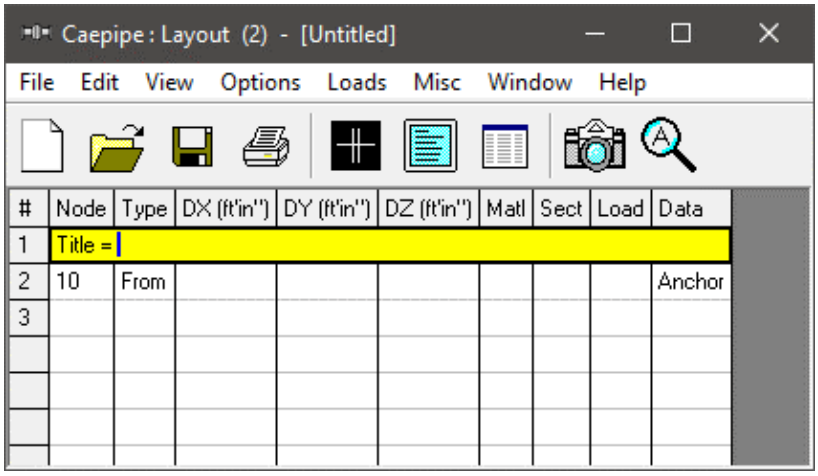
1. Enter Title
2. Select Analysis options (piping code etc.)
3. Define Material, Section and Loads for the model
4. Input Model Layout
5. Select Load Cases for Analysis
6. Analyze
7. View Results

Start CAEPIPE. Then click on the New file button. The New file dialog opens.

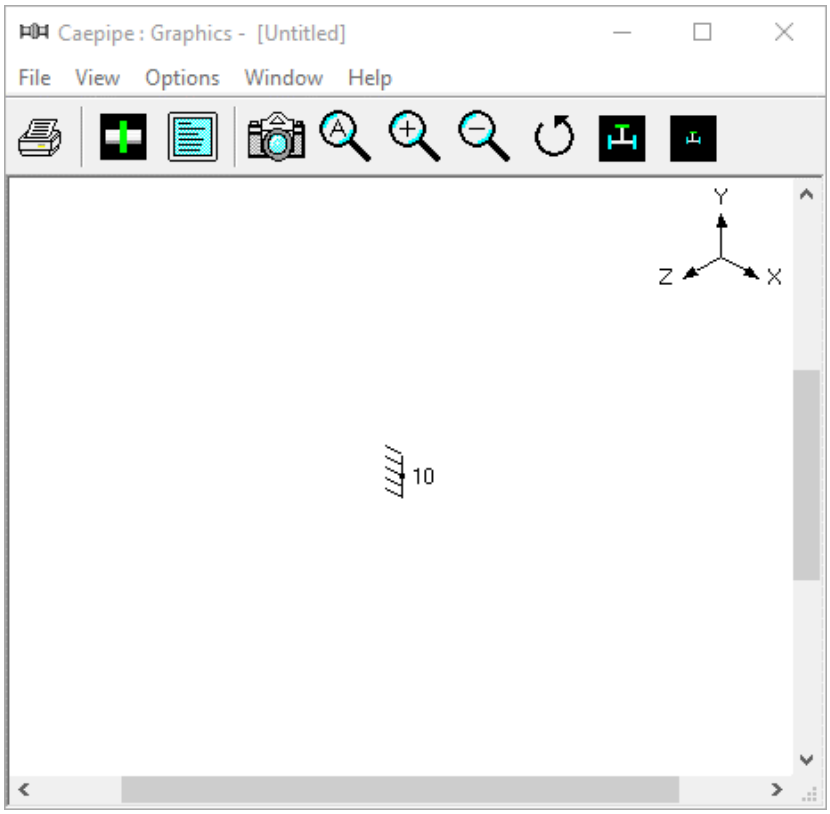


From the New file dialog, select the type of the new file as Model (.mod) file. This opens two independent windows: Layout and Graphics.

Layout window



Graphics window



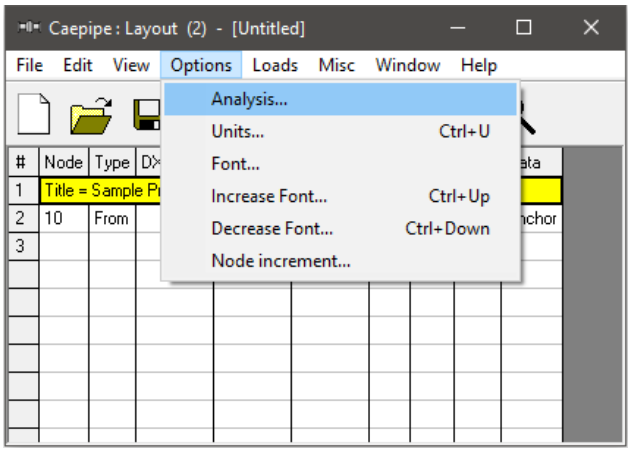
Adjust the size of the windows to fit your desktop such that you can view both comfortably at the same time.

1. Enter Title

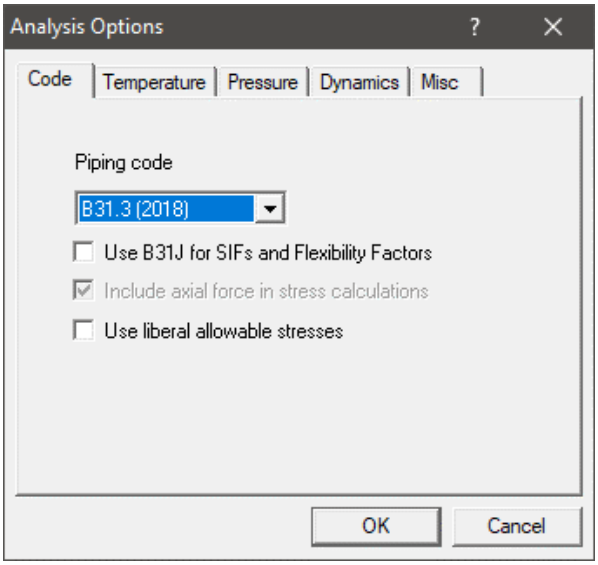
Type "Sample problem" as the title in the first row that contains "Title = ". Press Enter.

2. Select Analysis options (piping code etc.)

Click on the Options menu and then select Analysis (Options > Analysis) to specify options for analysis.



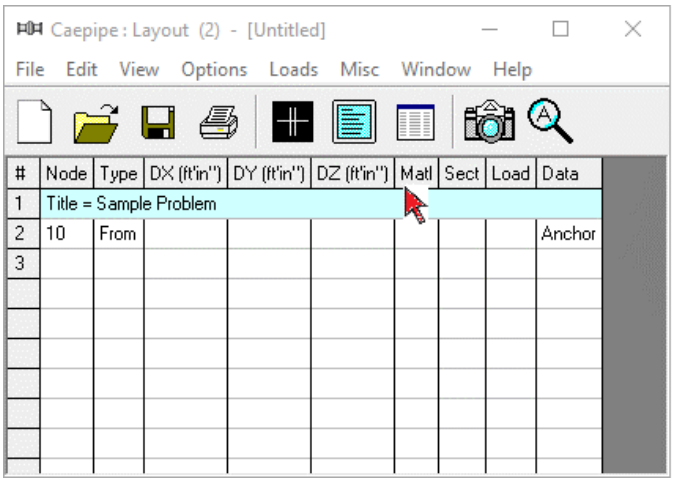
This opens the Analysis Options dialog.



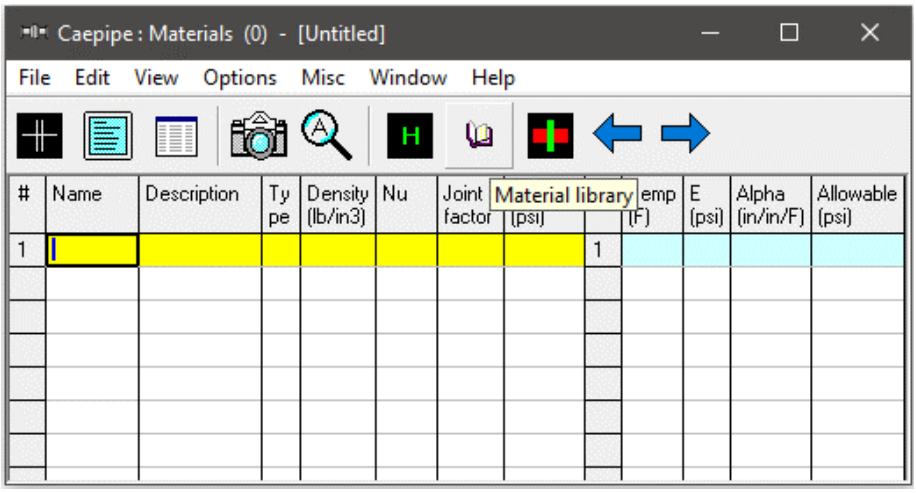
On the Code property page, select B31.3 (2018) for Piping code. Then click on OK to close Analysis Options dialog.

3. Define Material, Sections and Load Material

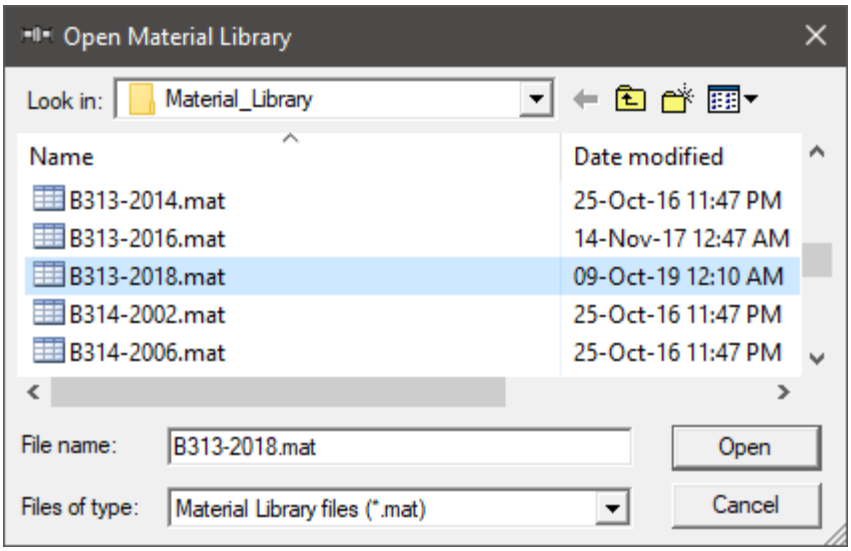
Click on "Matl" in the header in the Layout window (or press Ctrl+Shift+M)



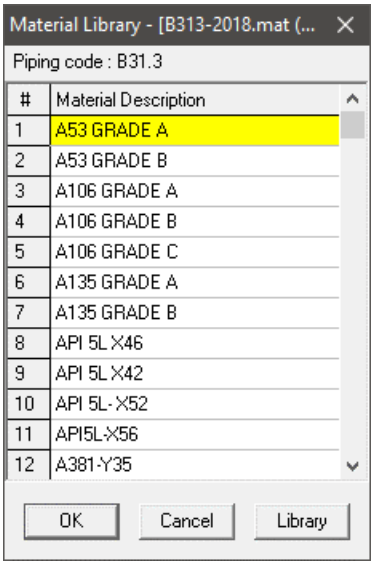
This opens up the Materials list in a separate List window. Position and resize the list window as you desire. Click on Library button on the Toolbar (or choose File > Library).



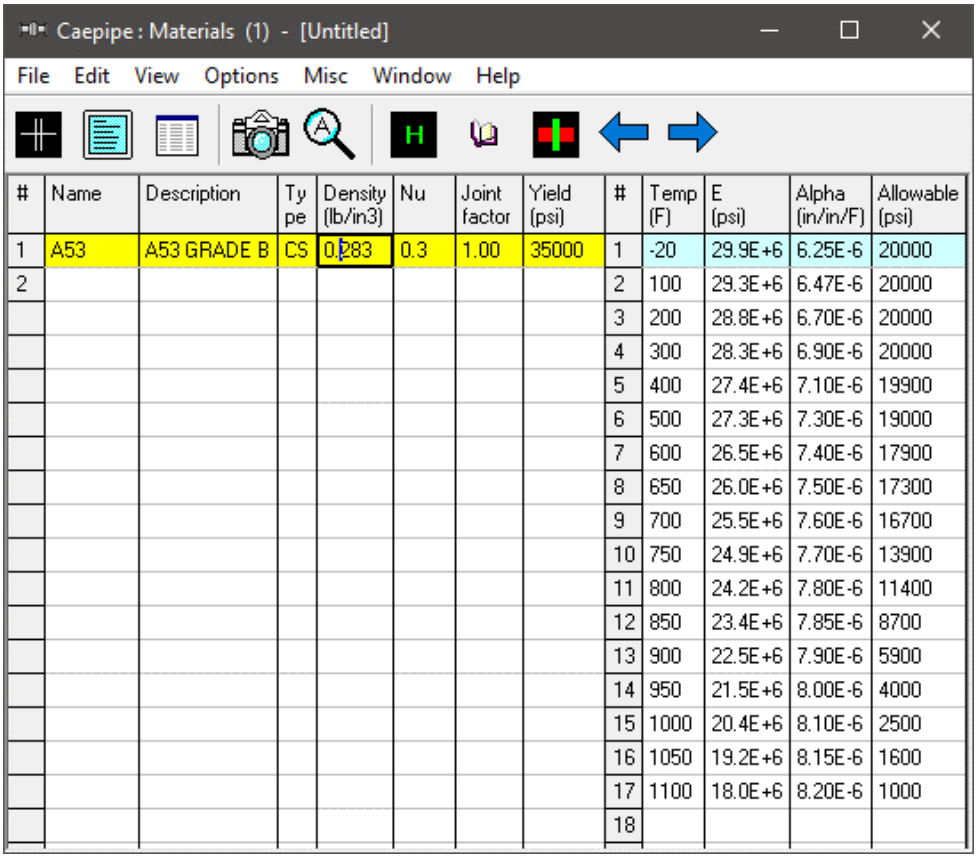
The Open Material Library dialog is shown.



Select B313-2018.mat as the library file to open by double clicking on it. The available materials in the library are shown.

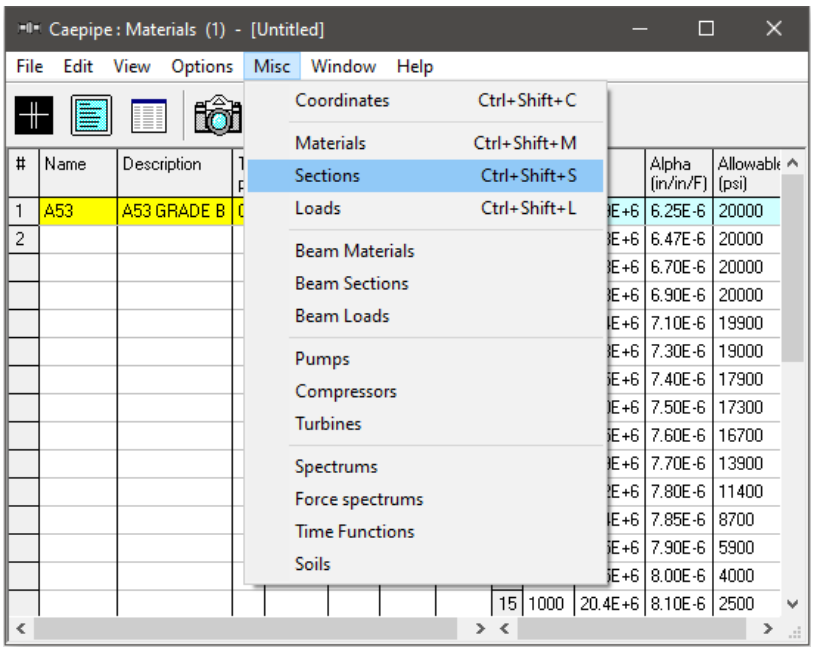


Double click on A53 Grade B material to select it. The properties for this material are transferred to the material in the List window. Type "A53" for material name and then press Enter.

