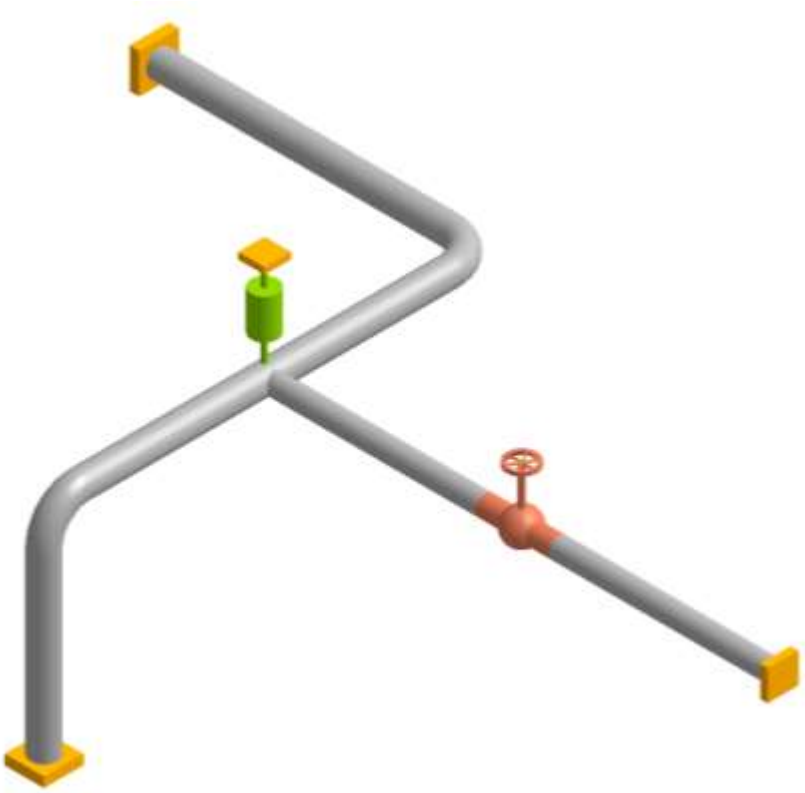
CAEPIPE™

Tutorial for Modeling and Results Review

Problem 1



SST SYSTEMS, INC.

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

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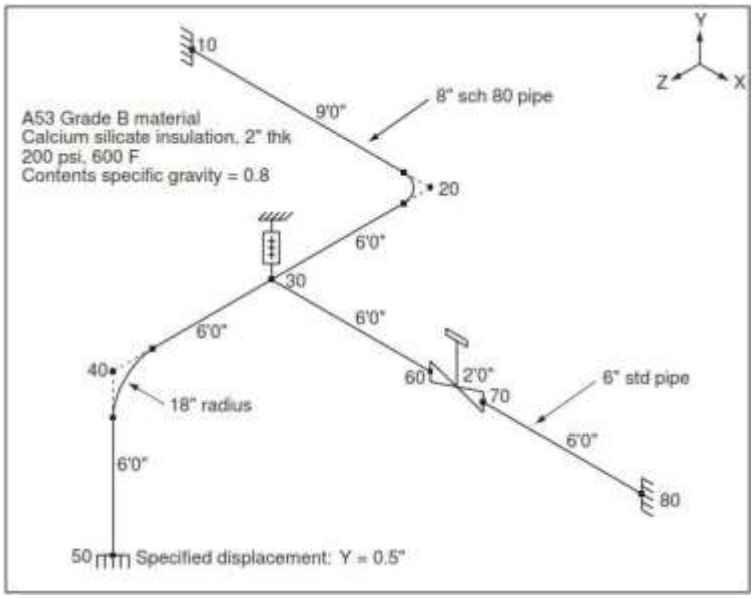
Tutorial for Modeling and Results Review – Problem 1

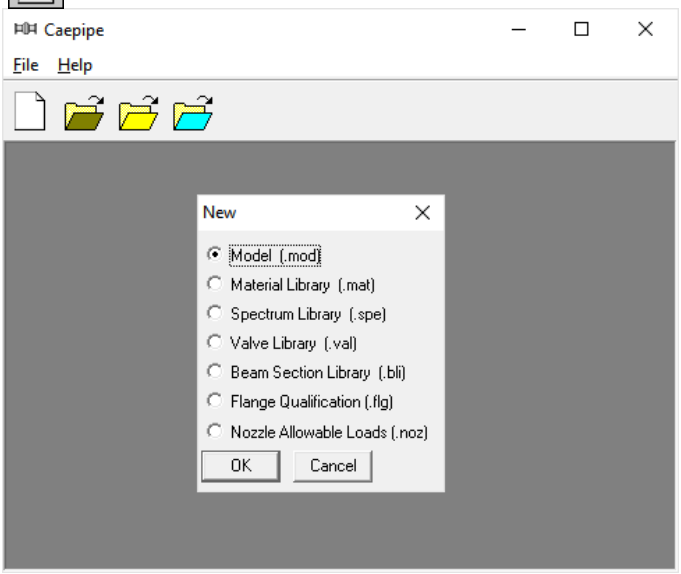
The best way to learn CAEPIPE is to try it yourself. In this tutorial we will create a simple model to help you understand the use of CAEPIPE. The details of the model are shown below:



You will learn how to:

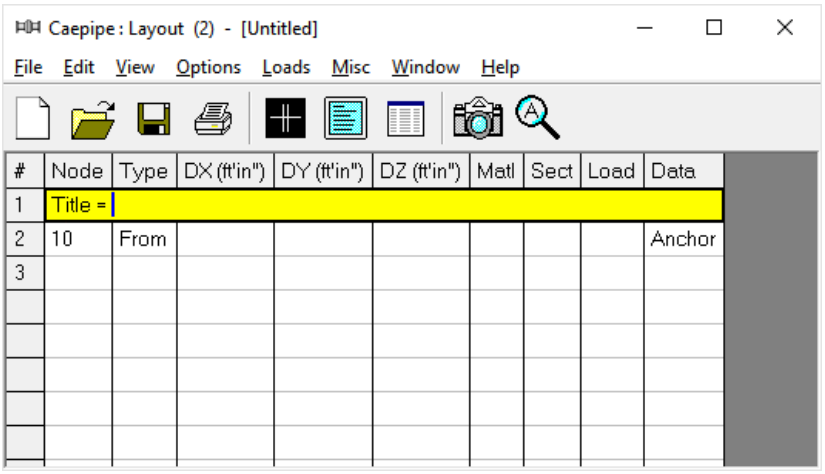
1. Enter Title
2. Select Analysis options (piping code etc.)
3. Define Material, Section and Loads for the model
4. Input Model Layout
5. Select Load Cases for Analysis
6. Analyze
7. View Results

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

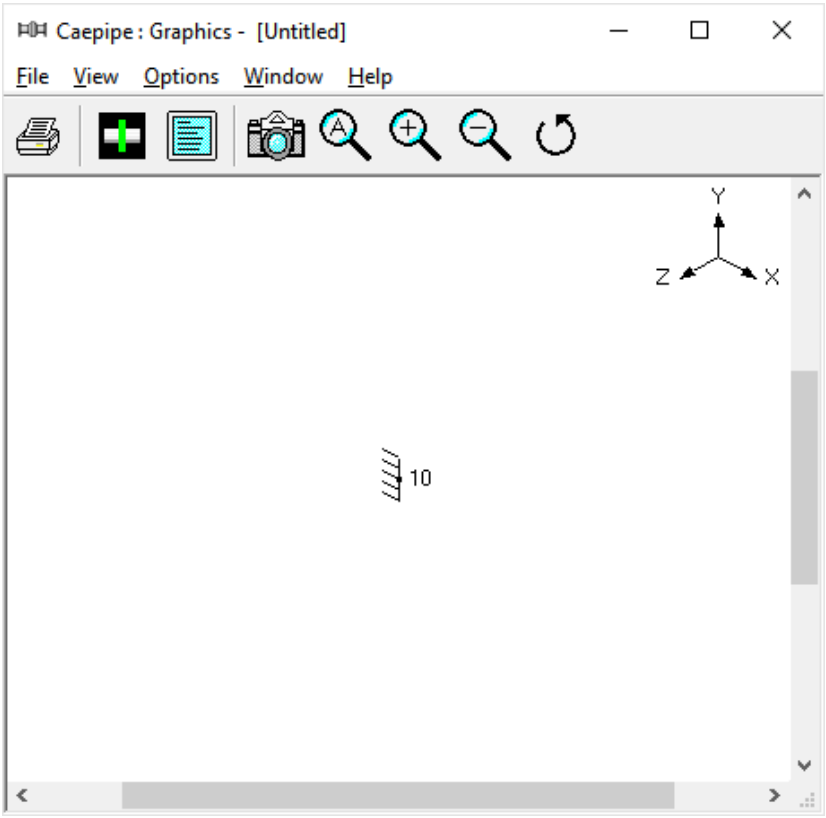


From the New file dialog, select the type of the new file as Model (.mod) file. This opens two independent windows: Layout and Graphics.

Layout window



Graphics window



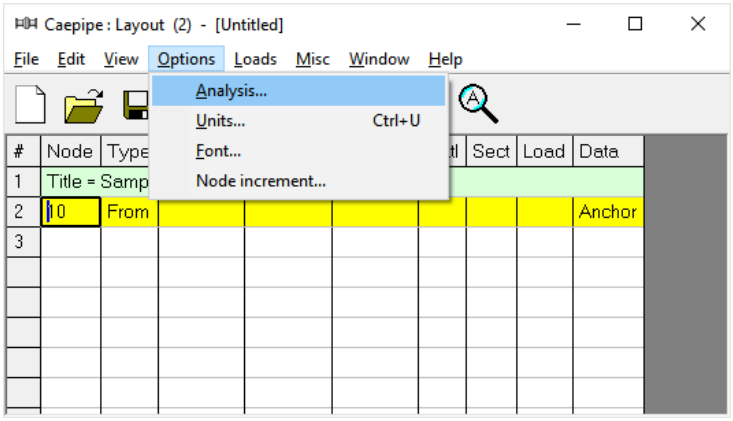
Adjust the size of the windows to fit your desktop such that you can view both comfortably at the same time.

1. Enter Title

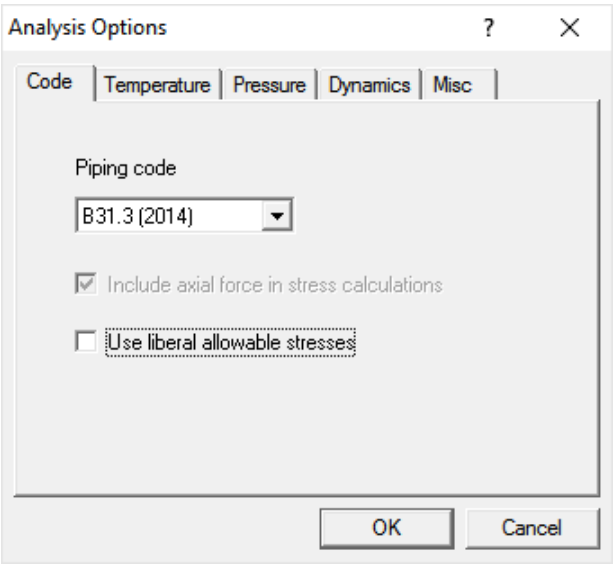
Type "Sample problem" as the title in the first row that contains "Title = ". Press Enter.

2. Select Analysis options (piping code etc.)

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



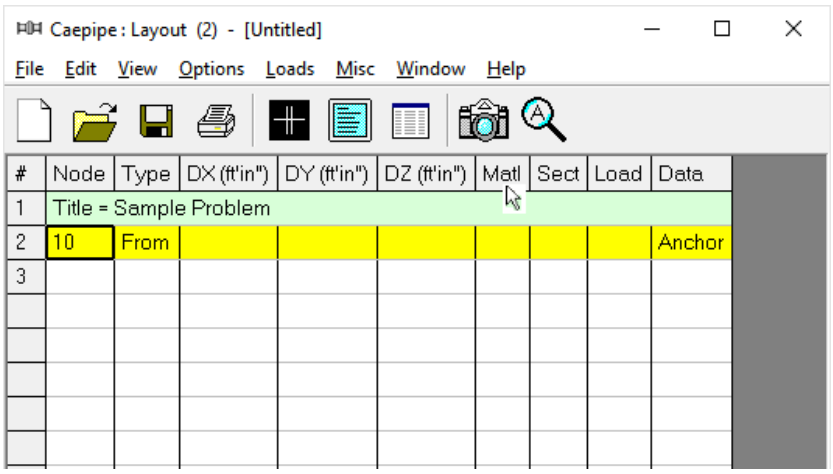
This opens the Analysis Options dialog.