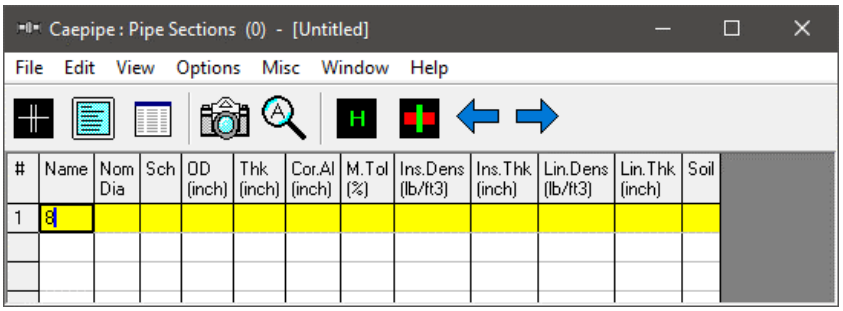


Sections

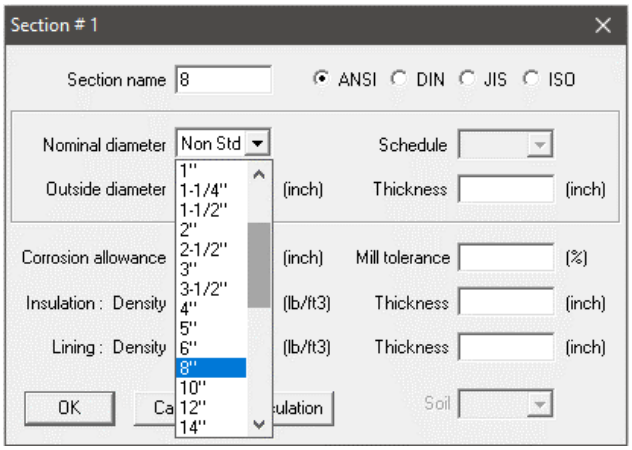
Select Sections from the Misc menu of the List window (or press Ctrl+Shift+S).



The Sections list is shown. To enter the first section, Type '8' for Section name and press Enter. The Section Properties dialog is shown with the section name 8.

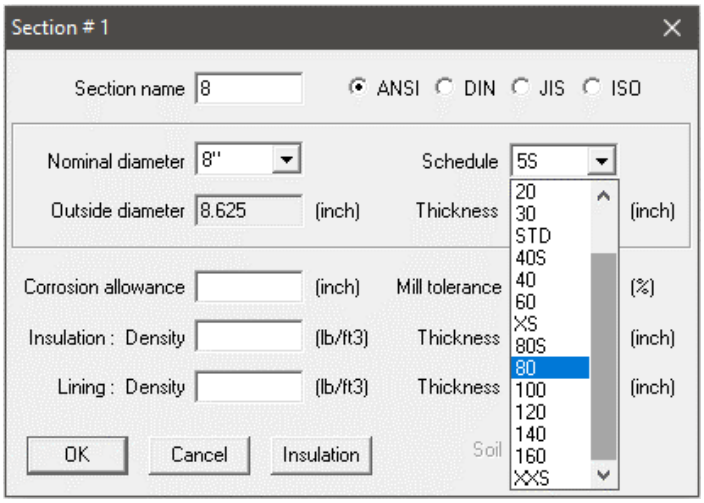


The Section Properties dialog is shown with the section name 8.



Click on the down arrow of the Drop Down combo box for Nominal diameter and select 8" for Nominal diameter. The Outside diameter (8.625") is automatically entered.

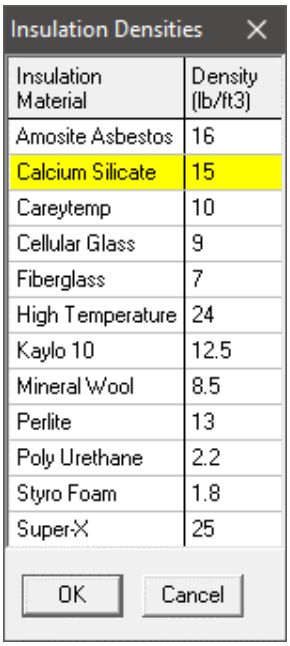
To select the schedule for the 8" pipe, click on the down arrow of the Drop Down combo box for Schedule and select 80 for Schedule.



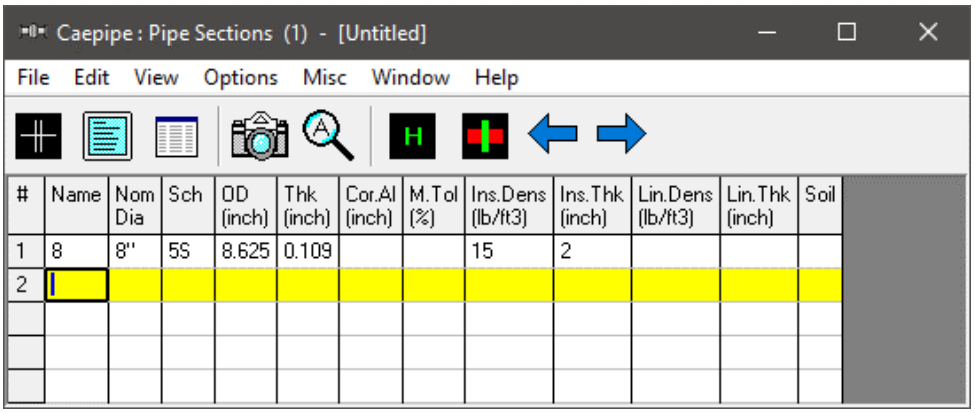
The Thickness (0.5") is automatically entered.

For Insulation density, click on the Insulation button or Press Alt+I.

A table of Insulation materials and their densities is shown.

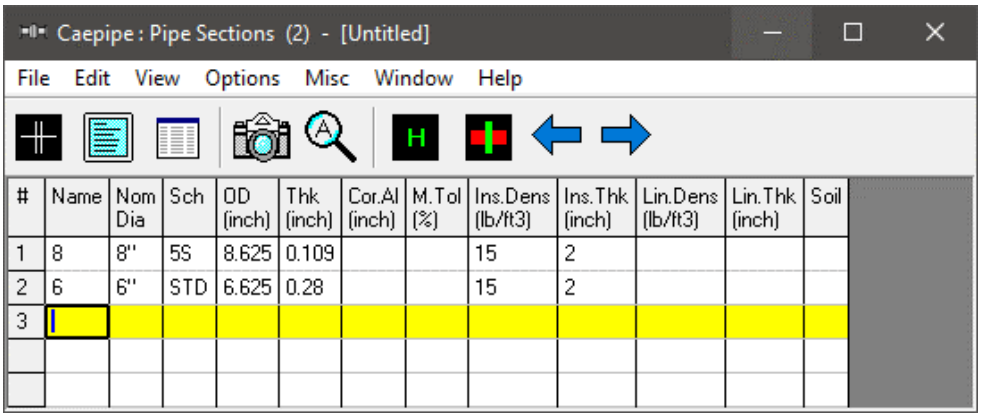


Double click on Calcium Silicate. The Insulation density (15.0 lb/ft3) is entered on the Section dialog. Type 2 (inches) for Insulation Thickness then press Enter or click OK to enter the first section.



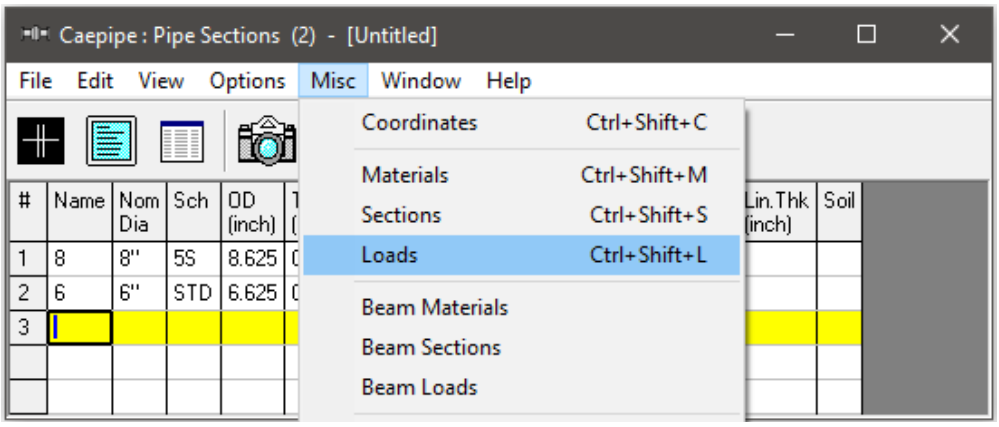
Now repeat the process for the second section.

In row # 2, Type 6 for Section name and press Enter. The Section Properties dialog is shown with the section name 6. Select 6" for Nominal diameter, STD for Schedule and 2" Calcium Silicate for Insulation. Press Enter or click on OK to enter the second section.



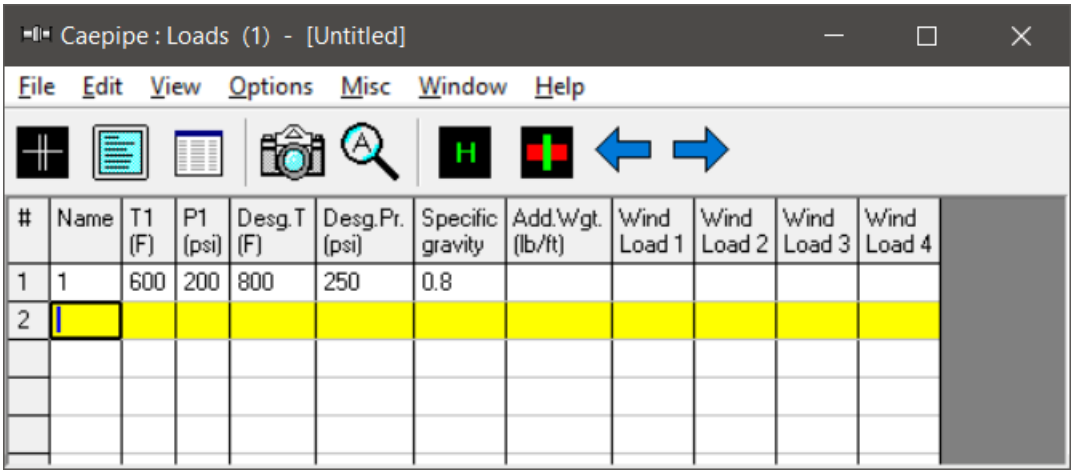
Load

Select Loads from the Misc menu (or press Ctrl+Shift+L).



The Loads list is shown. To enter the first load, Type '1' for Name, Tab to T1 and type 600, Tab to P1 and type 200, Tab to Desg.T and type 800, Tab to Desg. Pr. And type 250 and Tab to Specific gravity

and type 0.8. Then press Enter. That is it! The load is entered. (Alternately, you could have pressed Ctrl+E on the first row and typed in the same information in a dialog box).



#	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	1	600	200	800	250	0.8					
2											

Note:

Design Temperature and Design Pressure should always be greater than or equal to the Operating Temperature and Operating Pressure (T1 and P1 for this tutorial).

Design Temperature entered will be used to compute the allowable stress for material while computing the Allowable Pressure as per the piping code selected.

The Allowable Pressure computed as per the piping code selected is then compared against the Design Pressure entered above and reported in the Code Compliance results.

In addition to the above, starting CAEPIPE V.10.20, there is an additional load case for Design Pressure and Design Temperature that compute and show results for Displacements, Element Forces & Moments, Support Loads and Support Load Summary.

Click in the Layout window or press F3 to move the focus to the Layout window.

4. Input Model Layout

We are going to model the 8" header line first, followed by the 6" branch line.

NOTE

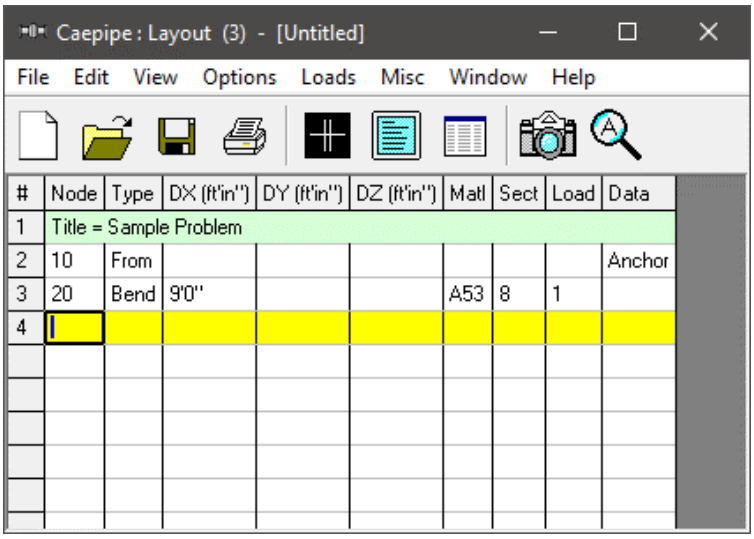
- In the following text, the word 'type' should be distinguished from the words 'Type column' or simply 'Type' (upper case 'T'). The former ('type') would mean press the keys for the text you want to type. The latter word 'Type' would refer to the Type column in the Layout spreadsheet.
- Also, the instruction "type B for Bend" does not necessarily mean the upper case 'B'. The lower case 'b' could also be typed.
- For items input in the Data column (such as Anchor or Hanger), the cursor needs to be in the Data column. This can be quickly done by pressing Ctrl+D from any column or clicking in the Data column. Another way is to Tab repeatedly to reach the Data column.
- As the graphics window is simultaneously updated, you should position the graphics window in such a way that you can see it along with the input window.

First the 8” header

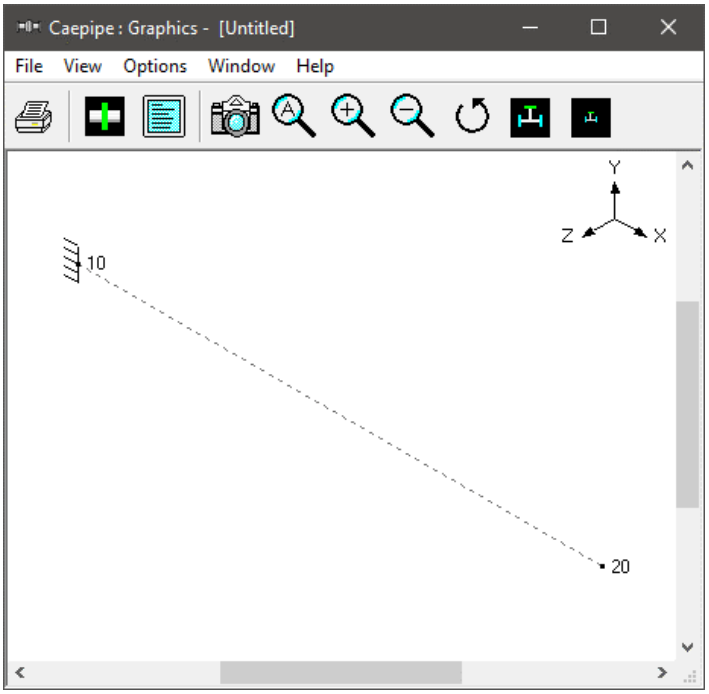
Following the Title at row #1, row #2 is already generated with Node 10 of Type “From” with an Anchor in the Data column.

Press Enter to move the highlight to the next row #3. Tab to the Type column. The next Node 20 is automatically assigned. In the Type column, type ‘b’ (for Bend), Tab to DX, type 9. Tab over to Material, type A53, Tab to Section, type 8, Tab to Load, type 1. Press Enter and the cursor moves to the next row(#4).

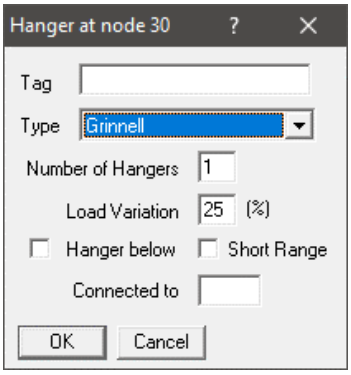
In row #4, Tab to the Type column. The next Node 30, is automatically assigned.



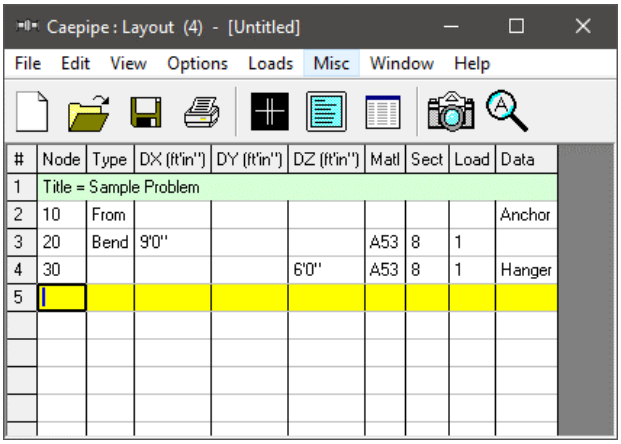
You will see the model in the graphics window as it is entered. You can press F2 to switch between text and graphics windows.