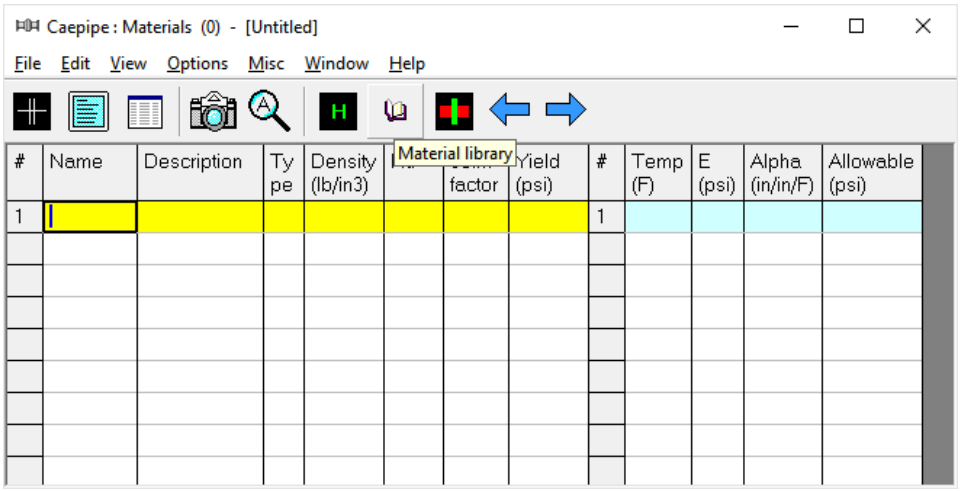
On the Code property page, select B31.3 for Piping code. Then click on OK to close Analysis Options dialog.

3. Define Material, Sections and Load Material

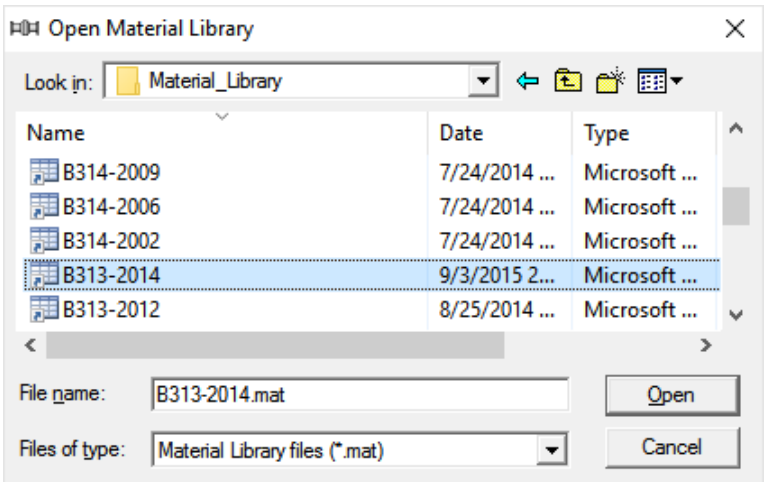
Click on "Matl" in the header in the Layout window (or press Ctrl+Shift+M)



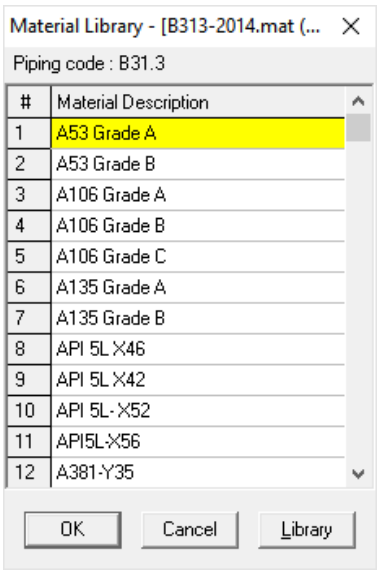
This opens up the Materials list in a separate List window. Position and resize the list window as you desire. Click on Library button on the Toolbar (or choose File > Library).



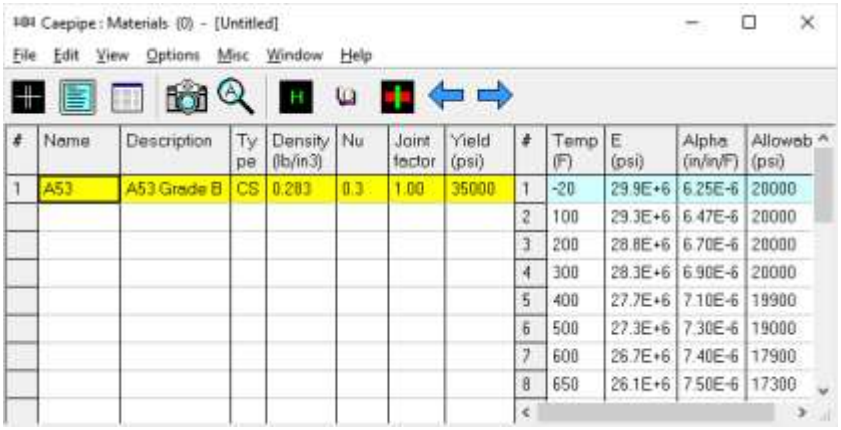
The Open Material Library dialog is shown.



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

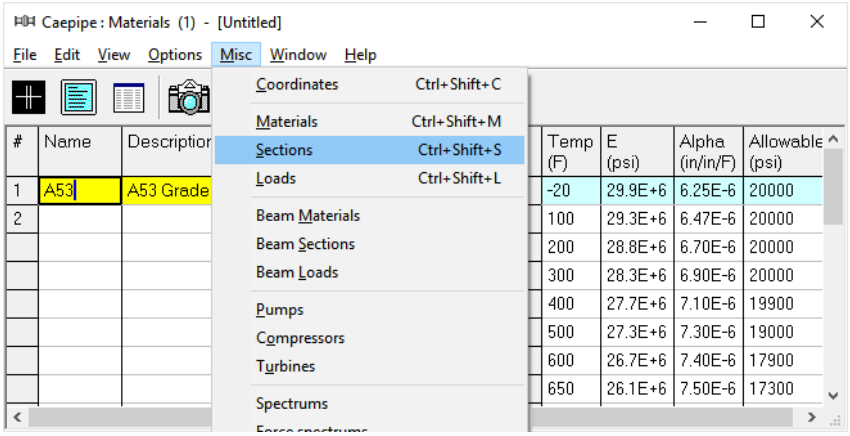


Double click on A53 Grade B material to select it. The properties for this material are transferred to the material in the List window. Type "A53" for material name and then press Enter.

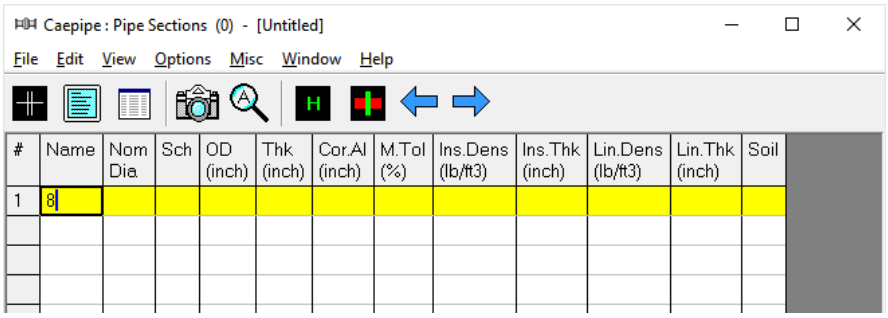


Sections

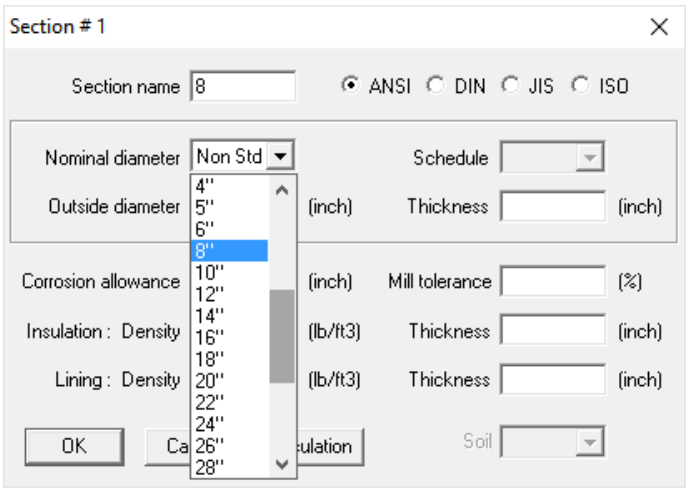
Select Sections from the Misc menu of the List window (or press Ctrl+Shift+S).



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.

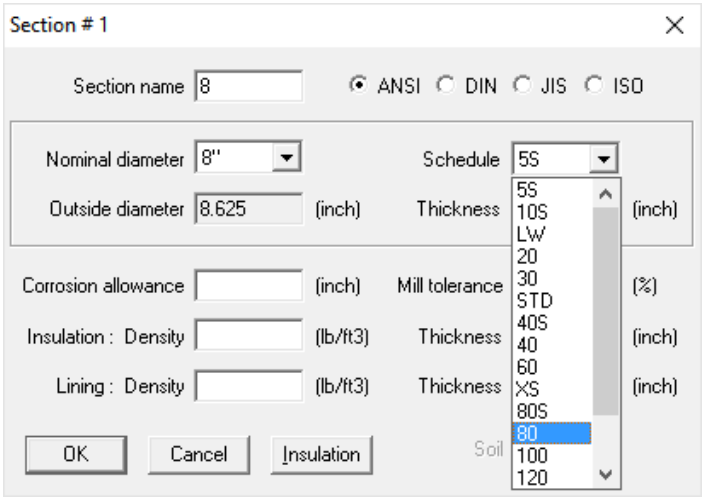


The Section Properties dialog is shown with the section name 8.



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

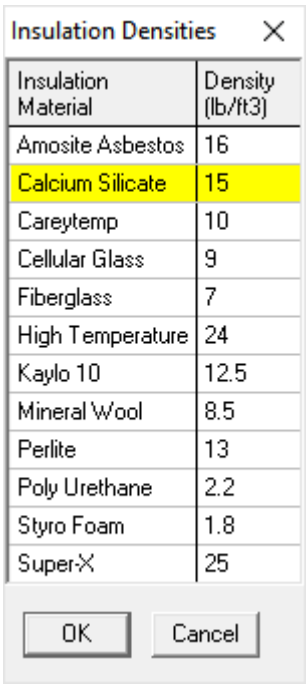
To select the schedule for the 8" pipe, click on the down arrow of the DropDown combo box for Schedule and select 80 for Schedule.



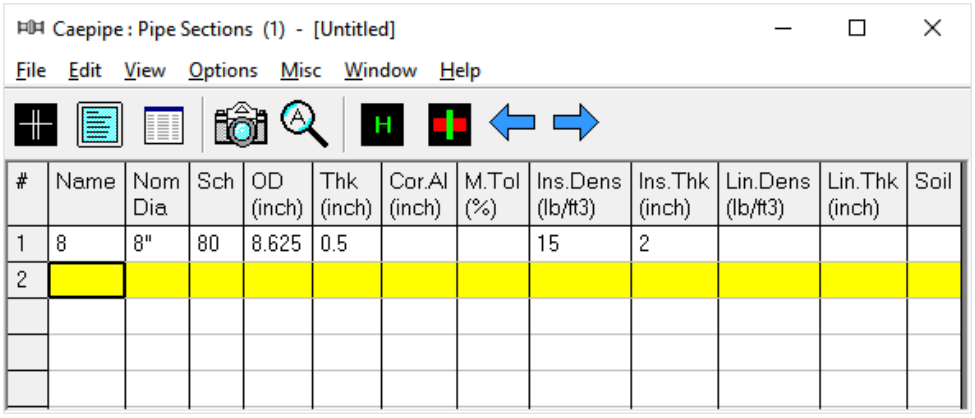
The Thickness (0.5") is automatically entered.

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

A table of Insulation materials and their densities is shown.

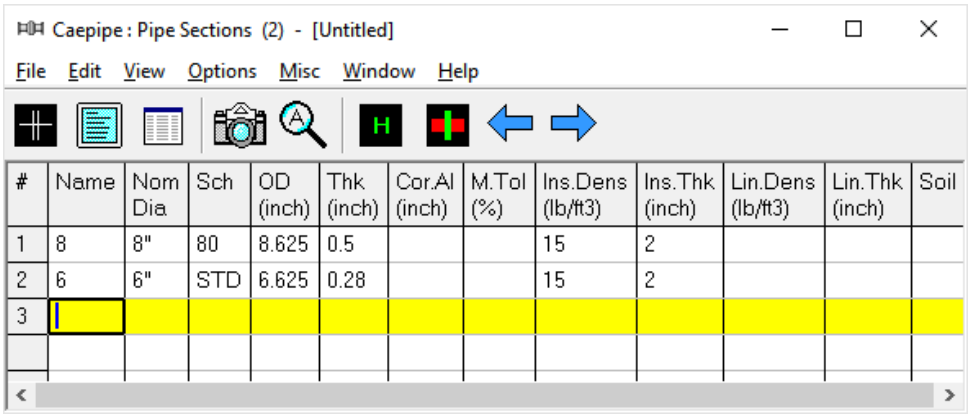


Double click on Calcium Silicate. The Insulation density (15.0 lb/ft3) is entered on the Section dialog. Type 2 (inches) for Insulation Thickness then press Enter or click OK to enter the first section.



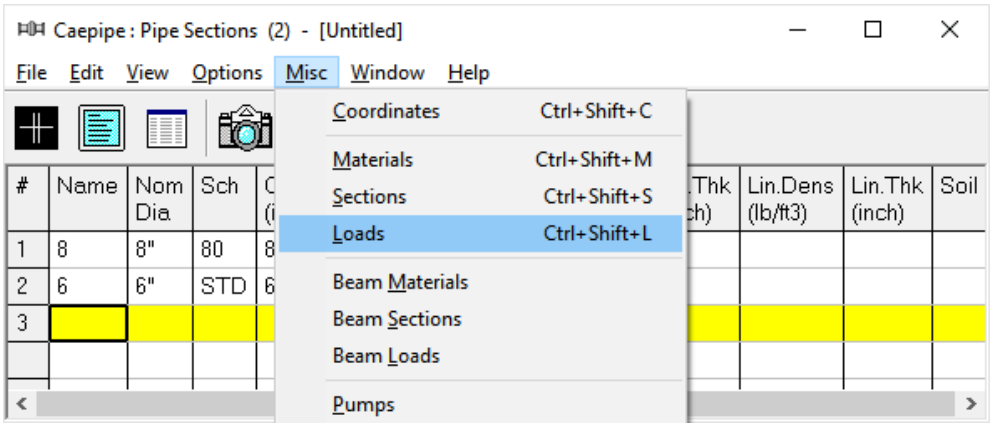
Now repeat the process for the second section.

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.

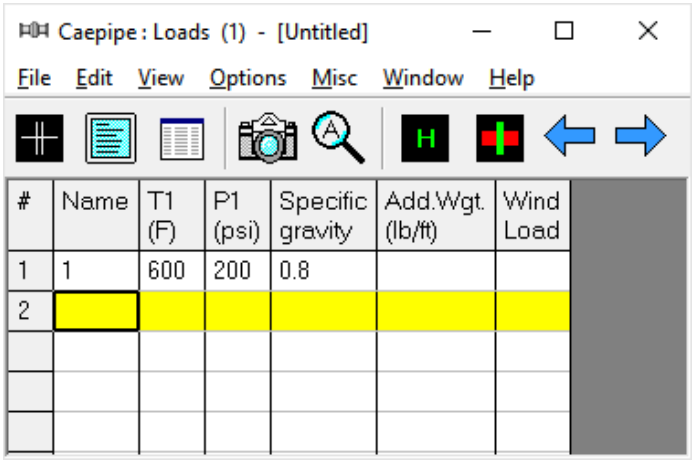


Load

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 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).



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

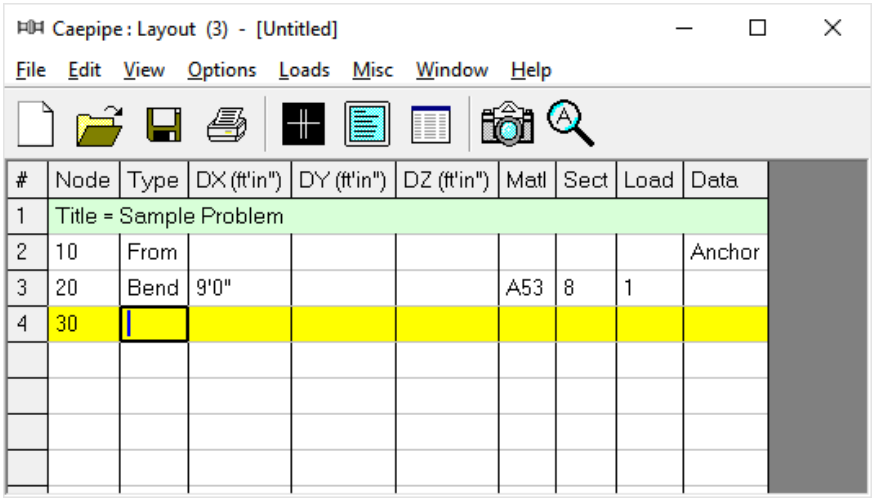
- In the following text, the word 'type' should be distinguished from the words 'Type column' or simply 'Type' (upper case 'T'). The former ('type') would mean press the keys for the text you want to type. The latter word 'Type' would refer to the Type column in the Layout spreadsheet.
- Also, the instruction "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.

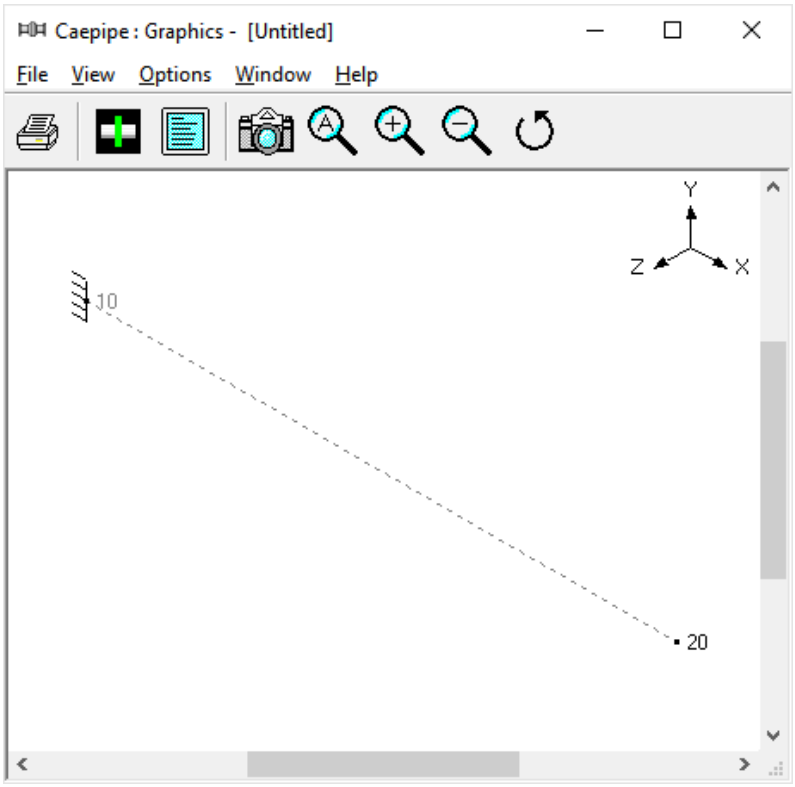
Press Enter to move the highlight to the next row(#3). Tab to the Type column. The next Node 20 is automatically assigned. In the Type column, type 'b' (for Bend), Tab to DX, type 9. Tab over to Material, type A53, Tab to Section, type 8, Tab to Load, type 1. Press Enter and the cursor moves to the next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

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

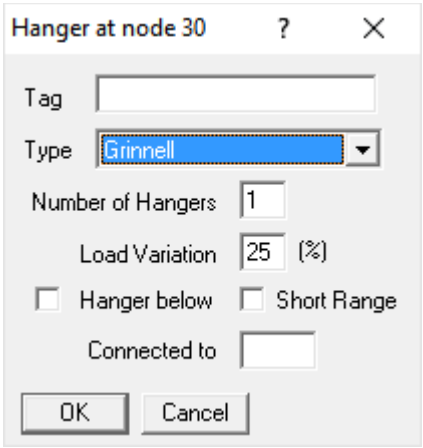


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30								

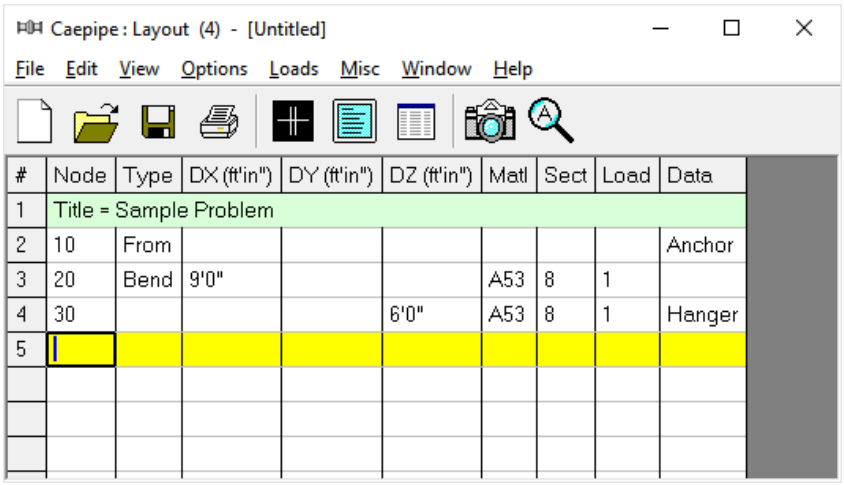
You will see the model in the graphics window as it is entered. You can press F2 to switch between text and graphics windows.



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

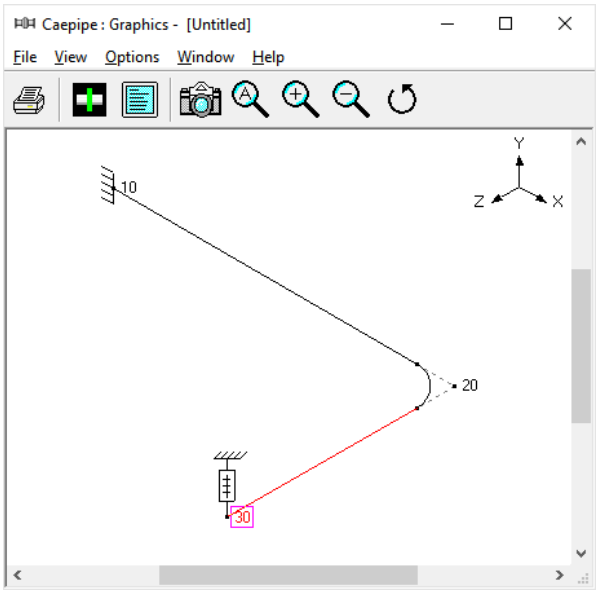


Press Enter or click on OK to input the hanger. The material, section and load are automatically inserted (based on the previous row's material, section and load), and the cursor moves to the next row.

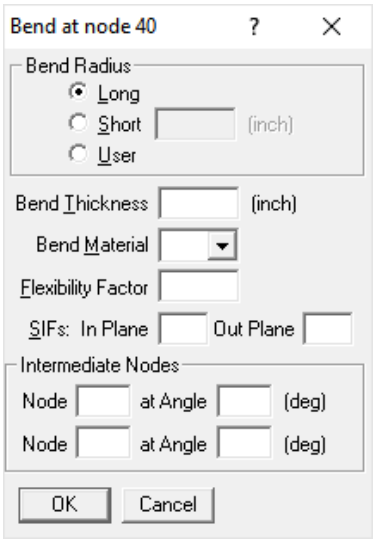


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5									

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). 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.

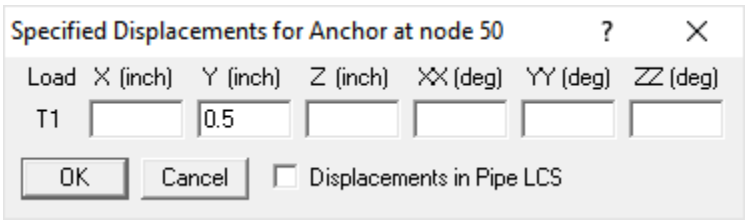
In row #6, Tab to the DY column. The next Node 50, is automatically assigned. In the DY column, type -6, Tab to the Data column or press Ctrl+D to move to the data column, then type 'a' (for Anchor). An anchor, material, section and load are automatically inserted, and the cursor moves to the next row.

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.

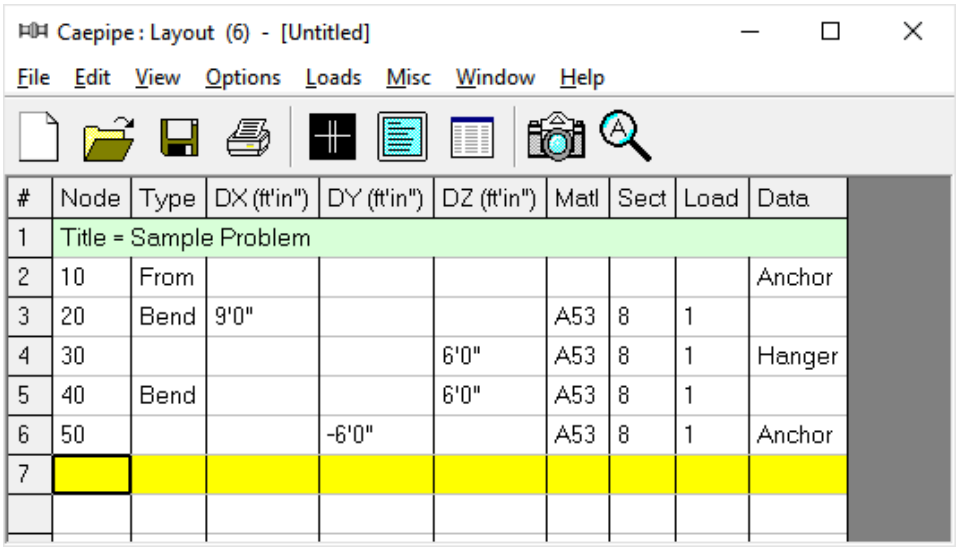
Note:

Option "Anchor in Pipe LCS" allows the user to input Anchor stiffnesses in the LCS of the adjoining pipe. On the other hand, if "Anchor in Pipe LCS" is not turned ON, then the user 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.