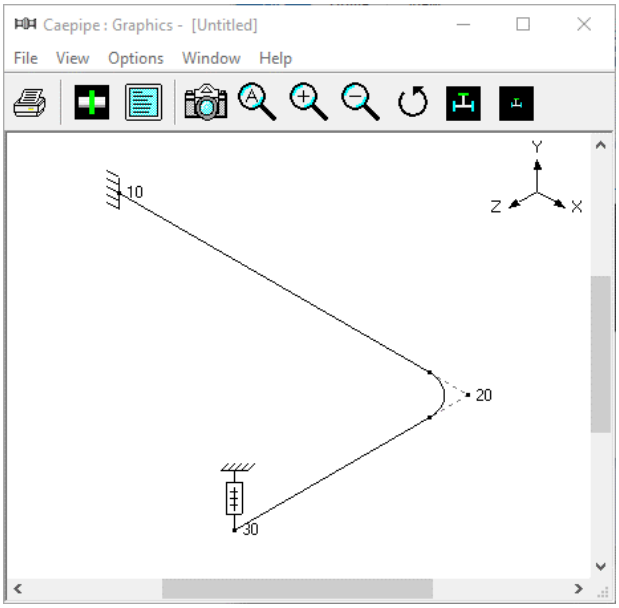
In row #4 with Node 30, Tab to DZ, type 6, Tab to Data (or press Ctrl+Shift+D), type 'h' (for a to be designed Hanger) and press Enter, the Hanger dialog is opened.



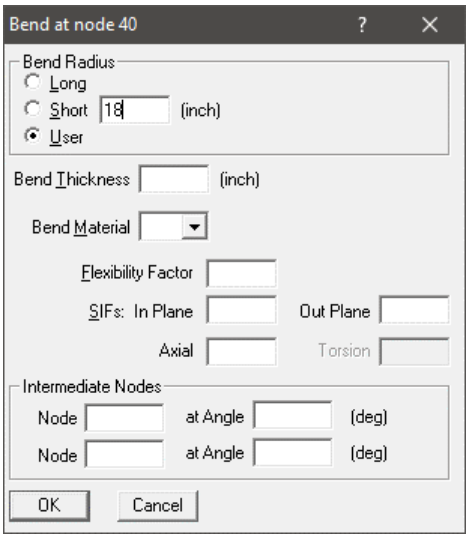
Press Enter or click on OK to input the hanger. The material, section and load are automatically inserted (based on the previous row's material, section and load), and the cursor moves to the next row.



The Graphics window will look like this.



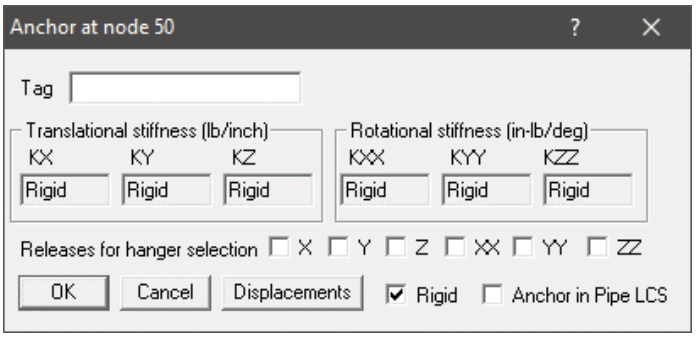
In row #5, Tab to the Type column. The next Node 40, is automatically assigned. In the Type column, type 'b' (for Bend) and press Tab. This bend has a non-standard (user defined) bend radius. Therefore the bend radius needs to be modified from the default long radius. Double click on the bend in the Type column or press Ctrl+T to bring up the bend dialog box. Click on User Bend Radius radio button and enter 18 for bend radius. Press Enter or click on OK to modify the bend.



While still in row #5, Tab to DZ, type 6 then press Enter. The material, section and load are automatically inserted like before, and the cursor moves to the next row.

In row #6, Tab to the DY column. The next Node 50, is automatically assigned. In the DY column, type -6, Tab to the Data column or press Ctrl+Shift+D to move to the data column, then type 'a' (for Anchor). An anchor, material, section and load are automatically inserted, and the cursor moves to the next row.

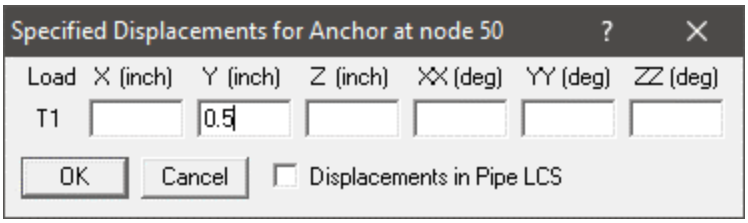
Let us specify a thermal anchor movement for the Anchor we just put in at node 50. Double click on the Anchor at node 50 in row #6. The Anchor dialog comes up.



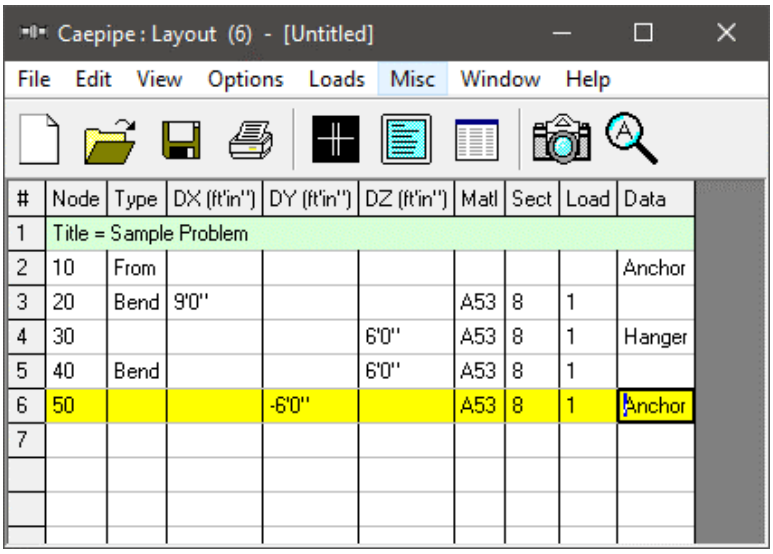
Note:

Option "Anchor in Pipe LCS" allows the user to input Anchor stiffnesses in the Local Coordinate System (LCS) of the adjoining pipe. On the other hand, if "Anchor in Pipe LCS" is not turned ON, then the user has to input Anchor stiffnesses in the Global Coordinate System (GCS).

Click on Displacements button. The Specified Displacements dialog for the anchor comes up. Tab to Y displacement field and type 0.5.

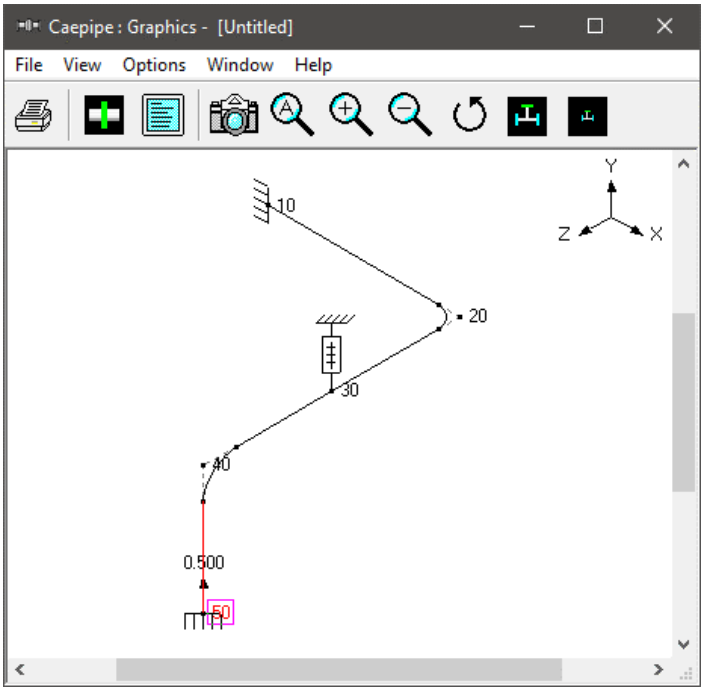


Press Enter to exit the Specified Displacements dialog. Press Enter again to exit the Anchor dialog. In the Layout window, press Enter to move to the next row.



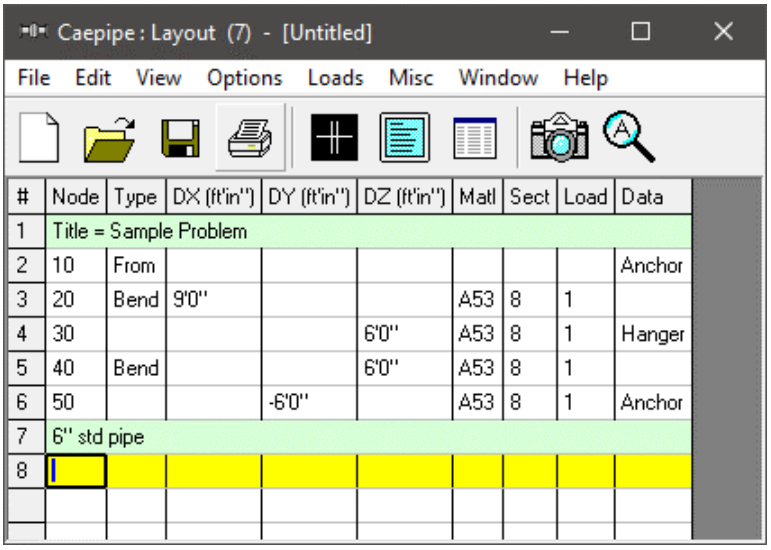
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7									

 Click on the Zoom All button (or press Ctrl+A) to view the 8" header line fully in the graphics window.



Now the 6” branch

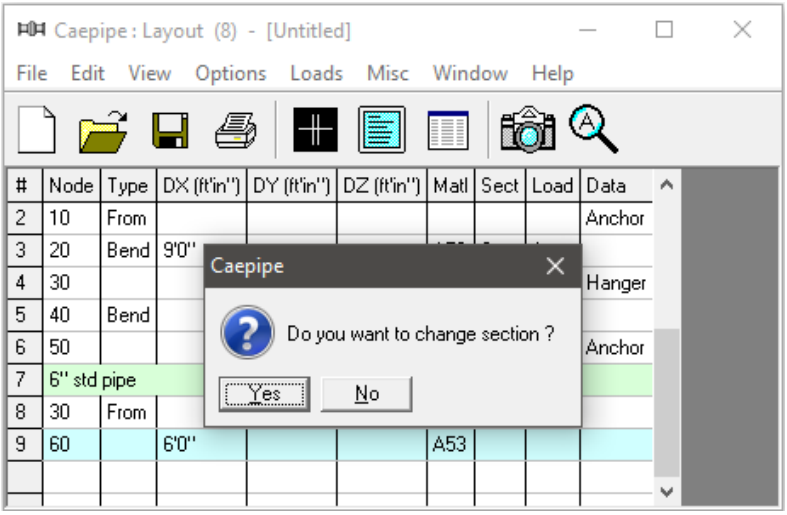
Let us input a comment saying that this is a 6” std pipe. On an empty row, if the first character in the Node field is input as ‘c’, that row becomes a comment row. On row #7, type ‘c’ to create the comment and then type: 6” std pipe and then press Enter to go to the next row.



#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8									

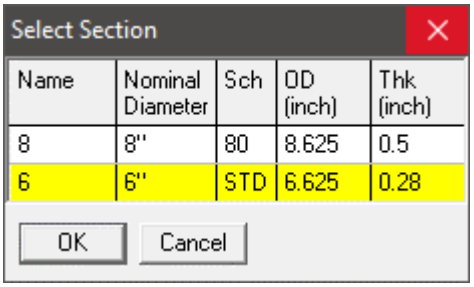
On the next row (#8), type 30 for Node, Tab to the Type column, type ‘f’ (for “From”, since we are beginning a new branch), press Enter. In the next row (#9), Tab to the DX column. The next Node 60, is automatically assigned. In the DX column, type 6 and press Enter.

CAEPIPE inserts the previous material, and automatically detects the new branch and asks if you want to change section.

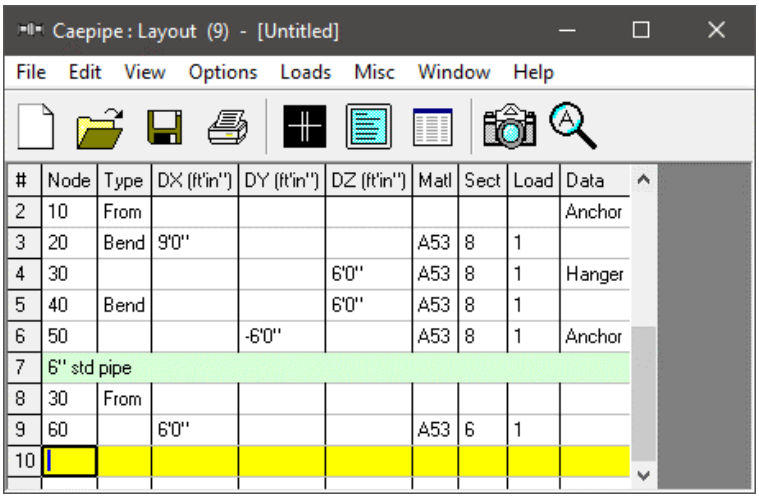


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
2	10	From							Anchor
3	20	Bend	9'0"						
4	30								Hanger
5	40	Bend							
6	50								Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53			

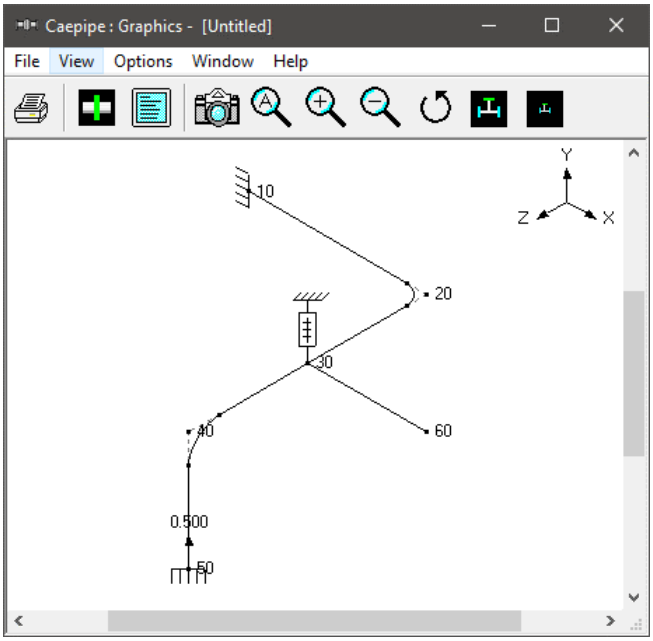
Since we want to change the section to 6, click on Yes. This opens the Section selection dialog.



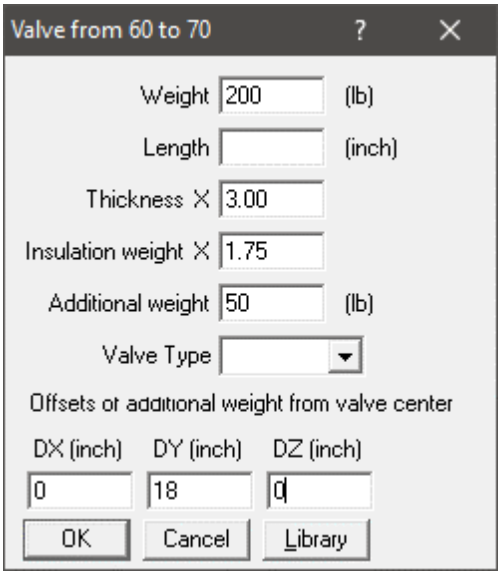
Select the 6" section by double clicking on it. The section (6) is entered in the Section column in the Layout window. Press Enter to go to the next row. The load is again automatically inserted from the previous load.



The graphics window will look like this.



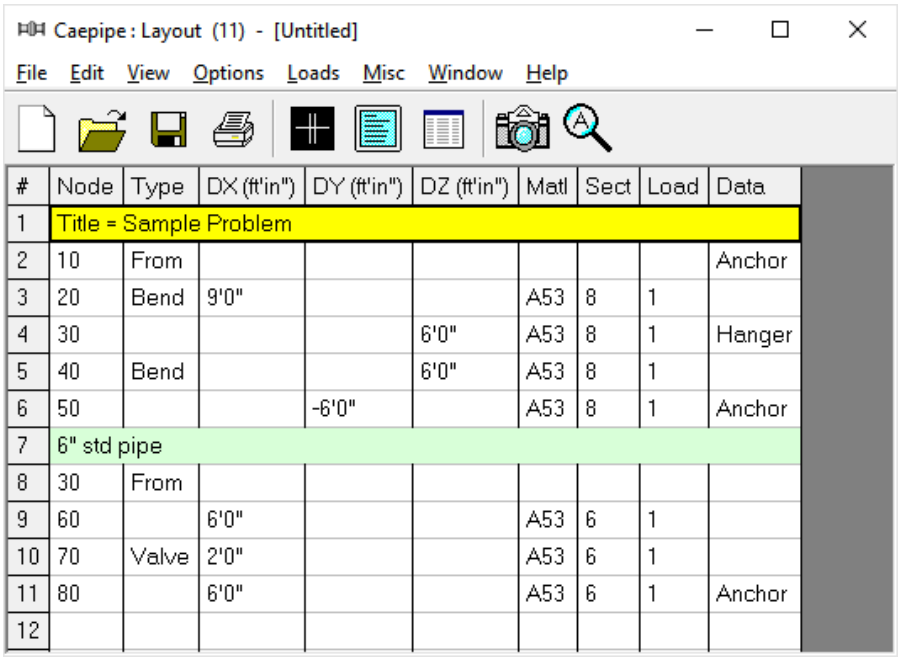
In the next row (#10), Tab to the Type column. The next Node 70, is automatically assigned. In the Type column, type 'v' (for Valve). This brings up the Valve dialog box.