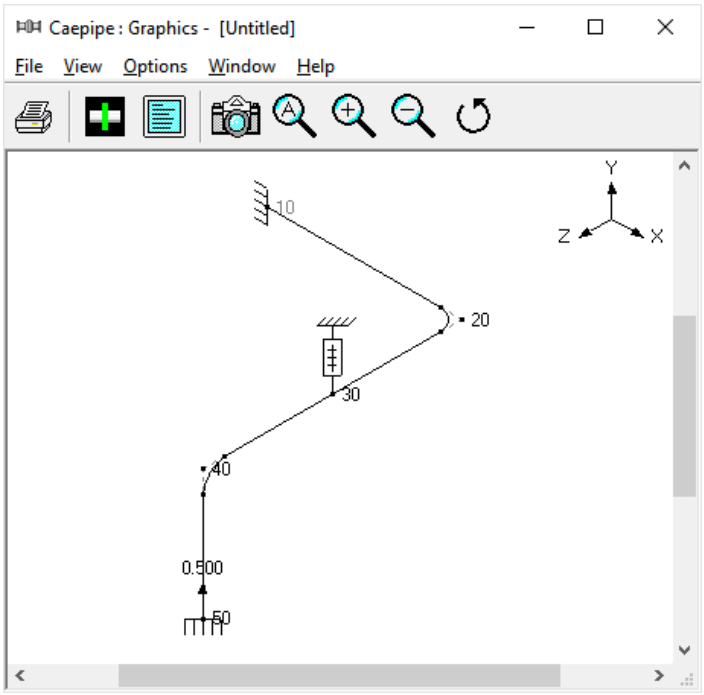


Press Enter to exit the Specified Displacements dialog. Press Enter again to exit the Anchor dialog. In the Layout window, press Enter to move to the next row.



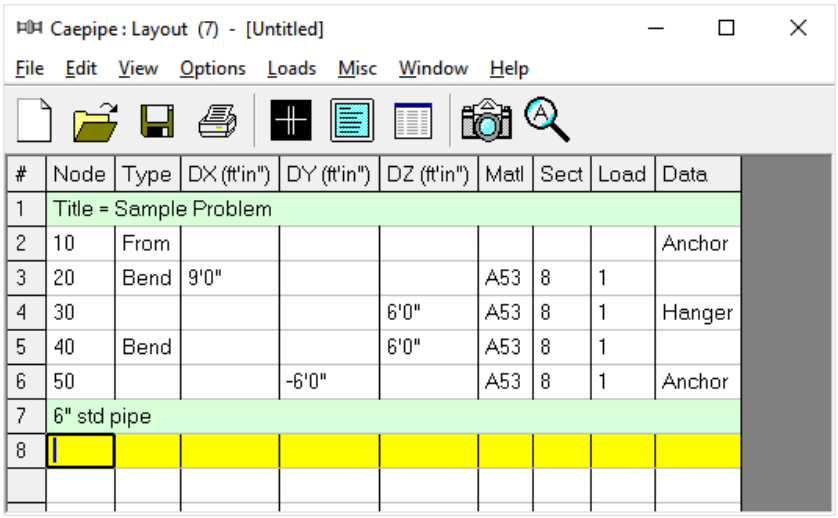
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7									

 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

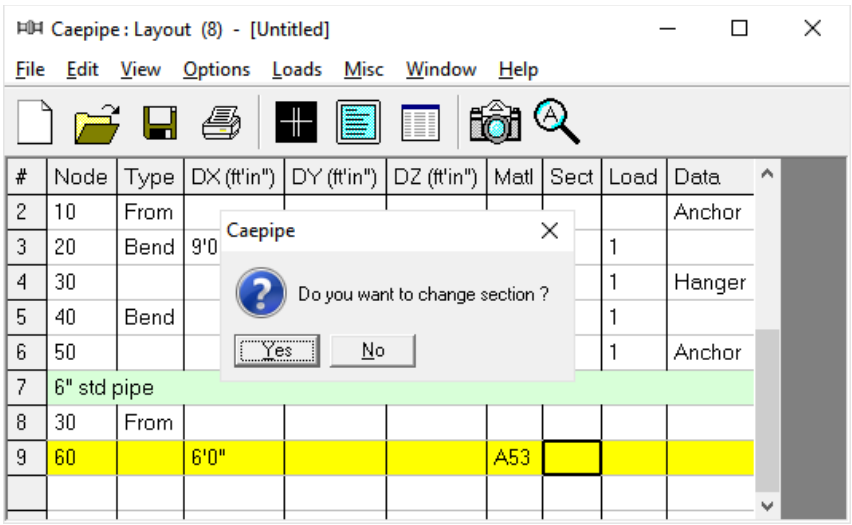
Let us input a comment saying that this is a 6" std pipe. On an empty row, if the first character in the Node field is input as 'c', that row becomes a comment row. On row #7, type 'c' to create the comment and then type: 6" std pipe and then press Enter to go to the next row.



#	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									

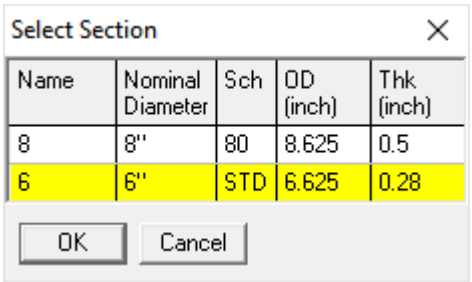
On the next row (#8), type 30 for Node, Tab to the Type column, type 'f' (for "From", since we are beginning a new branch), press Enter. In the next row (#9), Tab to the DX column. The next Node 60, is automatically assigned. In the DX column, type 6 and press Enter.

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



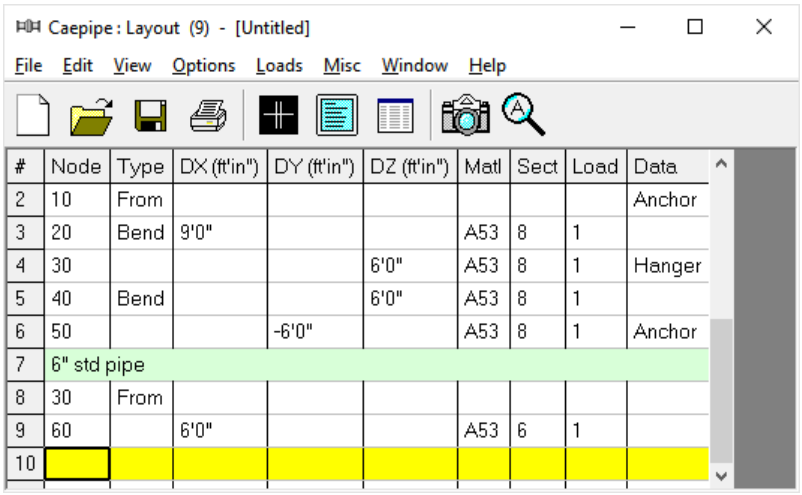
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
2	10	From							Anchor
3	20	Bend	9'0					1	
4	30							1	Hanger
5	40	Bend						1	
6	50							1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53			

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



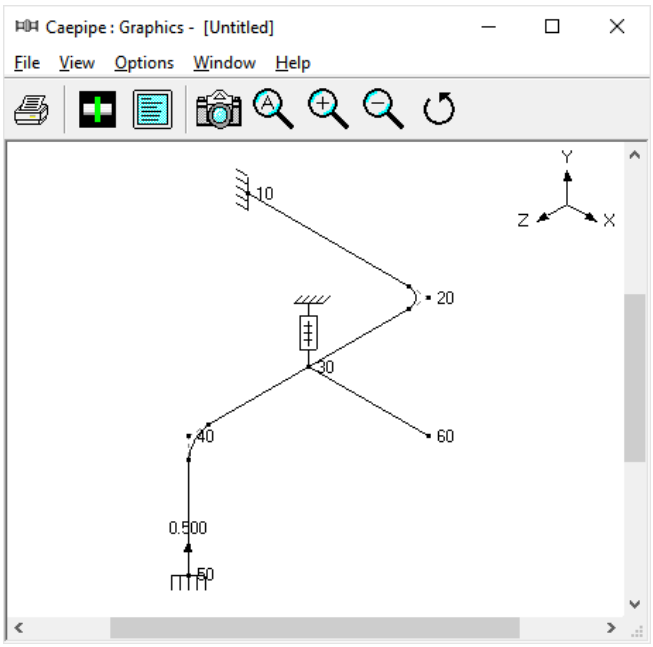
Name	Nominal Diameter	Sch	OD (inch)	Thk (inch)
8	8"	80	8.625	0.5
6	6"	STD	6.625	0.28

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.

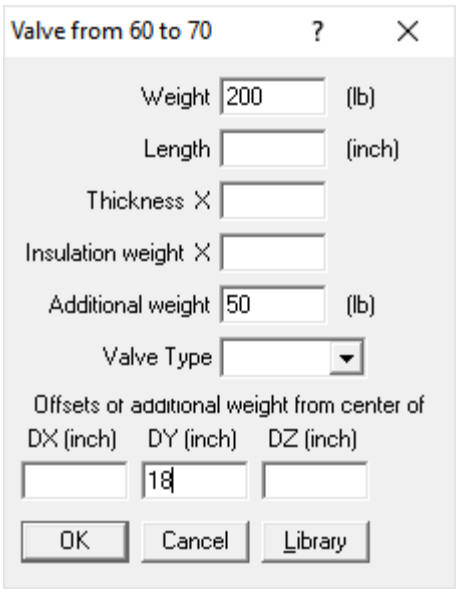


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10									

The graphics window will look like this.



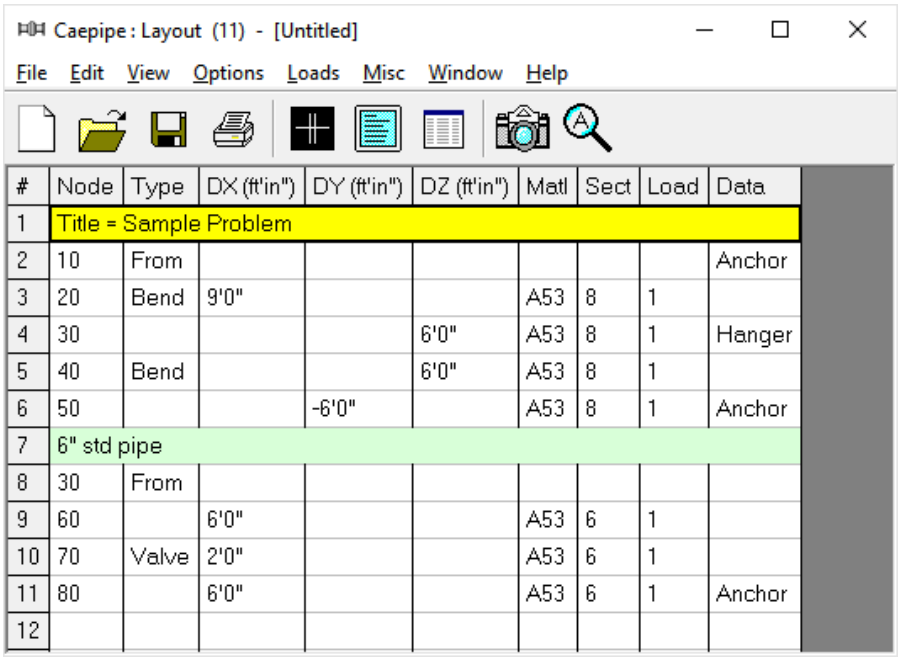
In the next row (#10), Tab to the Type column. The next Node 70, is automatically assigned. In the Type column, type 'v' (for Valve). This brings up the Valve dialog box.



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.

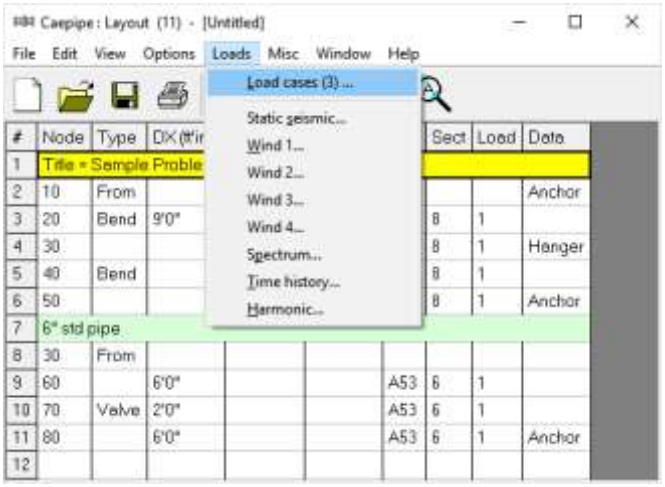
In the next row (#11), Tab to DX. The next Node 80, is automatically assigned. In the DX column, type 6. Tab to Data or press Ctrl D to move to the data column, then type 'a'(for Anchor). Material, section and load are automatically inserted like before, and the cursor moves to the next row.



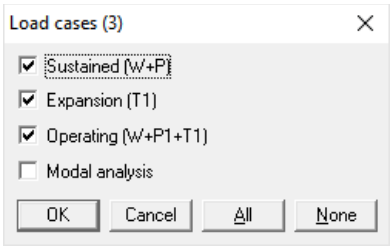
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10	70	Valve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

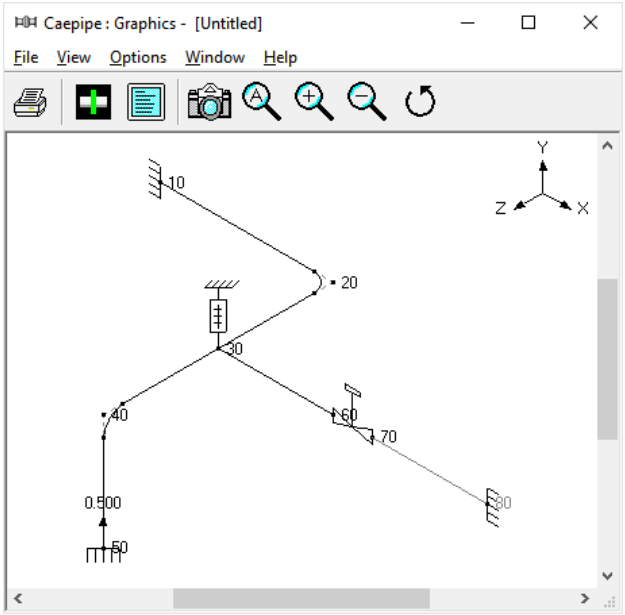


The Load cases dialog is shown.

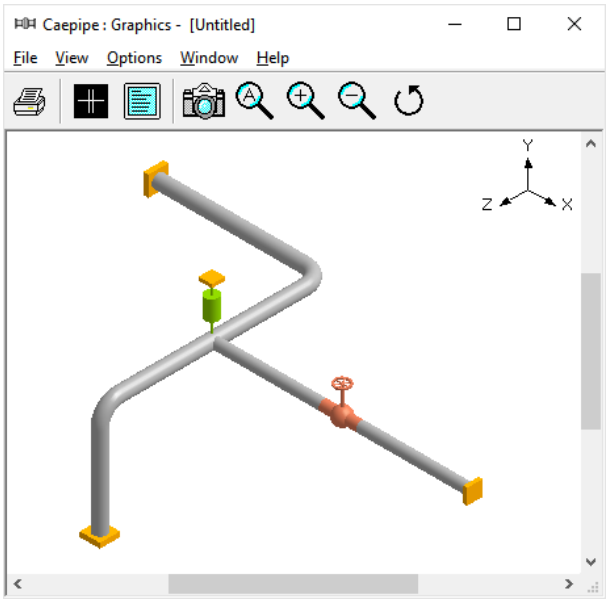


By default, Sustained(W+P), Expansion(T1) and Operating(W+P1+T1) load cases are already selected. Press OK to return to the Layout window. The model input is now complete.


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



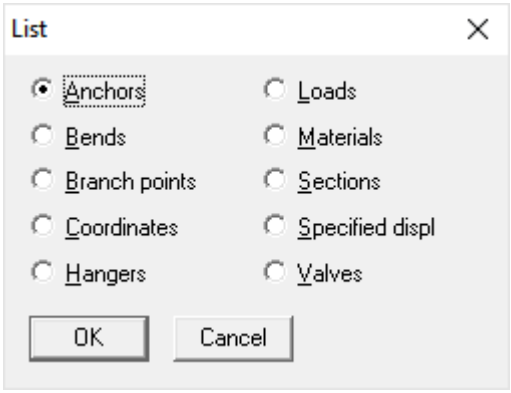
 To see a 3D rendered view of the model, click on the Render button (or press Ctrl+R) in the graphics window.



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

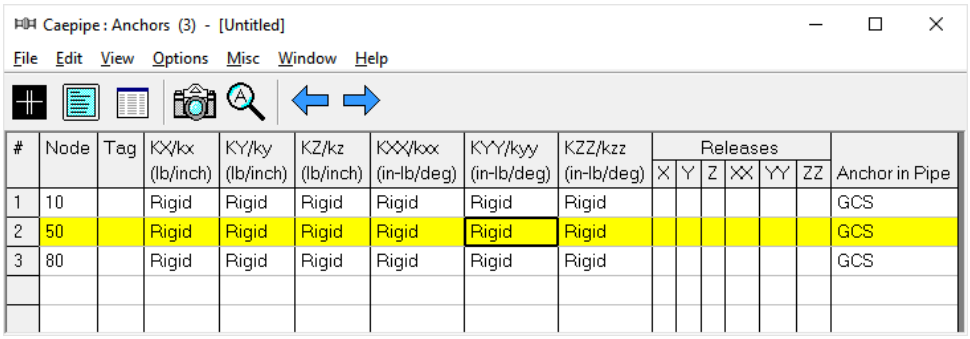
List

 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.

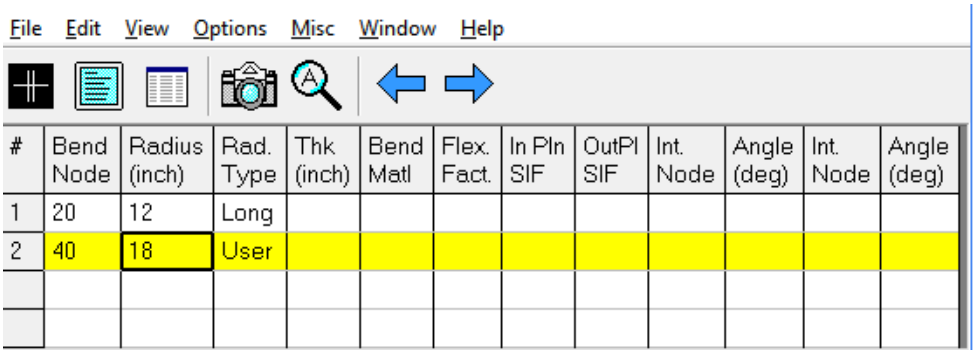
A list of all the anchors in the sample model is shown below:



#	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 X	Y	Z	XX	YY	ZZ	Anchor in Pipe
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.

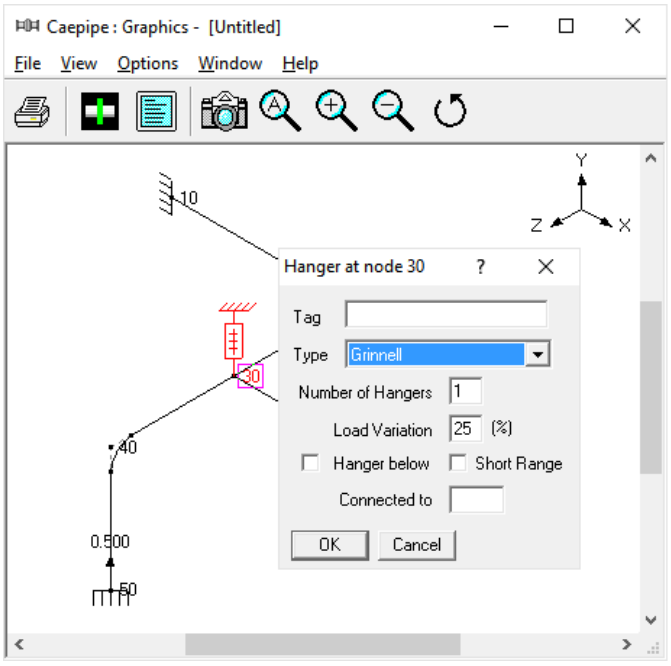
A list of all the bends in the sample model is shown below:



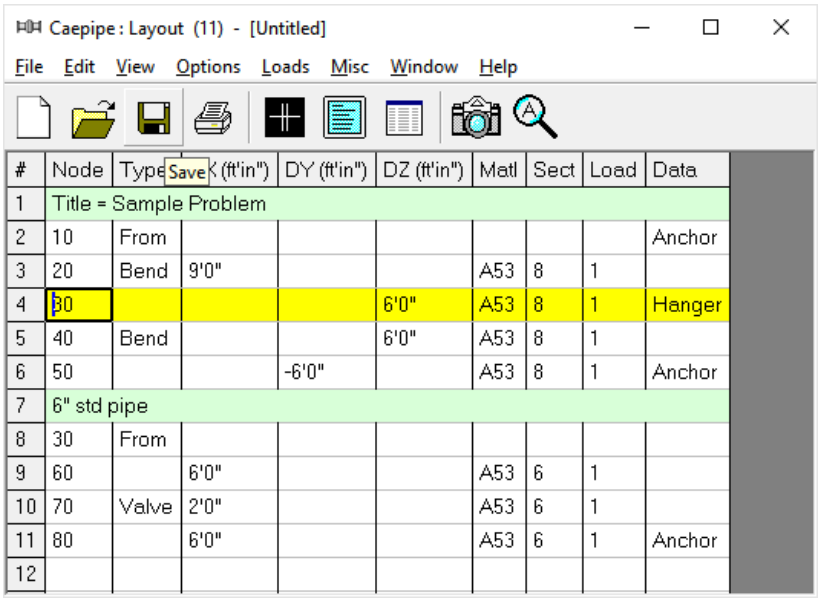
#	Bend Node	Radius (inch)	Rad. Type	Thk (inch)	Bend Matl	Flex. Fact.	In Pln SIF	OutPl SIF	Int. Node	Angle (deg)	Int. Node	Angle (deg)
1	20	12	Long									
2	40	18	User									

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.

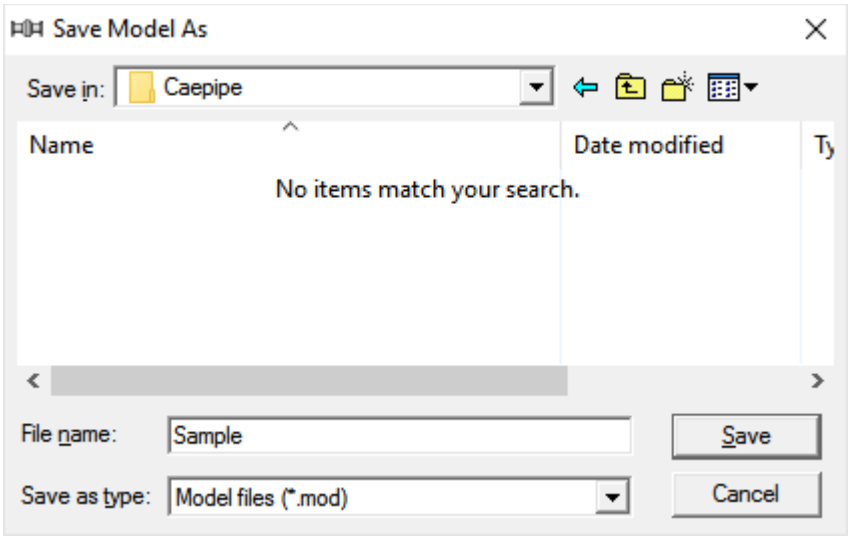


Save the model by clicking on the Save button.



#	Node	Type	X (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									

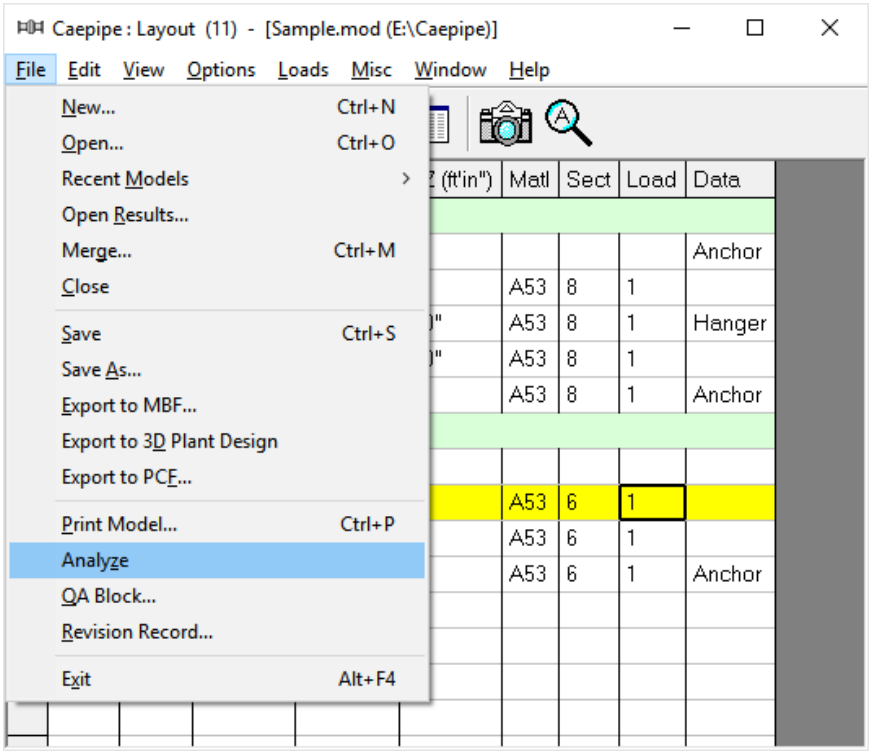
The "Save Model As" dialog is shown.