In the Valve dialog box, type 200 for Weight, 50 for Additional Weight and 18 for DY offset. Then press Enter or click on OK to input the valve.

In the Layout window, type 2 for DX offset and press Enter. The material, section and load are automatically inserted as before, and the cursor moves to the next row.

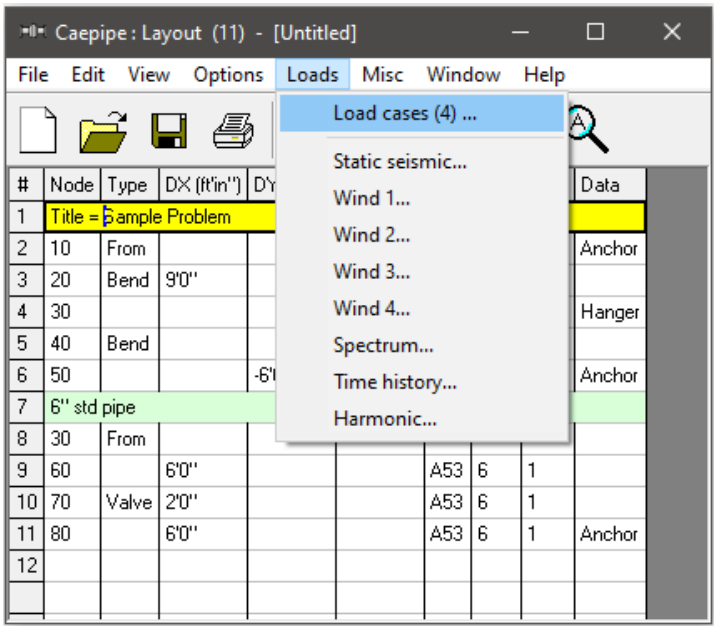
In the next row (#11), Tab to DX. The next Node 80, is automatically assigned. In the DX column, type 6. Tab to Data or press Ctrl+Shift+D to move to the data column, then type 'a' (for Anchor). Material, section and load are automatically inserted like before, and the cursor moves to the next row.



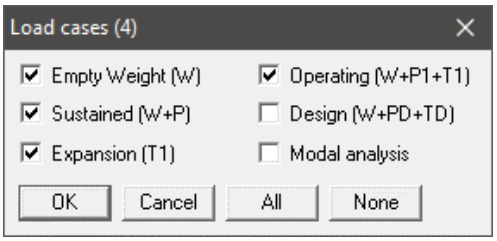
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10	70	Valve	2'0"			A53	6	1	
11	80		6'0"			A53	6	1	Anchor
12									

5. Select Load Cases for Analysis

Select Loads cases from the Loads menu.

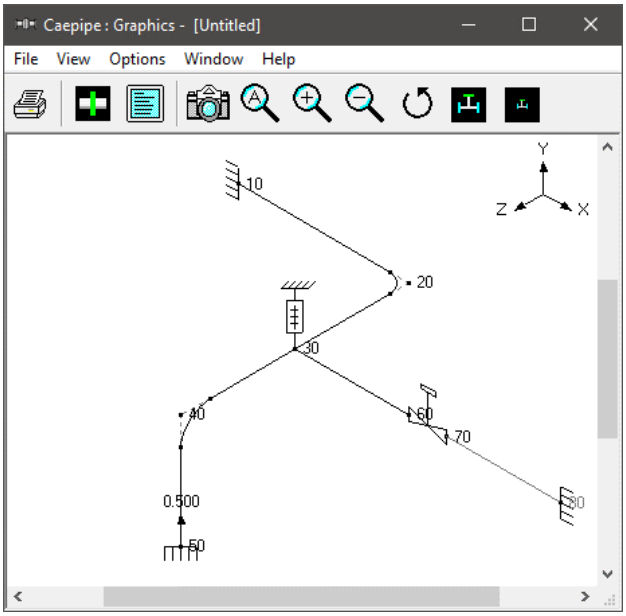


The Load cases dialog is shown.

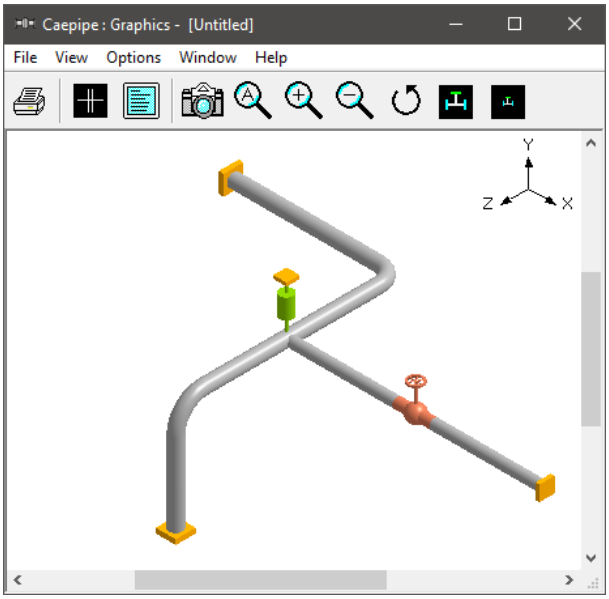


By default, Empty Weight (W), Sustained (W+P), Expansion (T1) and Operating (W+P1+T1) load cases are already selected. Design (W+PD+TD) load cases when selected for the Analysis, CAEPIPE will compute and show results for Displacements, Element Forces & Moments, Support Loads and Support Load Summary. A design load case does not include Stress Calculations, Rotating Equipment Qualifications and Flange Equivalent Pressure Calculations. Press OK to return to the Layout window. The model input is now complete.

 Click on the Zoom All button (or press Ctrl+A) to show the whole model in the graphics window.



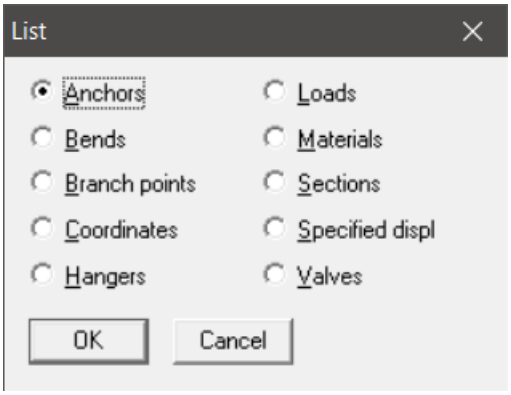

To see a 3D rendered view of the model, click on the Render button (or press Ctrl+R) in the graphics window.




To return to the non-rendered view, click on the Do not render button (or press Ctrl+R).

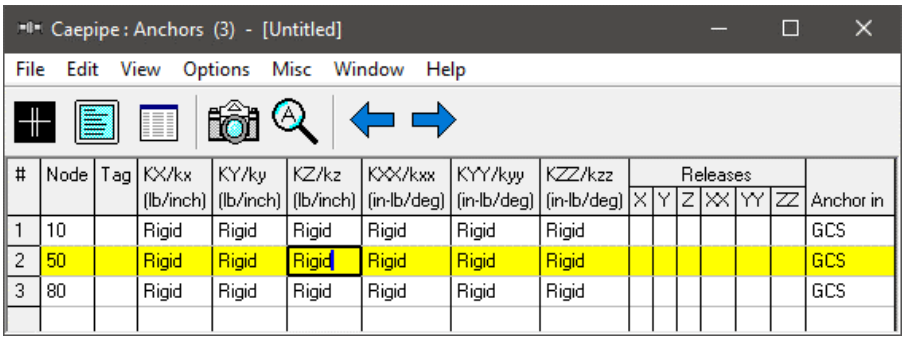
List


One of the useful features of CAEPIPE is the ability to show a list of all like items such as anchors, bends etc. in a separate List window. Click on the List button (or press Ctrl+L) to show the list dialog.



Click on an item of interest to show the list for that item.

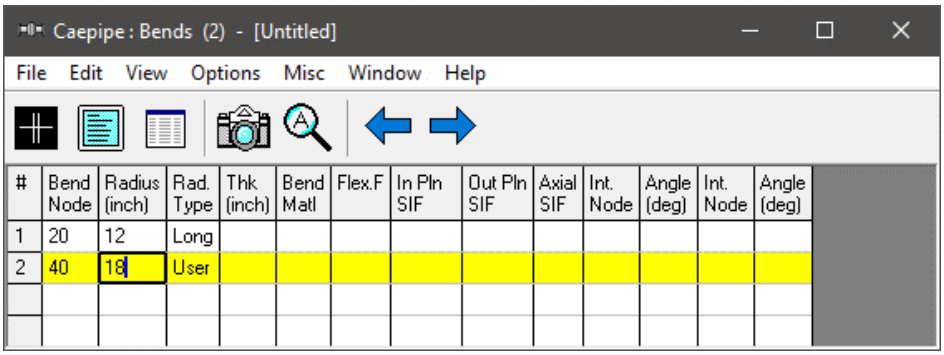
A list of all the anchors in the sample model is shown below:



#	Node	Tag	KX/kx (lb/inch)	KY/ky (lb/inch)	KZ/kz (lb/inch)	KXX/kxx (in-lb/deg)	KYY/kyy (in-lb/deg)	KZZ/kzz (in-lb/deg)	Releases						Anchor in
									X	Y	Z	XX	YY	ZZ	
1	10		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS
2	50		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS
3	80		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS

The highlighted item can be edited directly in the List window (in most cases) or in a dialog by pressing Ctrl+E. The items can be deleted by pressing Ctrl+X. The item is also highlighted in the graphics window by flashing and with a box around the node number.

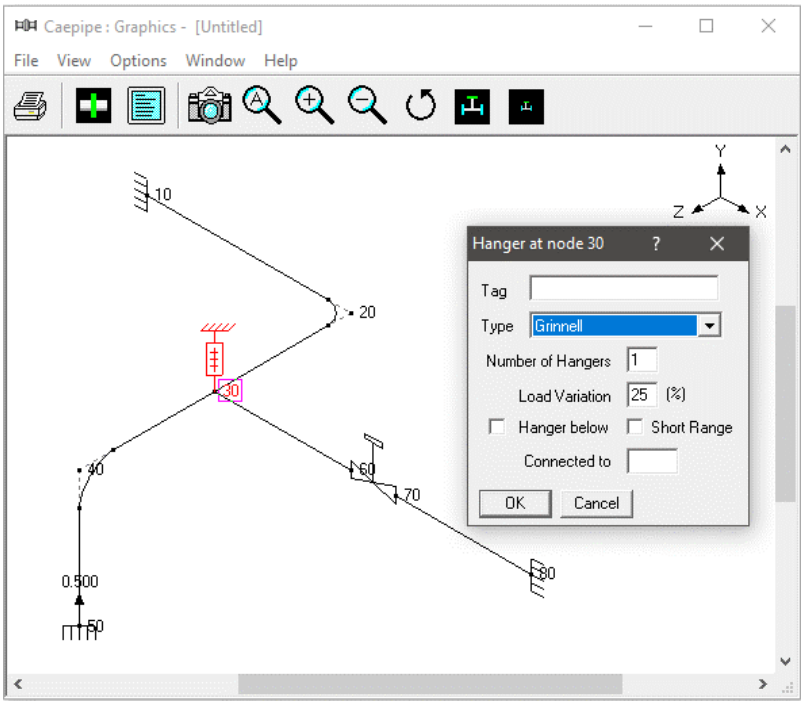
A list of all the bends in the sample model is shown below:



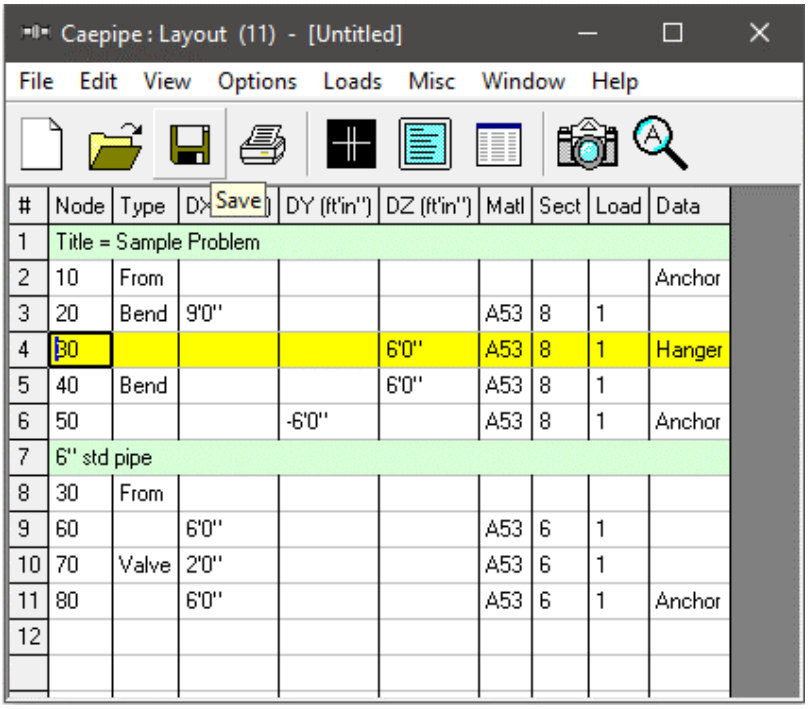
#	Bend Node	Radius (inch)	Rad. Type	Thk (inch)	Bend Matl	Flex.F	In Pln SIF	Out Pln SIF	Axial SIF	Int. Node	Angle (deg)	Int. Node	Angle (deg)
1	20	12	Long										
2	40	18	User										

Editing in the Graphics Window

Another useful feature is the ability to edit an item in the graphics window. When an item such as a Hanger is clicked in the graphics window, a dialog box for that item is opened, where it can be modified.

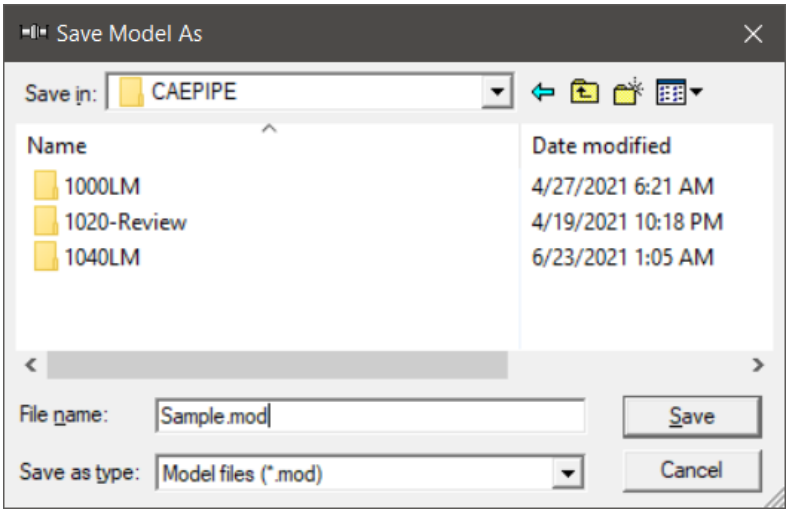



Save the model by clicking on the Save button.



#	Node	Type	DX	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10	70	Valve	2'0"			A53	6	1	
11	80		6'0"			A53	6	1	Anchor
12									

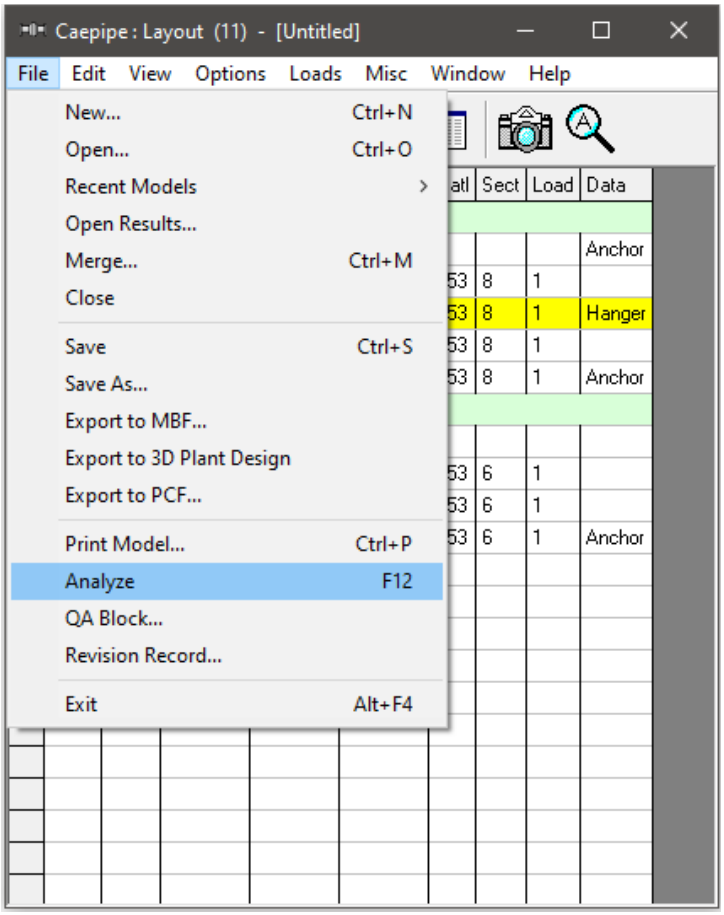
The "Save Model As" dialog is shown.