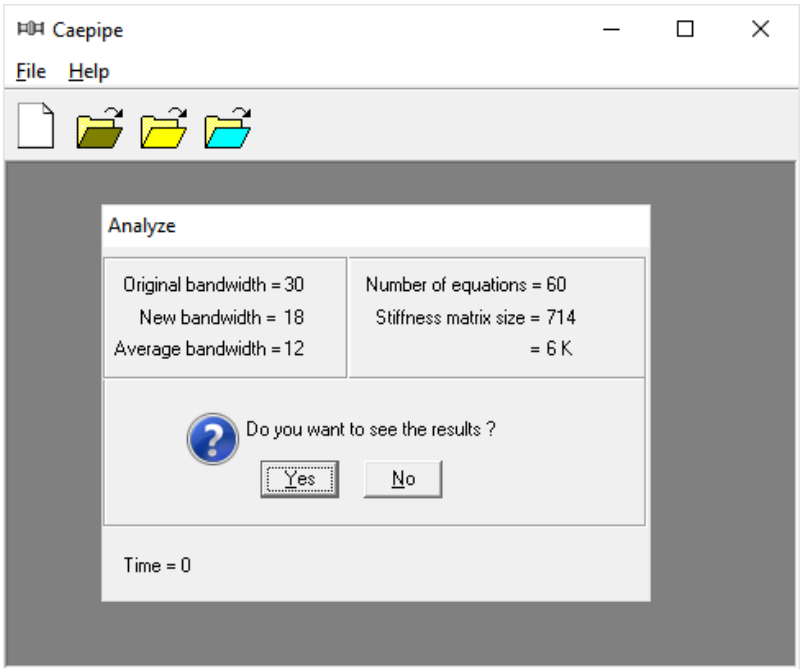
Type the File name as "Sample" and press Enter to save the model. We are done with modelling. Let us analyze now.

6. Analyze

Click on Analyze under the File menu.

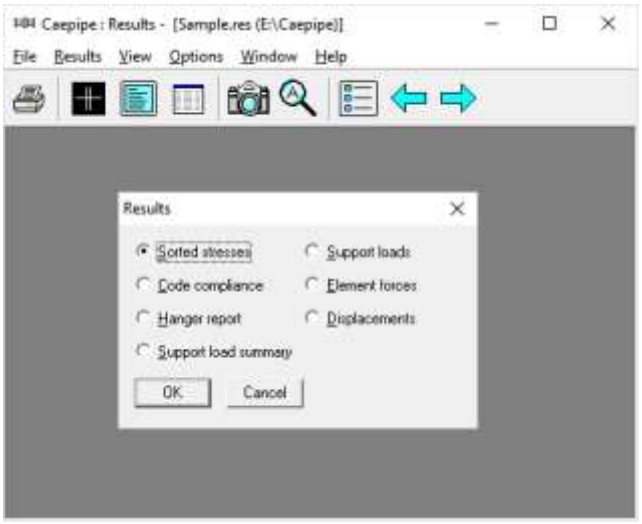


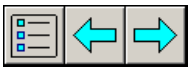
After the analysis, you are asked if you want to see the results. Select Yes.



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.



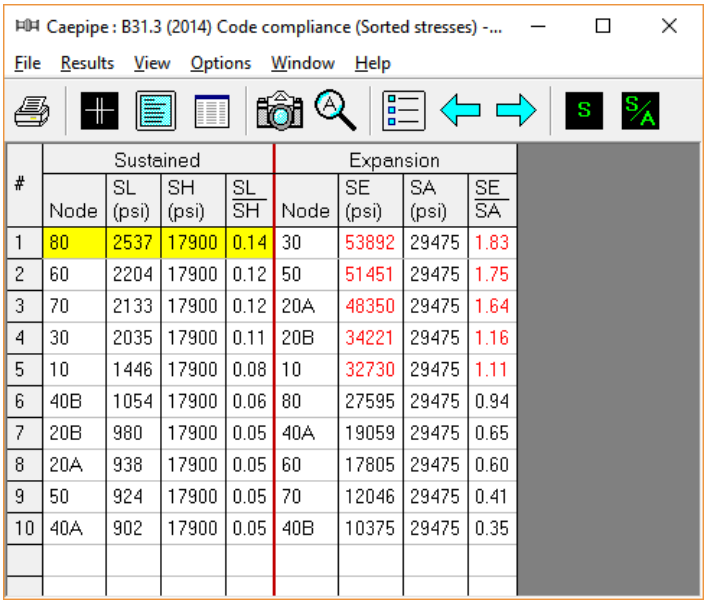


Select an item of interest by clicking on it. When you are viewing the results, use Tab (or Next Result button) to view the next result and Shift+Tab (or Previous Result button) to view the previous result. The Results dialog can be brought up by clicking on the Results button (or press Ctrl+R).

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 can not be modified while viewing the results. Some of the results from the sample problem are shown below:

Sorted Stresses

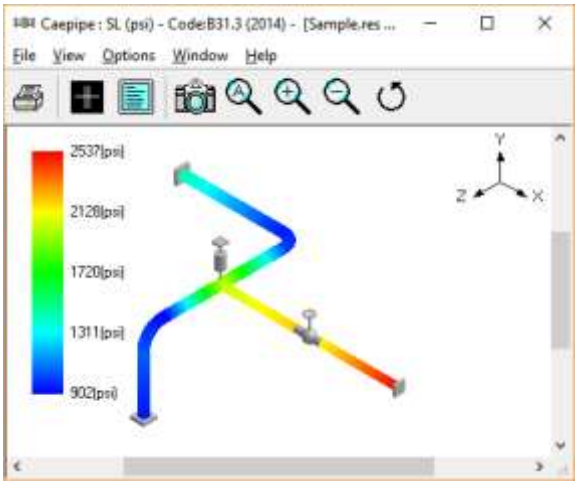
The computed stresses (sustained, expansion and occasional) are sorted in descending order by stress ratios.



#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
1	80	2537	17900	0.14	30	53892	29475	1.83
2	60	2204	17900	0.12	50	51451	29475	1.75
3	70	2133	17900	0.12	20A	48350	29475	1.64
4	30	2035	17900	0.11	20B	34221	29475	1.16
5	10	1446	17900	0.08	10	32730	29475	1.11
6	40B	1054	17900	0.06	80	27595	29475	0.94
7	20B	980	17900	0.05	40A	19059	29475	0.65
8	20A	938	17900	0.05	60	17805	29475	0.60
9	50	924	17900	0.05	70	12046	29475	0.41
10	40A	902	17900	0.05	40B	10375	29475	0.35

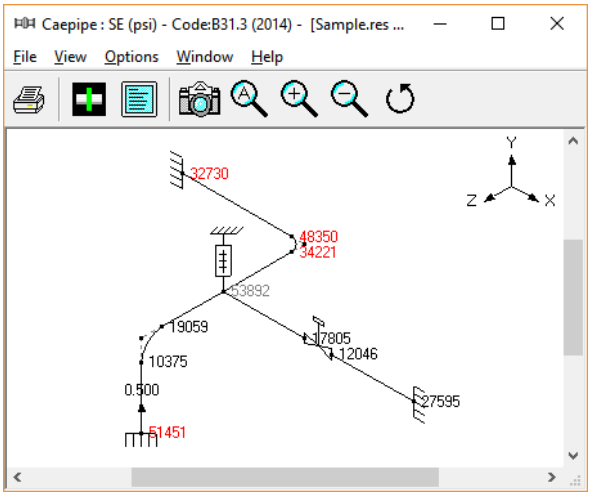
When the stress ratio exceeds 1.00, the stress and the stress ratio are shown in red. In this particular case, the high thermal stresses may be reduced by replacing the anchor at Node 80 by a guide. This allows the 6" pipe to expand more freely and reduce the thermal stresses. The maximum thermal stress is reduced to 22195 psi and the stress ratio is reduced to 0.76.

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.

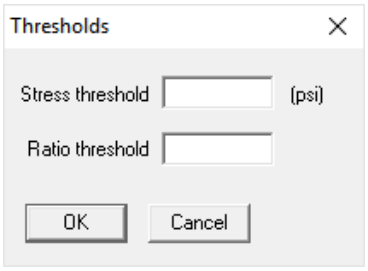


The stress ratios may similarly be rendered by using the Show stress rations button (or choose View > Show Stress Rations).

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

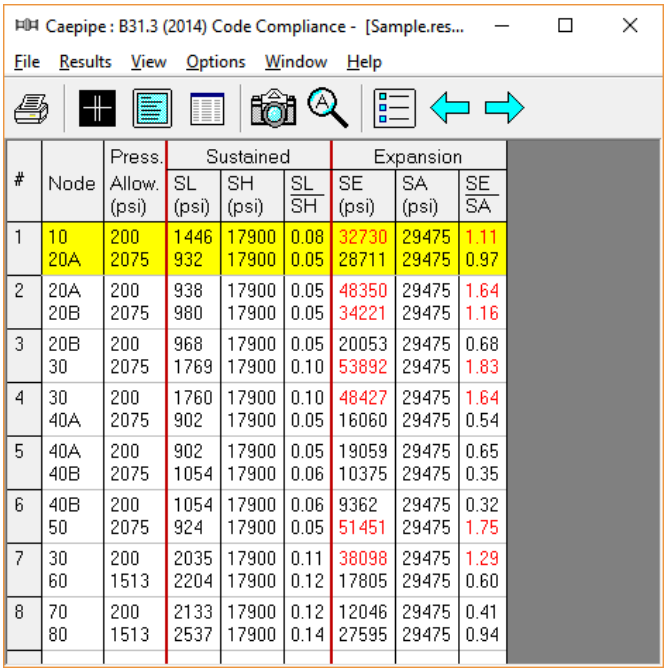


While plotting stresses or stress ratios, thresholds may be specified (choose View > Thresholds). Only the stresses or stress ratios exceeding the thresholds are plotted.



Code compliance

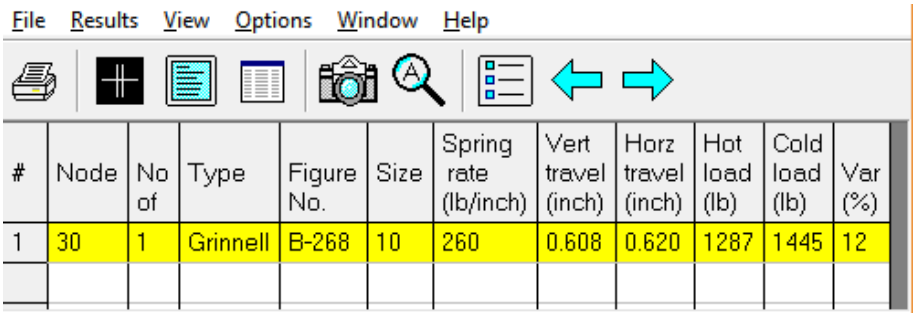
The element stresses calculated according to the piping code are shown under code compliance.



#	Node	Press. Allow. (psi)	Sustained SL (psi)	Sustained SH (psi)	Sustained SL/SH	Expansion SE (psi)	Expansion SA (psi)	Expansion SE/SA
1	10	200	1446	17900	0.08	32730	29475	1.11
	20A	2075	932	17900	0.05	28711	29475	0.97
2	20A	200	938	17900	0.05	48350	29475	1.64
	20B	2075	980	17900	0.05	34221	29475	1.16
3	20B	200	968	17900	0.05	20053	29475	0.68
	30	2075	1769	17900	0.10	53892	29475	1.83
4	30	200	1760	17900	0.10	48427	29475	1.64
	40A	2075	902	17900	0.05	16060	29475	0.54
5	40A	200	902	17900	0.05	19059	29475	0.65
	40B	2075	1054	17900	0.06	10375	29475	0.35
6	40B	200	1054	17900	0.06	9362	29475	0.32
	50	2075	924	17900	0.05	51451	29475	1.75
7	30	200	2035	17900	0.11	38098	29475	1.29
	60	1513	2204	17900	0.12	17805	29475	0.60
8	70	200	2133	17900	0.12	12046	29475	0.41
	80	1513	2537	17900	0.14	27595	29475	0.94

Hanger report

The hanger report is shown below.



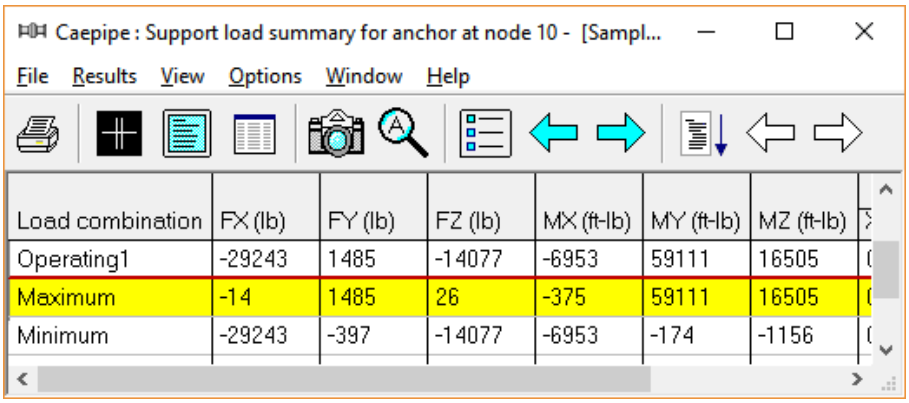
#	Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
1	30	1	Grinnell	B-268	10	260	0.608	0.620	1287	1445	12

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 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 case. The hot load is the hanger load for the operating condition and the cold load is the hanger load at zero deflection.

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

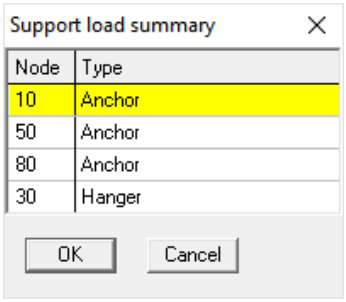
Support load summary

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.



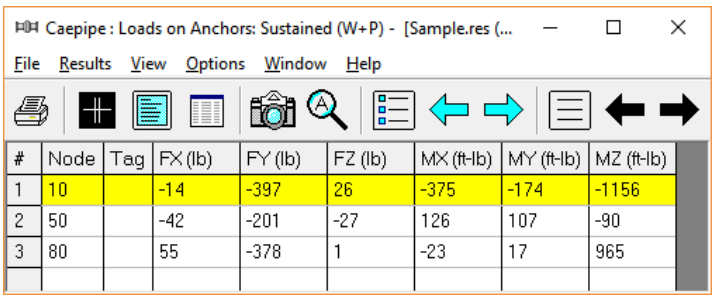
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Operating1	-29243	1485	-14077	-6953	59111	16505
Maximum	-14	1485	26	-375	59111	16505
Minimum	-29243	-397	-14077	-6953	-174	-1156

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

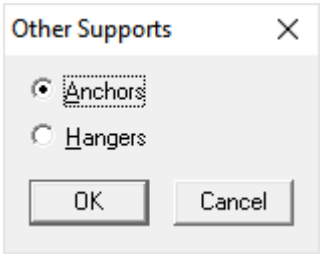
Support loads are the loads acting on the supports imposed by the piping system. The loads on anchors for the Sustained case are shown below.



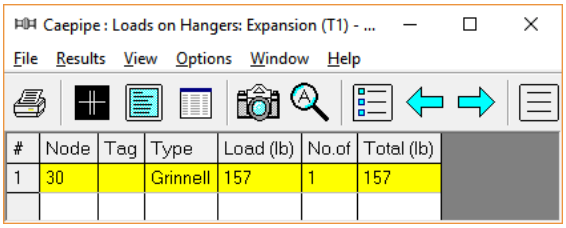
#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10		-14	-397	26	-375	-174	-1156
2	50		-42	-201	-27	126	107	-90
3	80		55	-378	1	-23	17	965

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.).



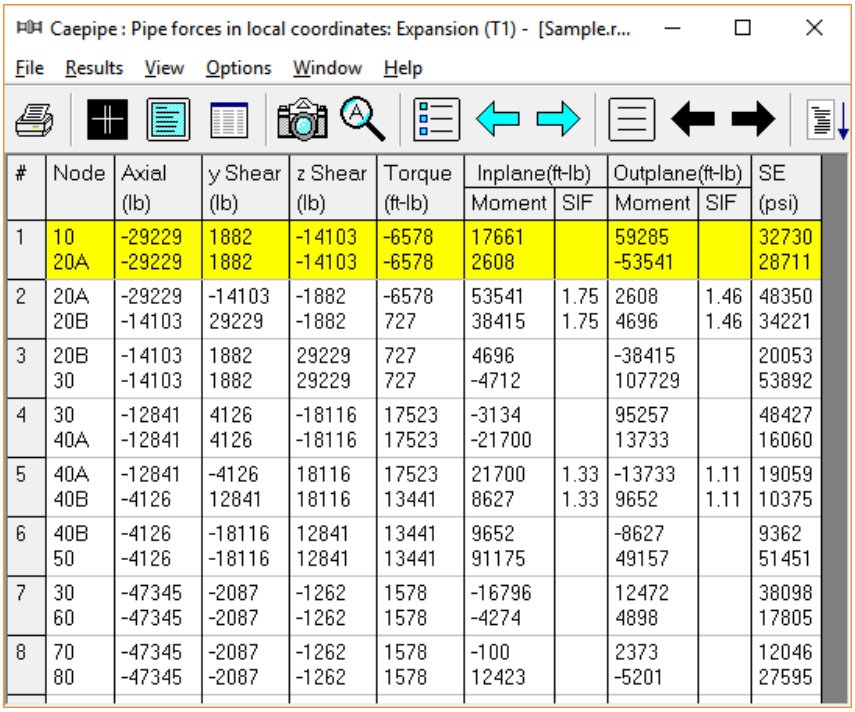
The loads on hangers (i.e. the loads acting at the hanger locations imposed by the piping system) for the Operating case are shown below.



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

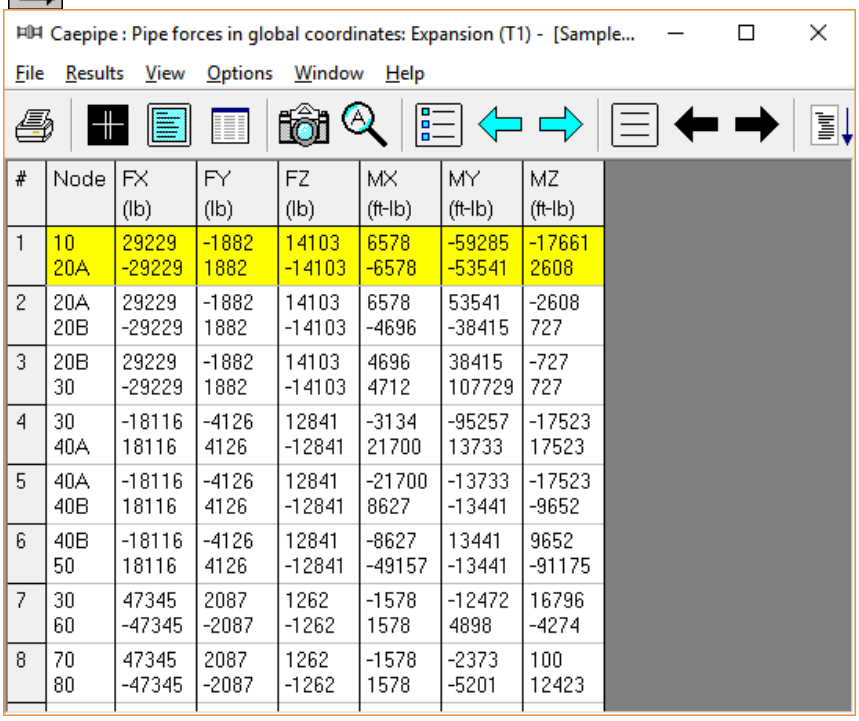
Element Forces

The element forces in local and global coordinates are shown. For pipe (also bend and reducer) element forces in local coordinates, the stress intensification factors (SIFs) and stresses are also shown.



#	Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torque (ft-lb)	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	SE (psi)
1	10 20A	-29229 -29229	1882 1882	-14103 -14103	-6578 -6578	17661 2608		59285 -53541		32730 28711
2	20A 20B	-29229 -14103	-14103 29229	-1882 -1882	-6578 727	53541 38415	1.75 1.75	2608 4696	1.46 1.46	48350 34221
3	20B 30	-14103 -14103	1882 1882	29229 29229	727 727	4696 -4712		-38415 107729		20053 53892
4	30 40A	-12841 -12841	4126 4126	-18116 -18116	17523 17523	-3134 -21700		95257 13733		48427 16060
5	40A 40B	-12841 -4126	-4126 12841	18116 18116	17523 13441	21700 8627	1.33 1.33	-13733 9652	1.11 1.11	19059 10375
6	40B 50	-4126 -4126	-18116 -18116	12841 12841	13441 13441	9652 91175		-8627 49157		9362 51451
7	30 60	-47345 -47345	-2087 -2087	-1262 -1262	1578 1578	-16796 -4274		12472 4898		38098 17805
8	70 80	-47345 -47345	-2087 -2087	-1262 -1262	1578 1578	-100 12423		2373 -5201		12046 27595

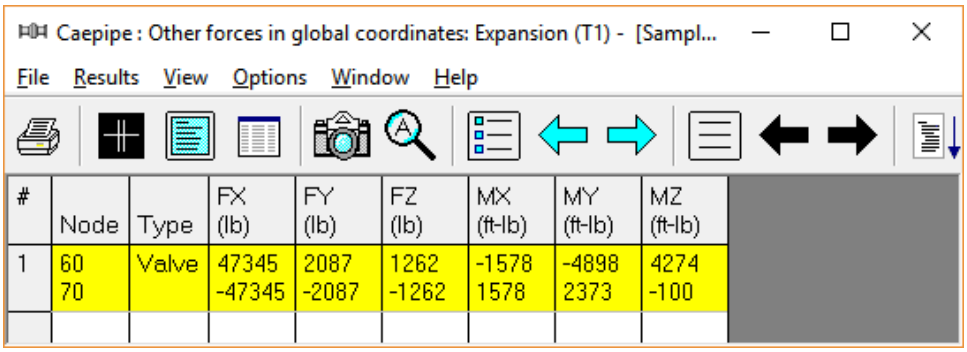
Use the Global forces button (F7) to see the element forces in global coordinates.



#	Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10 20A	29229 -29229	-1882 1882	14103 -14103	6578 -6578	-59285 -53541	-17661 2608
2	20A 20B	29229 -29229	-1882 1882	14103 -14103	6578 -4696	53541 -38415	-2608 727
3	20B 30	29229 -29229	-1882 1882	14103 -14103	4696 4712	38415 107729	-727 727
4	30 40A	-18116 18116	-4126 4126	12841 -12841	-3134 21700	-95257 13733	-17523 17523
5	40A 40B	-18116 18116	-4126 4126	12841 -12841	-21700 8627	-13733 -13441	-17523 -9652
6	40B 50	-18116 18116	-4126 4126	12841 -12841	-8627 -49157	13441 -13441	9652 -91175
7	30 60	47345 -47345	2087 -2087	1262 -1262	-1578 1578	-12472 4898	16796 -4274
8	70 80	47345 -47345	2087 -2087	1262 -1262	-1578 1578	-2373 -5201	100 12423

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

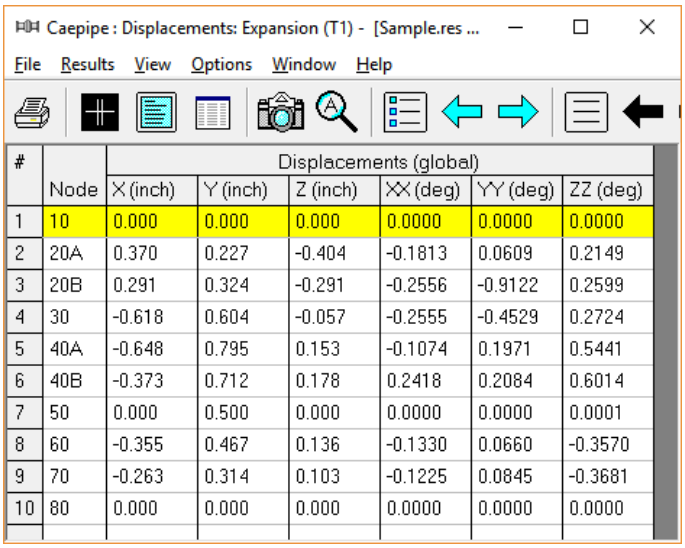
Use the Other forces button (F6), Next force button(Ctrl+Right arrow) or Previous force button (Ctrl+Left arrow) to see other element forces(e.g. valves, bellows etc.).



#	Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	60 70	Valve	47345 -47345	2087 -2087	1262 -1262	-1578 1578	-4898 2373	4274 -100

Displacements

The nodal displacements are shown.