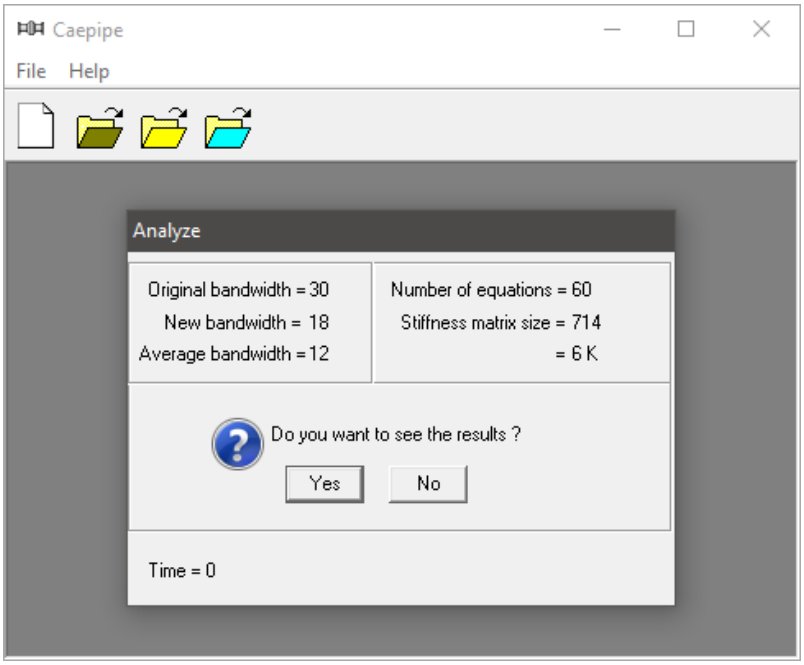
Type the File name as "Sample" and press Enter to save the model. We are done with modelling. Let us analyze now.

6. Analyze

Click on Analyze under the File menu.

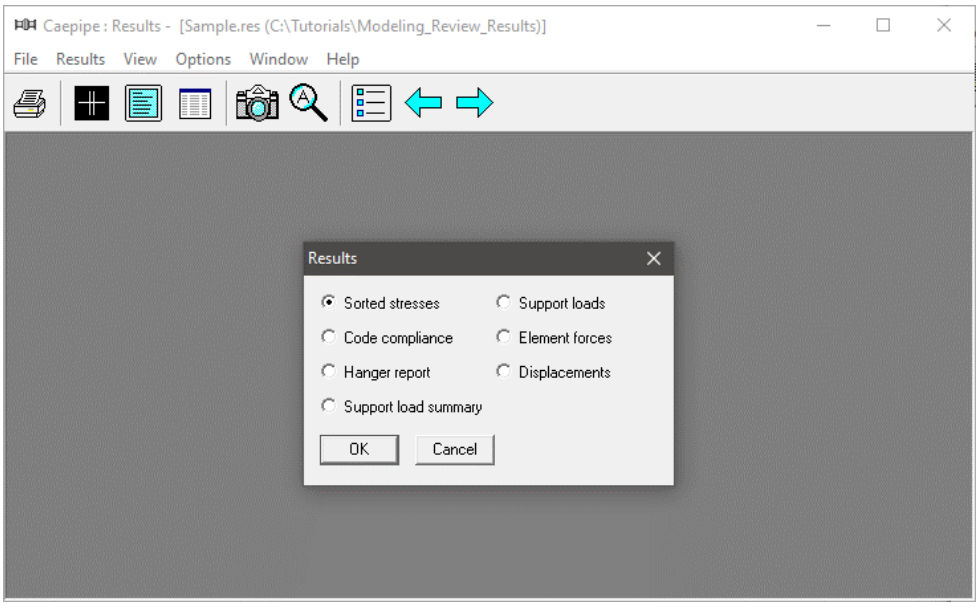


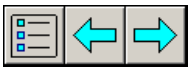
After the analysis, you are asked if you want to see the results. Select Yes.



7. View Results

After finishing the analysis and choosing to see the results or by opening the results file (.res), the results window is displayed. The Results dialog is opened automatically.



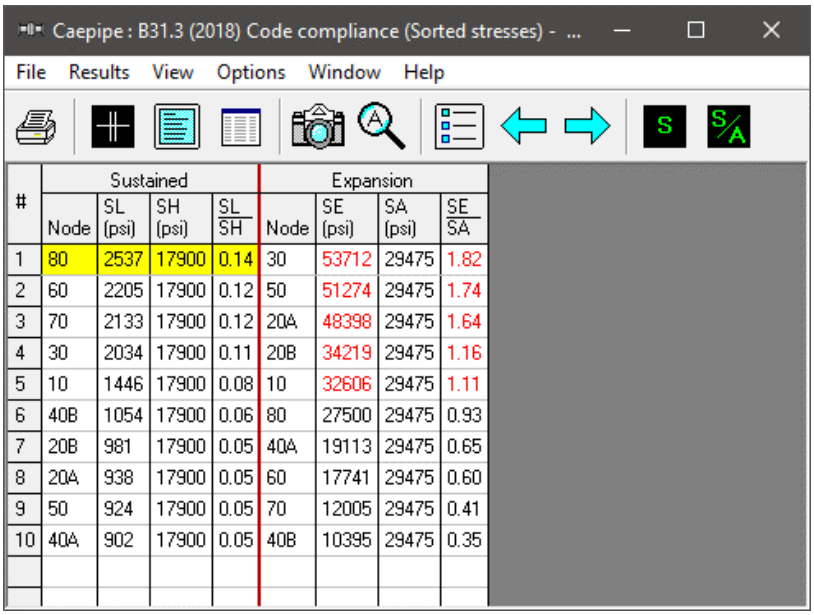


Select an item of interest by clicking on it. When you are viewing the results, use Tab (or Next Result button) to view the next result and Shift+Tab (or Previous Result button) to view the previous result. The Results dialog can be brought up by clicking on the Results button (or press Ctrl+R).

While viewing the results, the model data can also be simultaneously viewed in separate Layout and List windows. These are now "read only" windows, i.e. the model data cannot be modified while viewing the results. Some of the results from the sample problem are shown below:

Sorted Stresses

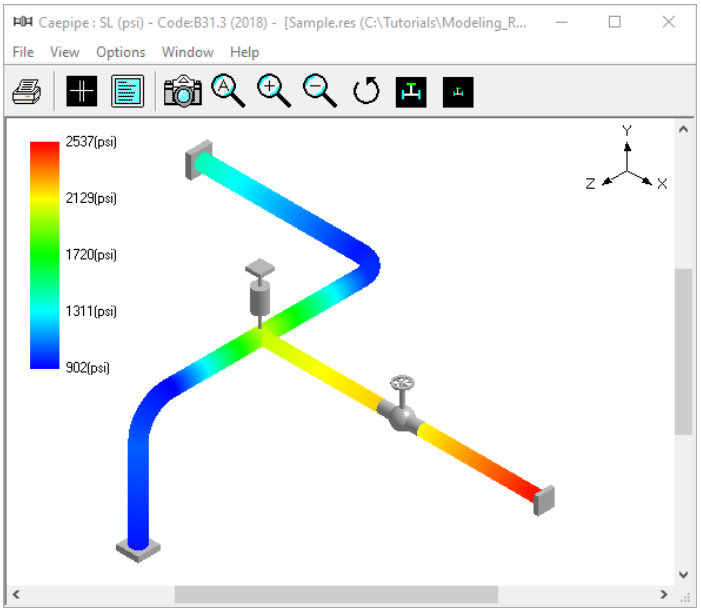
The computed stresses (sustained, expansion and occasional) are sorted in descending order by stress ratios.



#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
1	80	2537	17900	0.14	30	53712	29475	1.82
2	60	2205	17900	0.12	50	51274	29475	1.74
3	70	2133	17900	0.12	20A	48398	29475	1.64
4	30	2034	17900	0.11	20B	34219	29475	1.16
5	10	1446	17900	0.08	10	32606	29475	1.11
6	40B	1054	17900	0.06	80	27500	29475	0.93
7	20B	981	17900	0.05	40A	19113	29475	0.65
8	20A	938	17900	0.05	60	17741	29475	0.60
9	50	924	17900	0.05	70	12005	29475	0.41
10	40A	902	17900	0.05	40B	10395	29475	0.35

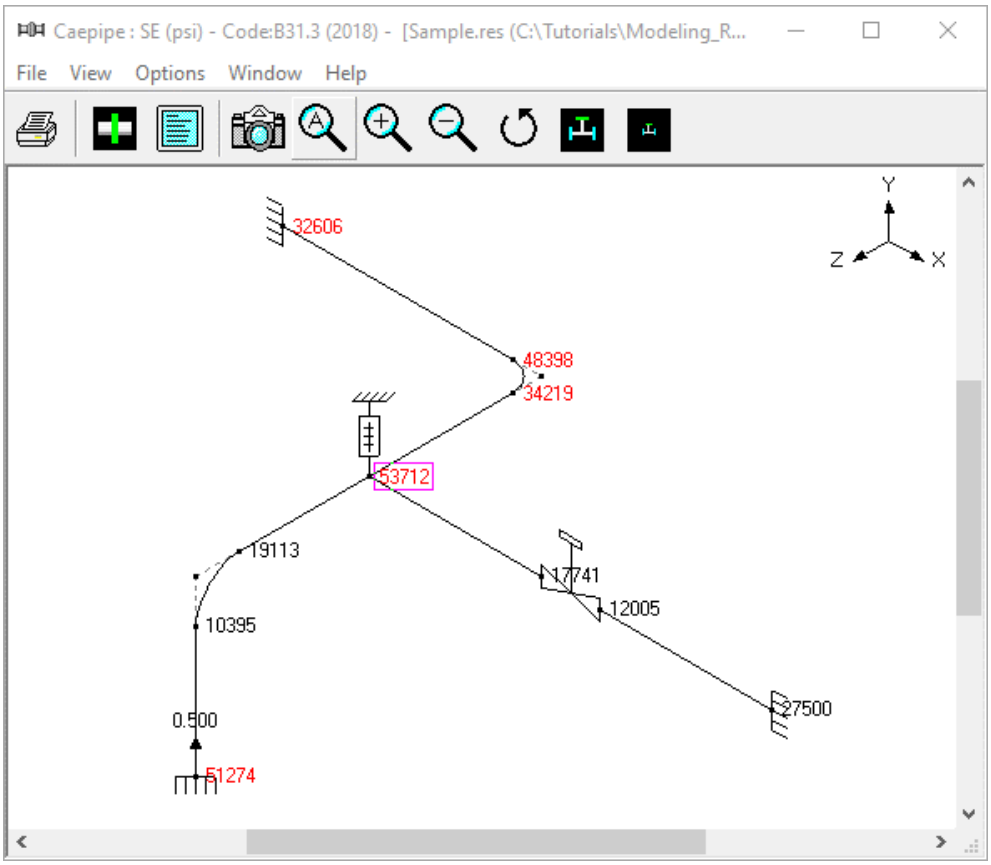
When the stress ratio exceeds 1.00, the stress and the stress ratio are shown in red. In this particular case, the high thermal stresses may be reduced by replacing the anchor at Node 80 by a guide. This allows the 6" pipe to expand more freely and reduce the thermal stresses. The maximum thermal stress is reduced to 22784 psi and the stress ratio is reduced to 0.77.

Color coded stresses may be rendered in the graphics window by pressing the Show stresses button (or choose View > Show Stresses). The stresses in the highlighted columns (the bar highlights three columns simultaneously) are displayed in the graphics window. Use the left and right arrow keys to change the highlighted column or click in a particular column.

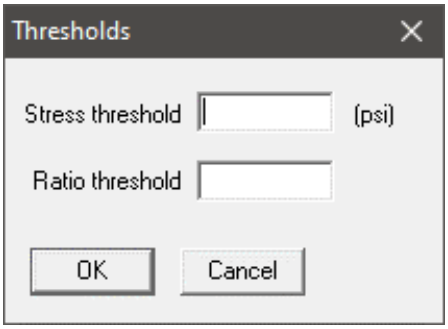


The stress ratios may similarly be rendered by using the Show stress ratios button (or choose View > Show Stress Ratios).

Instead of rendering color coded stresses/ratios, the values of stresses/stress ratios may be plotted by using the menu: View > No color coding.

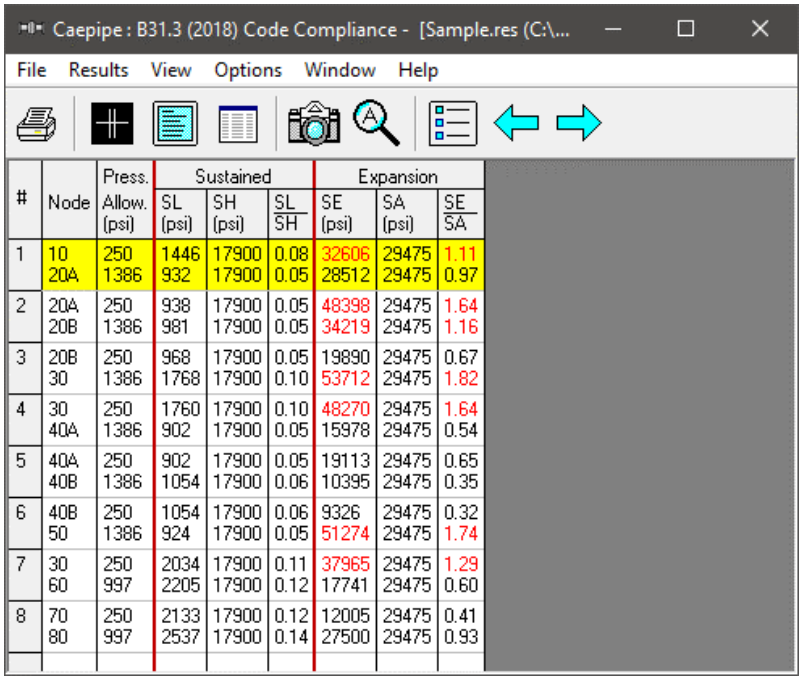


While plotting stresses or stress ratios, thresholds may be specified (choose View > Thresholds). Only the stresses or stress ratios exceeding the thresholds are plotted.



Code compliance

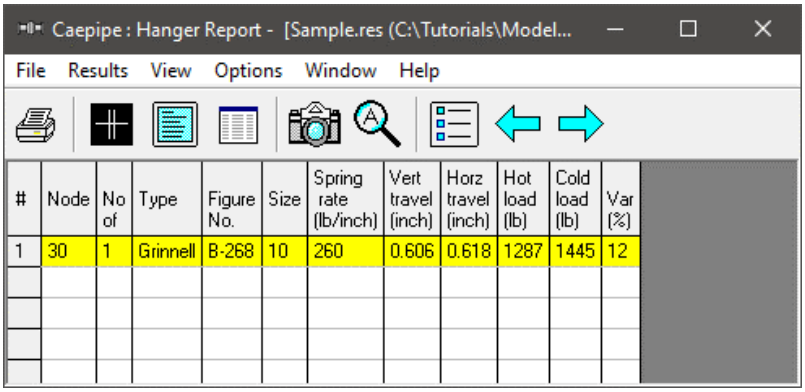
The element stresses and stress ratios calculated according to the piping code are shown under Code compliance. Design pressure and CAEPIPE calculated Allowable pressure are shown in 2nd column.



#	Node	Press. Allow. (psi)	Sustained SL (psi)	Sustained SH (psi)	Sustained SL/SH	Expansion SE (psi)	Expansion SA (psi)	Expansion SE/SA
1	10 20A	250 1386	1446 932	17900 17900	0.08 0.05	32606 28512	29475 29475	1.11 0.97
2	20A 20B	250 1386	938 981	17900 17900	0.05 0.05	48398 34219	29475 29475	1.64 1.16
3	20B 30	250 1386	968 1768	17900 17900	0.05 0.10	19890 53712	29475 29475	0.67 1.82
4	30 40A	250 1386	1760 902	17900 17900	0.10 0.05	48270 15978	29475 29475	1.64 0.54
5	40A 40B	250 1386	902 1054	17900 17900	0.05 0.06	19113 10395	29475 29475	0.65 0.35
6	40B 50	250 1386	1054 924	17900 17900	0.06 0.05	9326 51274	29475 29475	0.32 1.74
7	30 60	250 997	2034 2205	17900 17900	0.11 0.12	37965 17741	29475 29475	1.29 0.60
8	70 80	250 997	2133 2537	17900 17900	0.12 0.14	12005 27500	29475 29475	0.41 0.93

Hanger report

The hanger report is shown below.



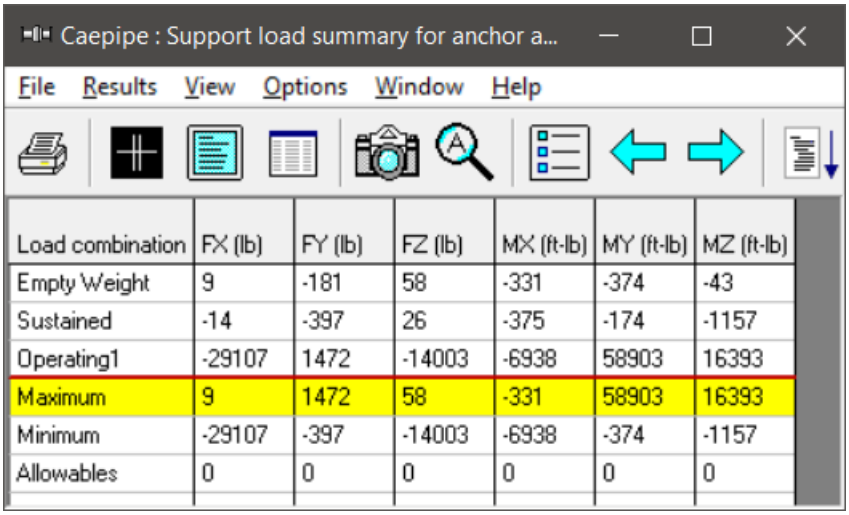
#	Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
1	30	1	Grinnell	B-268	10	260	0.606	0.618	1287	1445	12

The "No of" field shows the number of hangers required at the indicated location. The Figure No. and Size refer to the manufacturer's catalog. The vertical travel (also referred to as "Hanger travel") is the vertical deflection at the hanger location for the first operating load case. Similarly, the horizontal travel is the resultant horizontal deflection at the hanger location for the first operating load case. The hot load is the hanger load at the operating condition and the cold load is the hanger load at zero deflection.

Variability (%) = (Spring rate × Hanger travel / Hot load) × 100

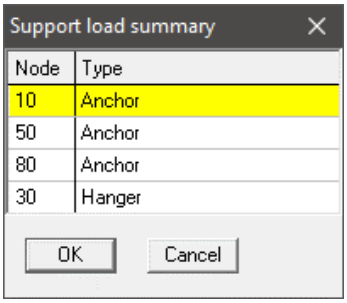
Support load summary

Support load summary for each support is created by considering all the load cases and appropriate combinations and then showing the maximum and minimum loads.



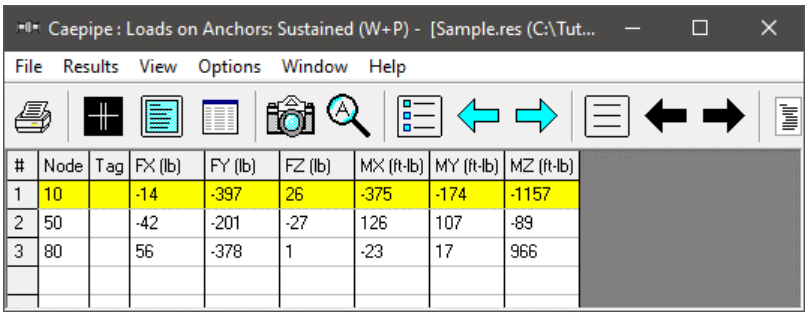
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Empty Weight	9	-181	58	-331	-374	-43
Sustained	-14	-397	26	-375	-174	-1157
Operating1	-29107	1472	-14003	-6938	58903	16393
Maximum	9	1472	58	-331	58903	16393
Minimum	-29107	-397	-14003	-6938	-374	-1157
Allowables	0	0	0	0	0	0

Use the Other supports button (F6), Next support button (Ctrl+Right arrow) or Previous support button (Ctrl+Left arrow) to see loads on other supports (e.g. other anchors, hangers etc.).



Support loads

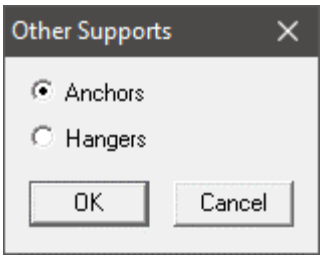
Support loads are the loads acting on the supports by the piping system for the selected load case. The loads on anchors for the Sustained case are shown below.



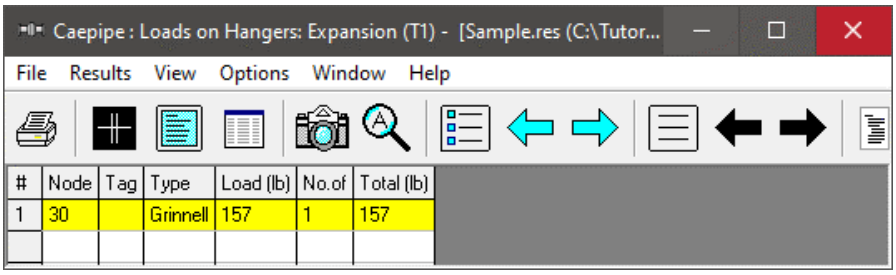
#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10		-14	-397	26	-375	-174	-1157
2	50		-42	-201	-27	126	107	-89
3	80		56	-378	1	-23	17	966

Use the Load cases button, Next load case button (Right arrow) or Previous load case button (Left arrow) to see loads for different load cases (e.g. Sustained, Expansion etc.).

Use the Other supports button (F6), Next support button (Ctrl+Right arrow) or Previous support button (Ctrl+Left arrow) to see loads on other supports (e.g. other anchors, hangers etc.).



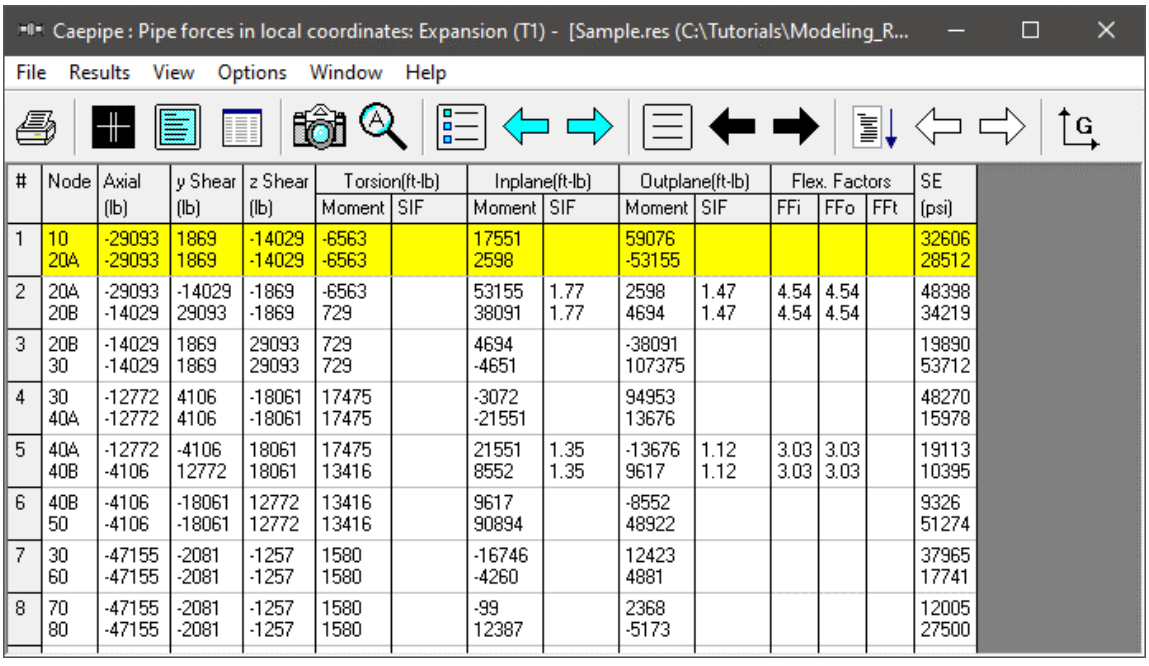
For example, the loads on hangers (i.e. the loads acting at the hanger locations imposed by the piping system) for the Expansion case are shown below.



#	Node	Tag	Type	Load (lb)	No.of	Total (lb)
1	30		Grinnell	157	1	157

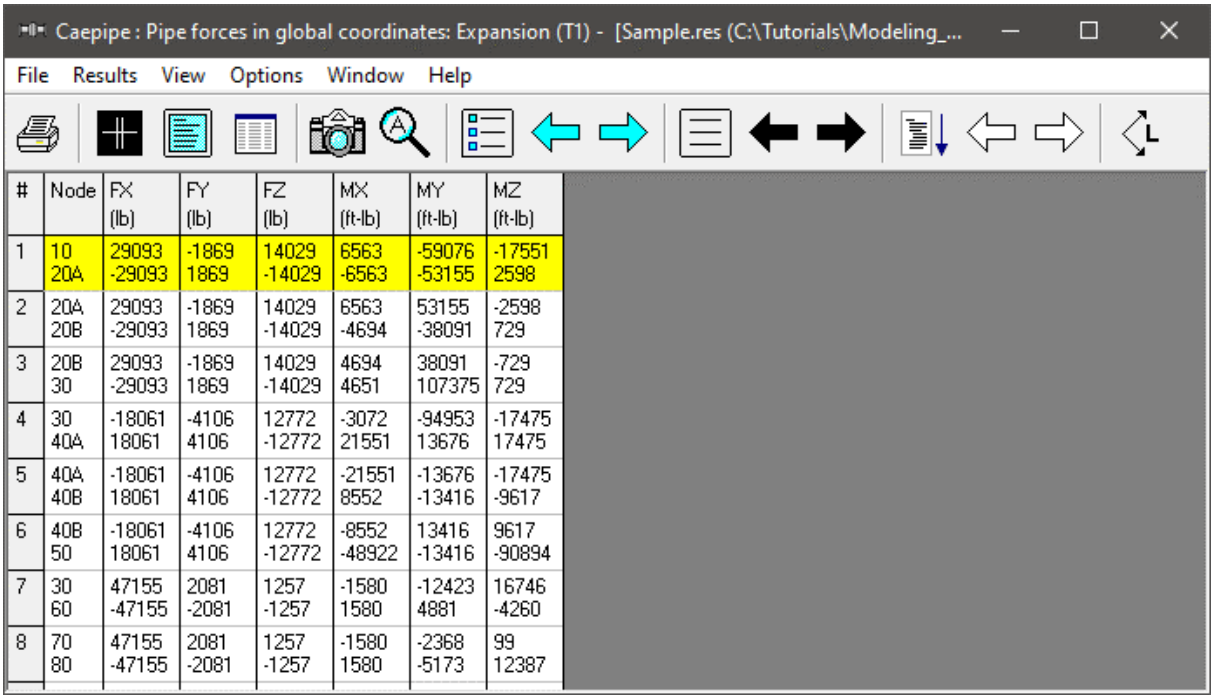
Element Forces

For pipe (also bend and reducer), element forces in local coordinates, Stress Intensification Factors (SIF), Flexibility Factors (FF) and stresses are shown by default for the selected load case.



#	Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SE (psi)
1	10 20A	-29093 -29093	1869 1869	-14029 -14029	-6563 -6563		17551 2598		59076 -53155					32606 28512
2	20A 20B	-29093 -14029	-14029 29093	-1869 -1869	-6563 729		53155 38091	1.77 1.77	2598 4694	1.47 1.47	4.54 4.54	4.54 4.54		48398 34219
3	20B 30	-14029 -14029	1869 1869	29093 29093	729 729		4694 -4651		-38091 107375					19890 53712
4	30 40A	-12772 -12772	4106 4106	-18061 -18061	17475 17475		-3072 -21551		94953 13676					48270 15978
5	40A 40B	-12772 -4106	-4106 12772	18061 18061	17475 13416		21551 8552	1.35 1.35	-13676 9617	1.12 1.12	3.03 3.03	3.03 3.03		19113 10395
6	40B 50	-4106 -4106	-18061 -18061	12772 12772	13416 13416		9617 90894		-8552 48922					9326 51274
7	30 60	-47155 -47155	-2081 -2081	-1257 -1257	1580 1580		-16746 -4260		12423 4881					37965 17741
8	70 80	-47155 -47155	-2081 -2081	-1257 -1257	1580 1580		-99 12387		2368 -5173					12005 27500

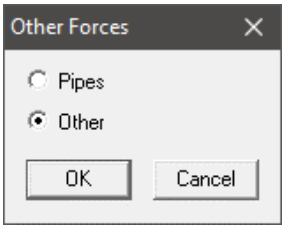
Use the Global forces button (F7) to see the element forces in global coordinates.

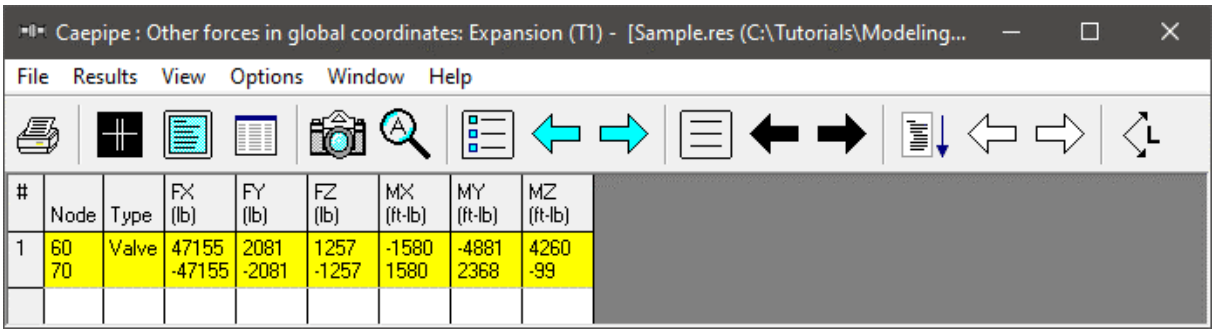


#	Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10 20A	29093 -29093	-1869 1869	14029 -14029	6563 -6563	-59076 -53155	-17551 2598
2	20A 20B	29093 -29093	-1869 1869	14029 -14029	6563 -4694	53155 -38091	-2598 729
3	20B 30	29093 -29093	-1869 1869	14029 -14029	4694 4651	38091 107375	-729 729
4	30 40A	-18061 18061	-4106 4106	12772 -12772	-3072 21551	-94953 13676	-17475 17475
5	40A 40B	-18061 18061	-4106 4106	12772 -12772	-21551 8552	-13676 -13416	-17475 -9617
6	40B 50	-18061 18061	-4106 4106	12772 -12772	-8552 -48922	13416 -13416	9617 -90894
7	30 60	47155 -47155	2081 -2081	1257 -1257	-1580 1580	-12423 4881	16746 -4260
8	70 80	47155 -47155	2081 -2081	1257 -1257	-1580 1580	-2368 -5173	99 12387

Use the Local forces button (F7) to see the element forces in local coordinates.

Use the Other forces button (F6), Next force button(Ctrl+Right arrow) or Previous force button (Ctrl+Left arrow) to see other element forces (e.g. valves, bellows etc.).

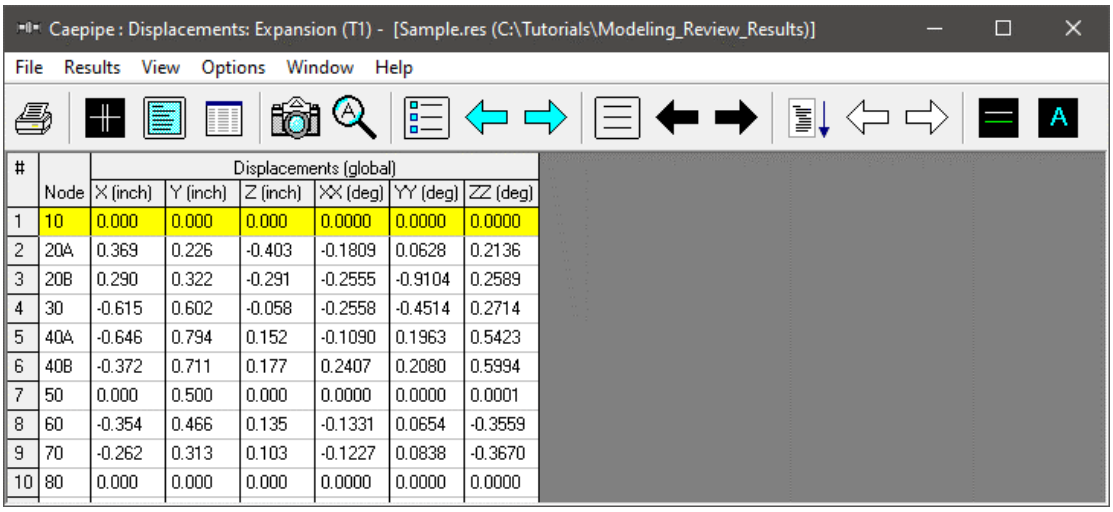




#	Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	60 70	Valve	47155 -47155	2081 -2081	1257 -1257	-1580 1580	-4881 2368	4260 -99

Displacements

The nodal displacements are shown.

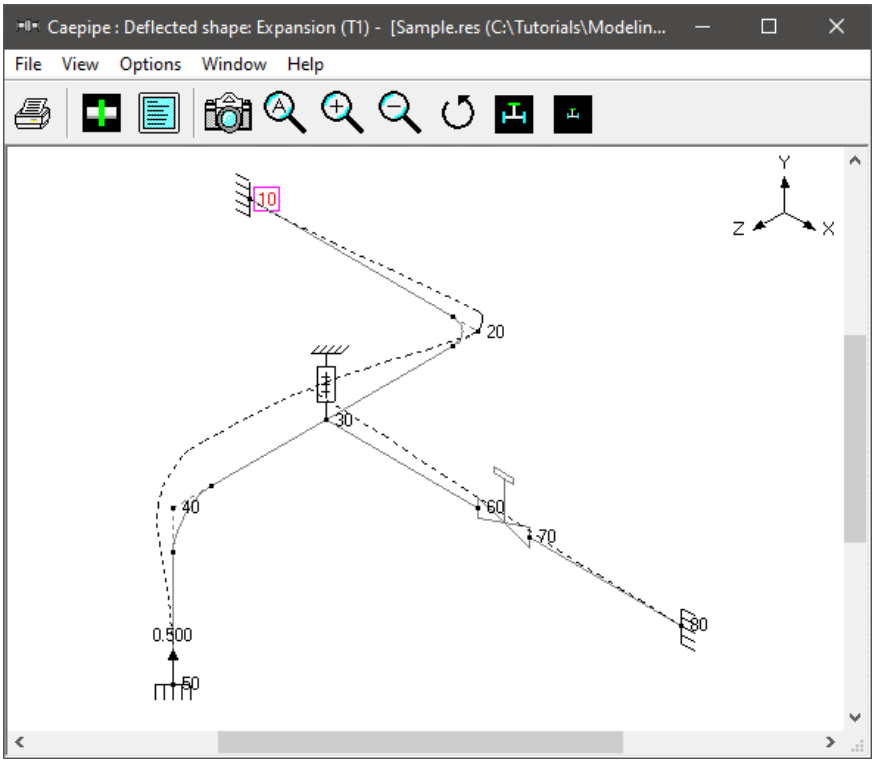


#	Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
1	10	0.000	0.000	0.000	0.0000	0.0000	0.0000
2	20A	0.369	0.226	-0.403	-0.1809	0.0628	0.2136
3	20B	0.290	0.322	-0.291	-0.2555	-0.9104	0.2589
4	30	-0.615	0.602	-0.058	-0.2558	-0.4514	0.2714
5	40A	-0.646	0.794	0.152	-0.1090	0.1963	0.5423
6	40B	-0.372	0.711	0.177	0.2407	0.2080	0.5994
7	50	0.000	0.500	0.000	0.0000	0.0000	0.0001
8	60	-0.354	0.466	0.135	-0.1331	0.0654	-0.3559
9	70	-0.262	0.313	0.103	-0.1227	0.0838	-0.3670
10	80	0.000	0.000	0.000	0.0000	0.0000	0.0000

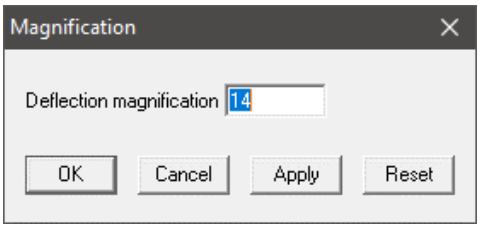
Use the Load cases button, Next load case button (Right arrow) or Previous load case button (Left arrow) to see displacements for different load cases (e.g. Sustained, Expansion etc.).

Use the Deflected shape button (or View > Show deflected shape) to plot the deflected shape in the graphics window.

Use the Animated deflected shape button (or View > Show animated deflected shape) to plot the animated deflected shape in the graphics window.



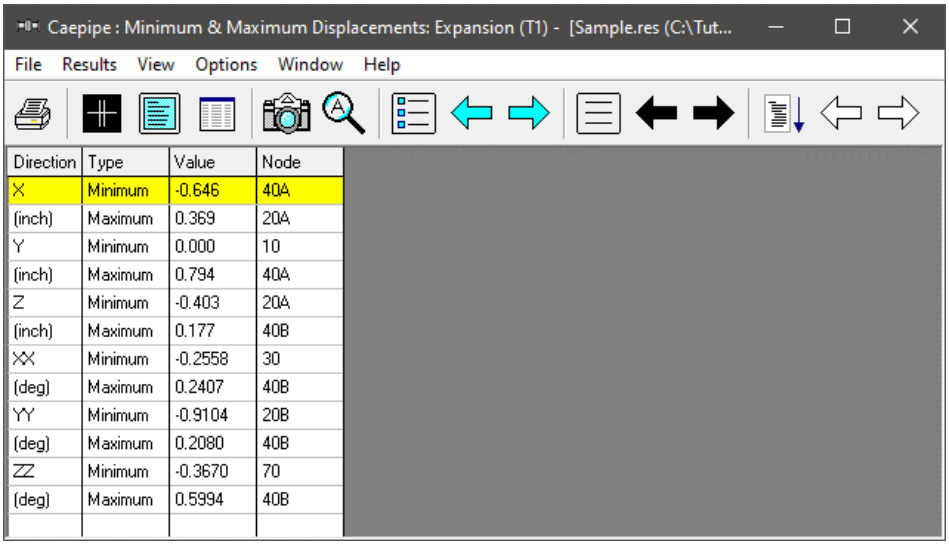
Choose View > Magnification to change the magnification of the deflected shape.



The reset button is used to calculate a default magnification factor which scales the maximum deflection to about 5% of the width of the graphics window.

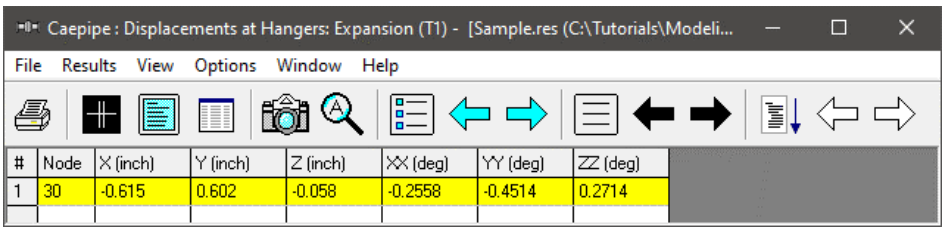
Use the Other displacements button (F6), Next displacement button (Ctrl+Right arrow) or Previous displacement button (Ctrl+Left arrow) to see other displacements (e.g. Min/Max, displacements at hangers, flex joints, limit stops etc.).

The minimum and maximum displacements for each of the directions and the corresponding nodes are shown below.



Direction	Type	Value	Node
X	Minimum	-0.646	40A
(inch)	Maximum	0.369	20A
Y	Minimum	0.000	10
(inch)	Maximum	0.794	40A
Z	Minimum	-0.403	20A
(inch)	Maximum	0.177	40B
XX	Minimum	-0.2558	30
(deg)	Maximum	0.2407	40B
YY	Minimum	-0.9104	20B
(deg)	Maximum	0.2080	40B
ZZ	Minimum	-0.3670	70
(deg)	Maximum	0.5994	40B

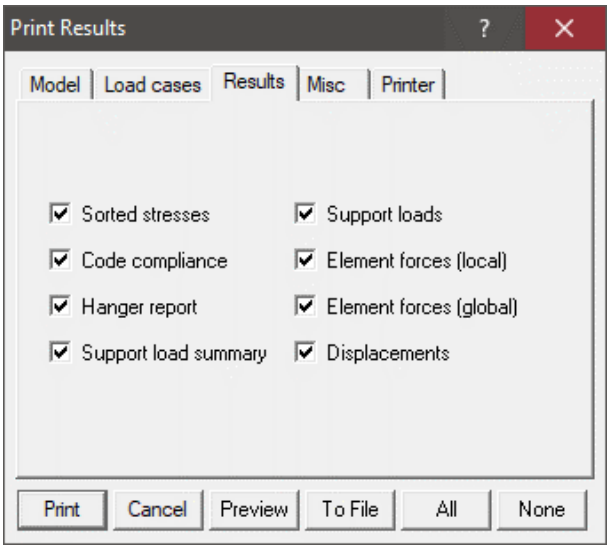
The displacements at hanger nodes are shown below.



#	Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
1	30	-0.615	0.602	-0.058	-0.2558	-0.4514	0.2714

Print

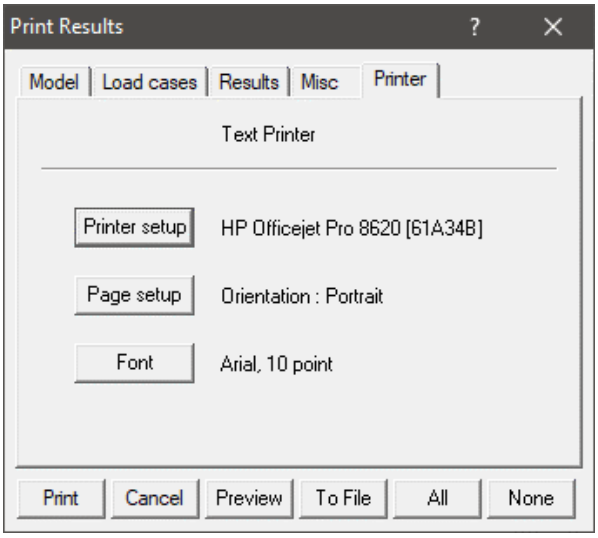
To print results and model data, click on the Print button (or press Ctrl+P). In the Print Results dialog, the items to print can be selected.



You can also print to a text file by using the To File button.

A preview of the printed output can be seen by using the Preview button.

The printing options such as choice of printer, margins, portrait or landscape and font can be set on the Printer tab.



The sample problem report is shown next. Observe that for sorted stresses and code compliance, when the stress ratio exceeds 1.00, the stress and the stress ratio are shown in white letters on black background.

This is the end of the tutorial. If you have questions or comments, please email them to:

support@sstusa.com.

Quality Assurance Block

Caepipe

Version 10.40

Client :

Project :

File Number :

Report Number :

Model Name : Sample

Title : Sample Problem

Analyzed : Wed Jun 23 00:50:32 2021

Prepared by : _____ Date:

Checked by : _____ Date:

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Caepipe Sample Problem Page 1

Analysis Options

Code : Piping code = B31.3 (2018)
Include axial force in stress calculations
Do not use liberal allowable stresses
Do not use B31J for SIFs and Flexibility Factors

Temperature : Reference temperature = 70 (F)
Number of thermal cycles = 7000
Number of thermal loads = 1
Thermal = Operating - Sustained
Use modulus at reference temperature

Pressure : Pressure stress = PD / 4t
Peak pressure factor = 1.00
Do not include Bourdon effect
Do not use pressure correction for bends

Dynamics : Cut off frequency = 33 Hz
Number of modes = 20
Include missing mass correction
Do not use friction in dynamic analysis

Misc. : Include hanger stiffness
Vertical direction = Y

Layout (11)

#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10	70	Valve	2'0"			A53	6	1	
11	80		6'0"			A53	6	1	Anchor

Anchors (3)

Node	Tag	KX/kx (lb/inch)	KY/ky (lb/inch)	KZ/kz (lb/inch)	KXX/kxx (in-lb/deg)	KYY/kyy (in-lb/deg)	KZZ/kzz (in-lb/deg)	Releases X	Y	Z	XX	YY	ZZ	Anchor in
10		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS
50		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS
80		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS

Bends (2)

Bend Node	Radius (inch)	Rad. Type	Thk (inch)	Bend Matl	Flex.F	SIF	Axial SIF	Int. Node	Angle (deg)	Int. Node	Angle (deg)
20	12	Long									
40	18	User									

Hangers (1)

Node	Tag	Type	No of	Load var%	Short range	Spring rate (lb/inch)	Load (lb)	Load Type	CNode
30		Grinnell	1	25					

Version 10.40 Sample Jun 23,2021

Specified Displacements (1)

Node	Type	Load	X/x (inch)	Y/y (inch)	Z/z (inch)	XX/xx (deg)	YY/yy (deg)	ZZ/zz (deg)	Disp. in
50	Anchor	T1		0.5					GCS

Valves (1)

From	To	Weight (lb)	Length (inch)	Thick X	Insul Wgt X	Add.Wgt (lb)	Offsets of Add.Wgt		
							DX (inch)	DY (inch)	DZ (inch)
60	70	200		3.00	1.75	50	0	18	0

Coordinates (12)

Node	X (ft'in")	Y (ft'in")	Z (ft'in")
10	0	0	0
20A	8'0"	0	0
20	9'0"	0	0
20B	9'0"	0	1'0"
30	9'0"	0	6'0"
40A	9'0"	0	10'6"
40	9'0"	0	12'0"
40B	9'0"	-1'6"	12'0"
50	9'0"	-6'0"	12'0"
60	15'0"	0	6'0"
70	17'0"	0	6'0"
80	23'0"	0	6'0"

Pipe material A53: a53 grade b

Density = 0.283 (lb/in3), Nu = 0.300, Joint factor = 1.00, Type = CS
Yield strength = 35000 (psi)

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
-20	29.9E+6	6.25E-6	20000
100	29.3E+6	6.47E-6	20000
200	28.8E+6	6.70E-6	20000
300	28.3E+6	6.90E-6	20000
400	27.7E+6	7.10E-6	19900
500	27.3E+6	7.30E-6	19000
600	26.7E+6	7.40E-6	17900
650	26.1E+6	7.50E-6	17300
700	25.5E+6	7.60E-6	16700
750	24.9E+6	7.70E-6	13900
800	24.2E+6	7.80E-6	11400
850	23.3E+6	7.85E-6	8700
900	22.4E+6	7.90E-6	5900
950	21.4E+6	8.00E-6	4000
1000	20.4E+6	8.10E-6	2500
1050	19.2E+6	8.15E-6	1600
1100	18.0E+6	8.20E-6	1000

Pipe Sections (2)

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
8	8"	80	8.625	0.5			15	2			
6	6"	STD	6.625	0.28			15	2			

Pipe Loads (1)

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	600	200	800	250	0.8					

B31.3 (2018) Code compliance (Sorted stresses)

Sustained				Expansion			
Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
80	2537	17900	0.14	30	53712	29475	1.82
60	2205	17900	0.12	50	51274	29475	1.74
70	2133	17900	0.12	20A	48398	29475	1.64
30	2034	17900	0.11	20B	34219	29475	1.16
10	1446	17900	0.08	10	32606	29475	1.11
40B	1054	17900	0.06	80	27500	29475	0.93
20B	981	17900	0.05	40A	19113	29475	0.65
20A	938	17900	0.05	60	17741	29475	0.60
50	924	17900	0.05	70	12005	29475	0.41
40A	902	17900	0.05	40B	10395	29475	0.35

B31.3 (2018) Code Compliance

Node	Press. Allow. (psi)	Sustained SL (psi)	Sustained SH (psi)	Sustained SL / SH	Expansion SE (psi)	Expansion SA (psi)	Expansion SE / SA
10	250	1446	17900	0.08	32606	29475	1.11
20A	1386	932	17900	0.05	28512	29475	0.97
20A	250	938	17900	0.05	48398	29475	1.64
20B	1386	981	17900	0.05	34219	29475	1.16
20B	250	968	17900	0.05	19890	29475	0.67
30	1386	1768	17900	0.10	53712	29475	1.82
30	250	1760	17900	0.10	48270	29475	1.64
40A	1386	902	17900	0.05	15978	29475	0.54
40A	250	902	17900	0.05	19113	29475	0.65
40B	1386	1054	17900	0.06	10395	29475	0.35
40B	250	1054	17900	0.06	9326	29475	0.32
50	1386	924	17900	0.05	51274	29475	1.74
30	250	2034	17900	0.11	37965	29475	1.29
60	997	2205	17900	0.12	17741	29475	0.60
70	250	2133	17900	0.12	12005	29475	0.41
80	997	2537	17900	0.14	27500	29475	0.93

Hanger Report

Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
30	1	Grinnell	B-268	10	260	0.606	0.618	1287	1445	12

Support load summary for anchor at node 10

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Empty Weight	9	-181	58	-331	-374	-43
Sustained	-14	-397	26	-375	-174	-1157
Operating1	-29107	1472	-14003	-6938	58903	16393
Maximum	9	1472	58	-331	58903	16393

Support load summary for anchor at node 10

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Minimum	-29107	-397	-14003	-6938	-374	-1157
Allowables	0	0	0	0	0	0

Support load summary for anchor at node 50

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Empty Weight	-23	33	-64	242	74	-88
Sustained	-42	-201	-27	126	107	-89
Operating1	-18103	-4308	12745	49048	13523	90805
Maximum	-23	33	12745	49048	13523	90805
Minimum	-18103	-4308	-64	126	74	-89
Allowables	0	0	0	0	0	0

Support load summary for anchor at node 80

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Empty Weight	14	-280	6	12	50	644
Sustained	56	-378	1	-23	17	966
Operating1	47210	1703	1258	-1603	5191	-11421
Maximum	47210	1703	1258	12	5191	966
Minimum	14	-378	1	-1603	17	-11421
Allowables	0	0	0	0	0	0

Support load summary for hanger at node 30

Displacements (global)	
Load combination	Load (lb)
Empty Weight	-1441
Sustained	-1443
Operating1	-1287
Maximum	-1287
Minimum	-1443

Loads on Anchors: Empty Weight (W)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		9	-181	58	-331	-374	-43
50		-23	33	-64	242	74	-88
80		14	-280	6	12	50	644

Loads on Hangers: Empty Weight (W)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-1441	1	-1441

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors		
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt
10	9	-181	58	-331		-43		-374				
20A	9	221	58	-331		-206		94				
20A	9	58	-221	-331		-94	1.77	-206	1.47	4.54	4.54	
20B	58	-9	-300	-456		-143	1.77	59	1.47	4.54	4.54	

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt
20B	58	300	-9	-456		59		143				
30	58	552	-9	-456		-2072		97				
30	64	-604	-23	225		-2084		64				
40A	64	-378	-23	225		126		-39				
40A	64	378	23	225		-126	1.35	39	1.12	3.03	3.03	
40B	259	-64	23	74		-532	1.35	-191	1.12	3.03	3.03	
40B	259	-23	-64	74		-191		532				
50	33	-23	-64	74		-88		242				
30	-14	-285	-6	-12		-681		33				
60	-14	-137	-6	-12		587		-2				
70	-14	132	-6	-12		592		-14				
80	-14	280	-6	-12		-644		-50				

Other forces in local coordinates: Empty Weight (W)

Node	Type	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
60	Valve	-14	-112	-6	-12	-2	612
70		-14	107	-6	-12	-14	617

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	-9	181	-58	331	374	43
20A	9	221	58	-331	94	-206
20A	-9	-221	-58	331	-94	206
20B	9	300	58	-59	143	-456
20B	-9	-300	-58	59	-143	456
30	9	552	58	2072	97	-456
30	-23	604	-64	-2084	-64	-225
40A	23	-378	64	-126	-39	225
40A	-23	378	-64	126	39	-225
40B	23	-259	64	-532	-74	191
40B	-23	259	-64	532	74	-191
50	23	-33	64	-242	-74	88
30	14	285	6	12	-33	681
60	-14	-137	-6	-12	-2	587
70	14	-132	6	12	14	-592
80	-14	280	-6	-12	-50	-644

Other forces in global coordinates: Empty Weight (W)

Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
60	Valve	14	112	6	12	2	-612
70		-14	107	-6	-12	-14	617

Displacements: Empty Weight (W)

Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.000	0.003	0.004	-0.0091	-0.0030	0.0030
20B	-0.000	0.006	0.004	-0.0100	-0.0005	0.0001

Displacements: Empty Weight (W)

Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
30	0.000	0.013	0.004	0.0019	0.0011	-0.0078
40A	0.001	0.003	0.004	0.0126	0.0012	-0.0043
40B	0.001	0.000	0.002	0.0046	0.0011	-0.0017
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
60	0.000	-0.005	0.002	0.0010	0.0020	-0.0062
70	0.000	-0.006	0.001	0.0009	0.0019	-0.0028
80	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Sustained (W+P)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-14	-397	26	-375	-174	-1157
50		-42	-201	-27	126	107	-89
80		56	-378	1	-23	17	966

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-1443	1	-1443

Pipe forces in local coordinates: Sustained (W+P)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL (psi)
10	-14	-397	26	-375		-1157		-174					1446
20A	-14	132	26	-375		-100		35					932
20A	-14	26	-132	-375		-35	1.77	-100	1.47	4.54	4.54		938
20B	26	14	-236	-270		-75	1.77	177	1.47	4.54	4.54		981
20B	26	236	14	-270		177		75					968
30	26	567	14	-270		-1831		144					1768
30	27	-550	-42	339		-1807		143					1760
40A	27	-252	-42	339		-4		-44					902
40A	27	252	42	339		4	1.35	44	1.12	3.03	3.03		902
40B	96	-27	42	107		-249	1.35	-277	1.12	3.03	3.03		1054
40B	96	-42	-27	107		-277		249					1054
50	-201	-42	-27	107		-89		126					924
30	-56	-327	-1	23		-610		1					2034
60	-56	-119	-1	23		730		-7					2205
70	-56	170	-1	23		679		-10					2133
80	-56	378	-1	23		-966		-17					2537

Other forces in local coordinates: Sustained (W+P)

Node	Type	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
60	Valve	-56	-94	-1	23	-7	755
70		-56	145	-1	23	-10	704

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	14	397	-26	375	174	1157
20A	-14	132	26	-375	35	-100
20A	14	-132	-26	375	-35	100
20B	-14	236	26	-177	75	-270

Pipe forces in global coordinates: Sustained (W+P)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
20B	14	-236	-26	177	-75	270
30	-14	567	26	1831	144	-270
30	-42	550	-27	-1807	-143	-339
40A	42	-252	27	4	-44	339
40A	-42	252	-27	-4	44	-339
40B	42	-96	27	-249	-107	277
40B	-42	96	-27	249	107	-277
50	42	201	27	-126	-107	89
30	56	327	1	-23	-1	610
60	-56	-119	-1	23	-7	730
70	56	-170	1	-23	10	-679
80	-56	378	-1	23	-17	-966

Other forces in global coordinates: Sustained (W+P)

Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
60	Valve	56	94	1	-23	7	-755
70		-56	145	-1	23	-10	704

Displacements: Sustained (W+P)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.000	-0.008	0.002	-0.0103	-0.0015	-0.0059
20B	-0.000	-0.007	0.002	-0.0129	-0.0004	-0.0067
30	0.000	0.004	0.002	-0.0038	0.0010	-0.0114
40A	0.002	0.002	0.002	0.0057	0.0016	-0.0061
40B	0.001	0.000	0.001	0.0022	0.0017	-0.0022
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
60	0.000	-0.013	0.001	-0.0020	0.0008	-0.0016
70	0.000	-0.012	0.001	-0.0018	0.0008	0.0024
80	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Expansion (T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-29093	1869	-14029	-6563	59076	17551
50		-18061	-4106	12772	48922	13416	90894
80		47155	2081	1257	-1580	5173	-12387

Loads on Hangers: Expansion (T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	157	1	157

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SE (psi)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
10	-29093	1869	-14029	-6563		17551		59076					32606
20A	-29093	1869	-14029	-6563		2598		-53155					28512
20A	-29093	-14029	-1869	-6563		53155	1.77	2598	1.47	4.54	4.54		48398
20B	-14029	29093	-1869	729		38091	1.77	4694	1.47	4.54	4.54		34219

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SE (psi)
20B	-14029	1869	29093	729		4694		-38091					19890
30	-14029	1869	29093	729		-4651		107375					53712
30	-12772	4106	-18061	17475		-3072		94953					48270
40A	-12772	4106	-18061	17475		-21551		13676					15978
40A	-12772	-4106	18061	17475		21551	1.35	-13676	1.12	3.03	3.03		19113
40B	-4106	12772	18061	13416		8552	1.35	9617	1.12	3.03	3.03		10395
40B	-4106	-18061	12772	13416		9617		-8552					9326
50	-4106	-18061	12772	13416		90894		48922					51274
30	-47155	-2081	-1257	1580		-16746		12423					37965
60	-47155	-2081	-1257	1580		-4260		4881					17741
70	-47155	-2081	-1257	1580		-99		2368					12005
80	-47155	-2081	-1257	1580		12387		-5173					27500

Other forces in local coordinates: Expansion (T1)

Node	Type	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
60	Valve	-47155	-2081	-1257	1580	4881	-4260
70		-47155	-2081	-1257	1580	2368	-99

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	29093	-1869	14029	6563	-59076	-17551
20A	-29093	1869	-14029	-6563	-53155	2598
20A	29093	-1869	14029	6563	53155	-2598
20B	-29093	1869	-14029	-4694	-38091	729
20B	29093	-1869	14029	4694	38091	-729
30	-29093	1869	-14029	4651	107375	729
30	-18061	-4106	12772	-3072	-94953	-17475
40A	18061	4106	-12772	21551	13676	17475
40A	-18061	-4106	12772	-21551	-13676	-17475
40B	18061	4106	-12772	8552	-13416	-9617
40B	-18061	-4106	12772	-8552	13416	9617
50	18061	4106	-12772	-48922	-13416	-90894
30	47155	2081	1257	-1580	-12423	16746
60	-47155	-2081	-1257	1580	4881	-4260
70	47155	2081	1257	-1580	-2368	99
80	-47155	-2081	-1257	1580	-5173	12387

Other forces in global coordinates: Expansion (T1)

Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
60	Valve	47155	2081	1257	-1580	-4881	4260
70		-47155	-2081	-1257	1580	2368	-99

Displacements: Expansion (T1)

Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.369	0.226	-0.403	-0.1809	0.0628	0.2136
20B	0.290	0.322	-0.291	-0.2555	-0.9104	0.2589

Displacements: Expansion (T1)

Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
30	-0.615	0.602	-0.058	-0.2558	-0.4514	0.2714
40A	-0.646	0.794	0.152	-0.1090	0.1963	0.5423
40B	-0.372	0.711	0.177	0.2407	0.2080	0.5994
50	0.000	0.500	0.000	0.0000	0.0000	0.0001
60	-0.354	0.466	0.135	-0.1331	0.0654	-0.3559
70	-0.262	0.313	0.103	-0.1227	0.0838	-0.3670
80	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Operating (W+P1+T1)

Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10		-29107	1472	-14003	-6938	58903	16393
50		-18103	-4308	12745	49048	13523	90805
80		47210	1703	1258	-1603	5191	-11421

Loads on Hangers: Operating (W+P1+T1)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-1287	1	-1287

Pipe forces in local coordinates: Operating (W+P1+T1)

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torsion(ft-lb) Moment	Torsion(ft-lb) SIF	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	Sopr (psi)
10	-29107	1472	-14003	-6938		16393		58903					28704
20A	-29107	2001	-14003	-6938		2498		-53120					24835
20A	-29107	-14003	-2001	-6938		53120	1.77	2498	1.47	4.54	4.54		44686
20B	-14003	29107	-2105	459		38016	1.77	4870	1.47	4.54	4.54		32833
20B	-14003	2105	29107	459		4870		-38016					18528
30	-14003	2436	29107	459		-6482		107519					52494
30	-12745	3557	-18103	17815		-4879		95096					47285
40A	-12745	3854	-18103	17815		-21554		13631					15092
40A	-12745	-3854	18103	17815		21554	1.35	-13631	1.12	3.03	3.03		18158
40B	-4010	12745	18103	13523		8304	1.35	9340	1.12	3.03	3.03		10561
40B	-4010	-18103	12745	13523		9340		-8304					9562
50	-4308	-18103	12745	13523		90805		49048					51477
30	-47210	-2408	-1258	1603		-17356		12423					22957
60	-47210	-2200	-1258	1603		-3530		4874					1522
70	-47210	-1911	-1258	1603		581		2358					3165
80	-47210	-1703	-1258	1603		11421		-5191					10589

Other forces in local coordinates: Operating (W+P1+T1)

Node	Type	fx (lb)	fy (lb)	fz (lb)	mx (ft-lb)	my (ft-lb)	mz (ft-lb)
60	Valve	-47210	-2175	-1258	1603	4874	-3505
70		-47210	-1936	-1258	1603	2358	606

Pipe forces in global coordinates: Operating (W+P1+T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	29107	-1472	14003	6938	-58903	-16393
20A	-29107	2001	-14003	-6938	-53120	2498
20A	29107	-2001	14003	6938	53120	-2498
20B	-29107	2105	-14003	-4870	-38016	459

Pipe forces in global coordinates: Operating (W+P1+T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
20B	29107	-2105	14003	4870	38016	-459
30	-29107	2436	-14003	6482	107519	459
30	-18103	-3557	12745	-4879	-95096	-17815
40A	18103	3854	-12745	21554	13631	17815
40A	-18103	-3854	12745	-21554	-13631	-17815
40B	18103	4010	-12745	8304	-13523	-9340
40B	-18103	-4010	12745	-8304	13523	9340
50	18103	4308	-12745	-49048	-13523	-90805
30	47210	2408	1258	-1603	-12423	17356
60	-47210	-2200	-1258	1603	4874	-3530
70	47210	1911	1258	-1603	-2358	-581
80	-47210	-1703	-1258	1603	-5191	11421

Other forces in global coordinates: Operating (W+P1+T1)

Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
60	Valve	47210	2175	1258	-1603	-4874	3505
70		-47210	-1936	-1258	1603	2358	606

Displacements: Operating (W+P1+T1)

	Displacements (global)					
Node	X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.369	0.217	-0.402	-0.1912	0.0613	0.2077
20B	0.290	0.315	-0.289	-0.2684	-0.9108	0.2522
30	-0.615	0.606	-0.056	-0.2596	-0.4504	0.2601
40A	-0.645	0.796	0.154	-0.1033	0.1979	0.5363
40B	-0.371	0.711	0.178	0.2430	0.2097	0.5972
50	0.000	0.500	0.000	0.0000	0.0000	0.0001
60	-0.354	0.453	0.136	-0.1351	0.0662	-0.3575
70	-0.262	0.301	0.103	-0.1245	0.0846	-0.3646
80	0.000	0.000	0.000	0.0000	0.0000	0.0000

Weight & Center of gravity

Empty weight = 1551.2 (lb)
Insulation weight = 267.8 (lb)
Content weight = 550.32 (lb)
Lining weight = 0 (lb)
Additional weight = 50 (lb)
Total weight = 2419.3 (lb)
Center of Gravity for Total weight
X = 9.9313, Y = -0.4653, Z = 5.4705 (ft'in")

Bill of materials: Materials

#	Name	Description
1	A53	a53 grade b

Bill of materials: Pipes

#	Material	OD (inch)	Thk (inch)	Total length (ft'in")	Total weight (lb)
1	A53	6.625	0.28	12'0"	227.45

Bill of materials: Pipes

#	Material	OD (inch)	Thk (inch)	Total length (ft'in")	Total weight (lb)
2	A53	8.625	0.5	22'0"	953.53

Bill of materials: Bends

#	Material	OD (inch)	Thk (inch)	Radius (inch)	Angle (deg)	Count	Total weight (lb)
1	A53	8.625	0.5	12	90.00	1	68.082
2	A53	8.625	0.5	18	90.00	1	102.12

Bill of materials: Valves

#	OD (inch)	Thk (inch)	Weight (lb)	Add.Weight (lb)	Count	Total weight (lb)
1	6.625	0.28	200	50	1	250

Bill of materials: Itemized Element Weights

#	From	To	Type	Length (inch)	OD (inch)	Thk (inch)	Mat.Den (lb/in3)	Fluid.Den (lb/in3)	Ins.Den (lb/in3)	Ins.Thk (inch)	Lin.Den (lb/in3)	Lin.Thk (inch)	Empty.Wt (lb)	Fluid.Wt (lb)
1	10	20A		96	8.625	0.5	0.283	0.029	0.009	2			346.74	126.57
2	20A	20B	Bend	18.85	8.625	0.5	0.283	0.029	0.009	2			68.082	24.851
3	20B	30		60	8.625	0.5	0.283	0.029	0.009	2			216.71	79.104
4	30	40A		54	8.625	0.5	0.283	0.029	0.009	2			195.04	71.193
5	40A	40B	Bend	28.274	8.625	0.5	0.283	0.029	0.009	2			102.12	37.277
6	40B	50		54	8.625	0.5	0.283	0.029	0.009	2			195.04	71.193
7	30	60		72	6.625	0.28	0.283	0.029	0.009	2			113.73	60.057
8	60	70	Valve	24	6.625	0.84	0.283	0.029	0.009	2			200	20.019
9	70	80		72	6.625	0.28	0.283	0.029	0.009	2			113.73	60.057