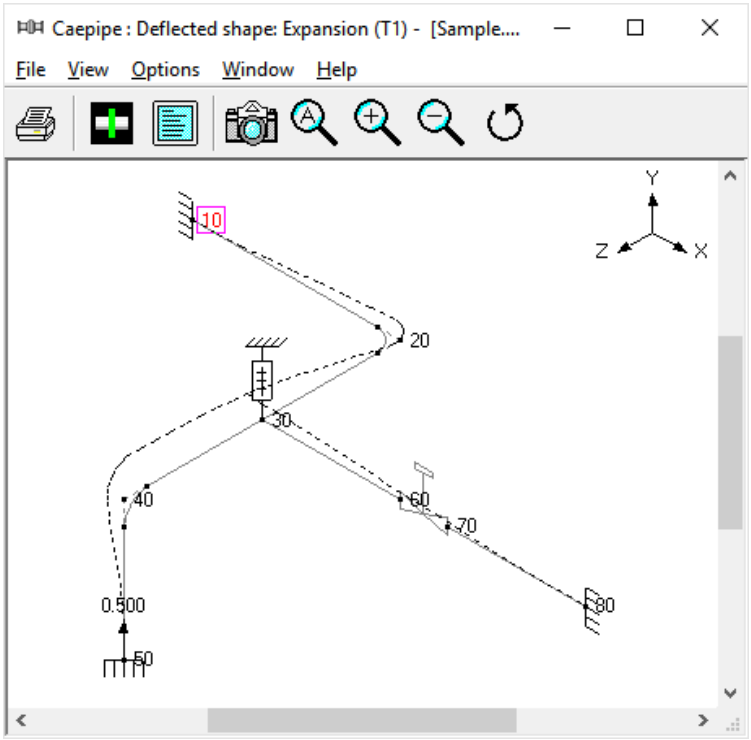


#	Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
1	10	0.000	0.000	0.000	0.0000	0.0000	0.0000
2	20A	0.370	0.227	-0.404	-0.1813	0.0609	0.2149
3	20B	0.291	0.324	-0.291	-0.2556	-0.9122	0.2599
4	30	-0.618	0.604	-0.057	-0.2555	-0.4529	0.2724
5	40A	-0.648	0.795	0.153	-0.1074	0.1971	0.5441
6	40B	-0.373	0.712	0.178	0.2418	0.2084	0.6014
7	50	0.000	0.500	0.000	0.0000	0.0000	0.0001
8	60	-0.355	0.467	0.136	-0.1330	0.0660	-0.3570
9	70	-0.263	0.314	0.103	-0.1225	0.0845	-0.3681
10	80	0.000	0.000	0.000	0.0000	0.0000	0.0000

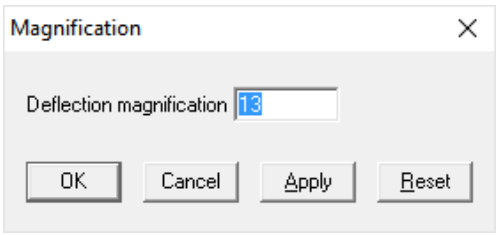
Use the Load cases button, Next load case button (Right arrow) or Previous load case button (Left arrow) to see loads for different load cases(e.g. Sustained, Expansion etc.).

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.

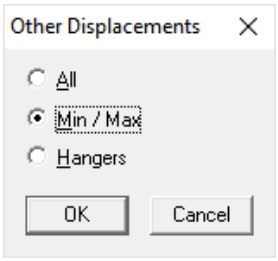


Choose View > Magnification to change the magnification of the deflected shape.

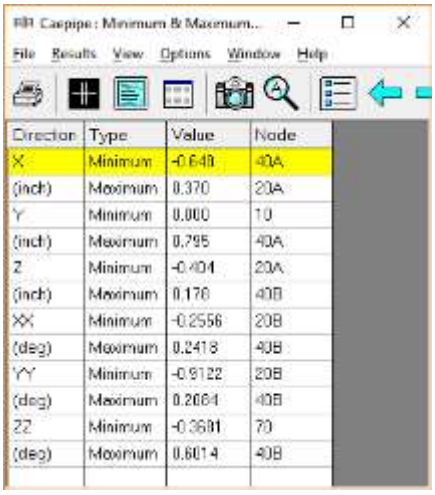


The reset button is used to calculate a default magnification factor which scales the maximum deflection to about 5% of the width of the graphics window.

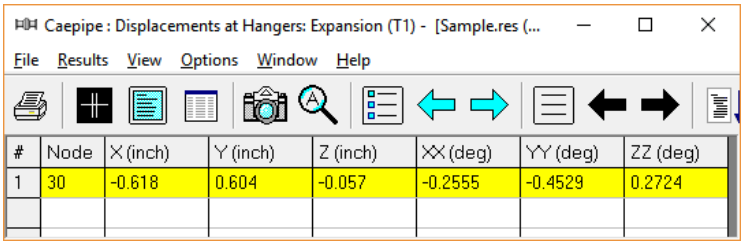
Use the Other displacements button (F6), Next displacement button (Ctrl+Right arrow) or Previous displacement button (Ctrl+Left arrow) to see other displacements (e.g. Min/Max, displacements at hangers, flex joints, limit stops etc.).



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

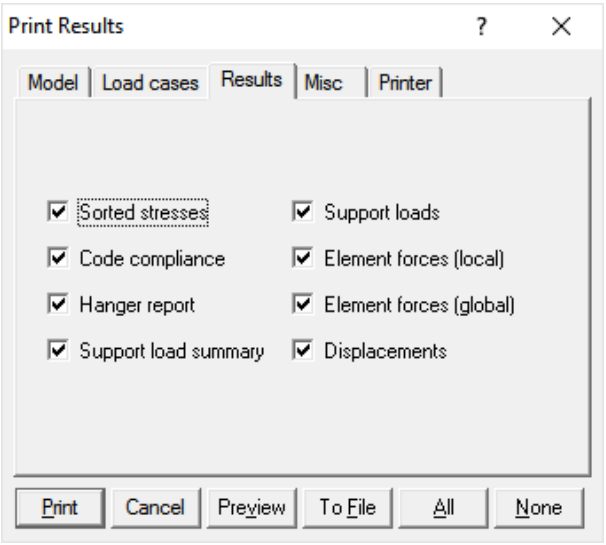


The displacements at hanger nodes are shown below.



Print

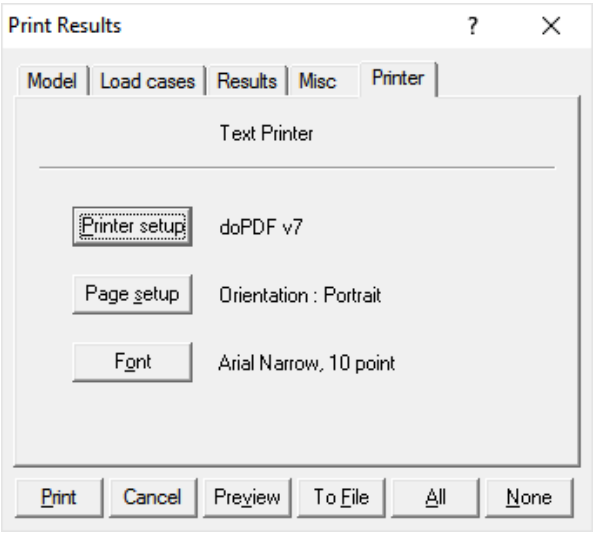
To print results and model data, click on the Print button (or press Ctrl+P). In the Print Results dialog, the item to print can be selected in the property pages.



You can also be 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.

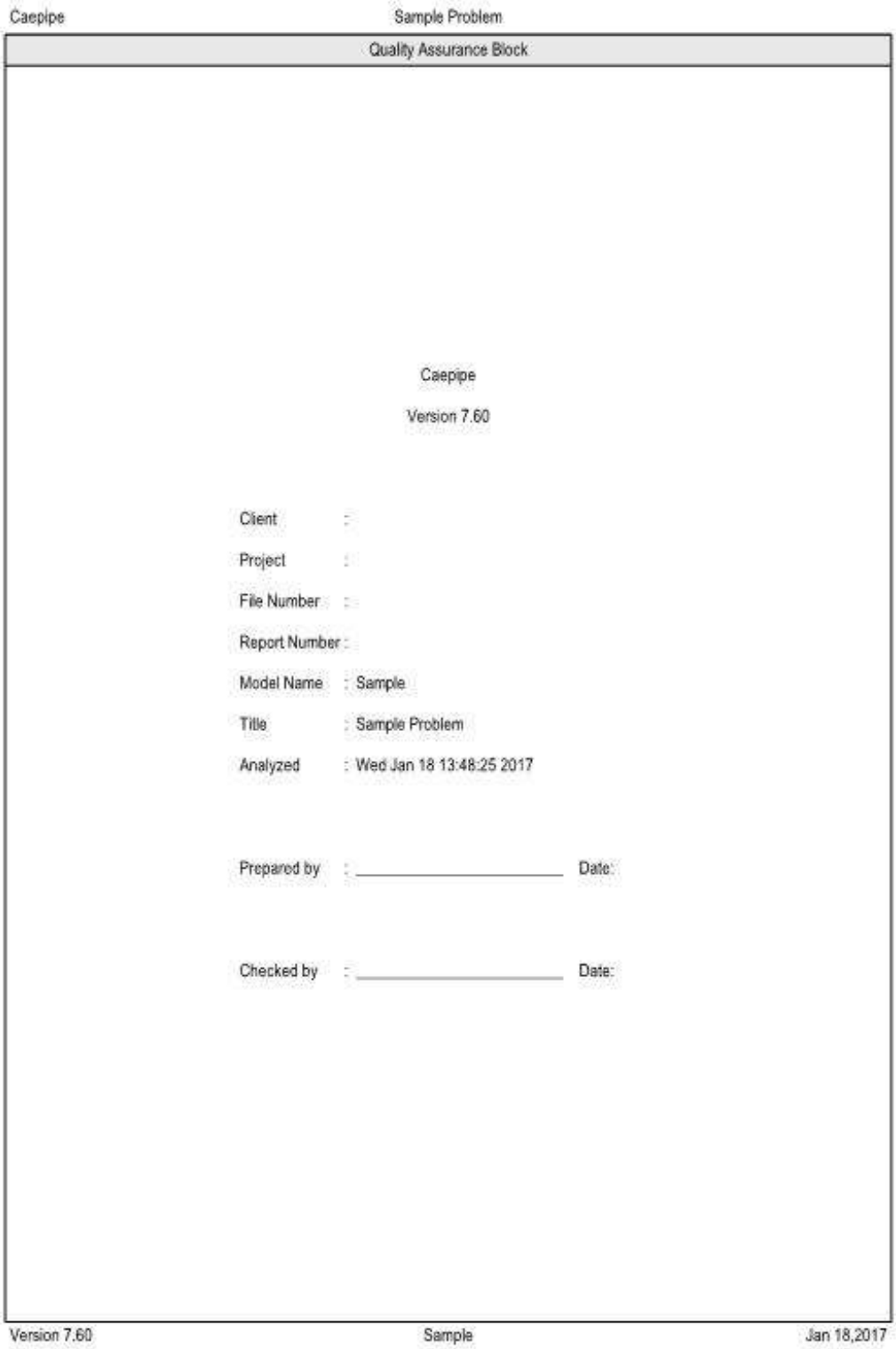

Caepipe
Sample Problem
Quality Assurance Block
Caepipe
Version 7.60
Client :
Project :
File Number :
Report Number :
Model Name : Sample
Title : Sample Problem
Analyzed : Wed Jan 18 13:48:25 2017
Prepared by : _____ Date:
Checked by : _____ Date:
Version 7.60
Sample
Jan 18,2017

Table of Contents

Caepipe — Sample Problem — Page 1

Analysis Options

Code : Piping code = B31.3 (2014)
Include axial force in stress calculations
Do not use liberal allowable stresses

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
Include Bourdon effect
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 Pipe
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. Fact.	In Pln SIF	OutPl 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					

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 Pipe
50	Anchor	T1		0.5					GCS

Version 7.60 — Sample — Jan 18,2017

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	6'0"	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)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load
1	600	200	0.8		

B31.3 (2014) 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	53892	29475	1.83
60	2204	17900	0.12	50	51451	29475	1.75
70	2133	17900	0.12	20A	48350	29475	1.64
30	2035	17900	0.11	20B	34221	29475	1.16
10	1446	17900	0.08	10	32730	29475	1.11
40B	1054	17900	0.06	80	27595	29475	0.94
20B	980	17900	0.05	40A	19059	29475	0.65
20A	938	17900	0.05	60	17805	29475	0.60
50	924	17900	0.05	70	12046	29475	0.41
40A	902	17900	0.05	40B	10375	29475	0.35

B31.3 (2014) Code Compliance

	Press.	Sustained			Expansion		
Node	Allow. (psi)	SL (psi)	SH (psi)	SL / SH	SE (psi)	SA (psi)	SE / SA
10	200	1446	17900	0.08	32730	29475	1.11
20A	2075	932	17900	0.05	28711	29475	0.97
20A	200	938	17900	0.05	48350	29475	1.64
20B	2075	980	17900	0.05	34221	29475	1.16
20B	200	968	17900	0.05	20053	29475	0.68
30	2075	1769	17900	0.10	53892	29475	1.83
30	200	1760	17900	0.10	48427	29475	1.64
40A	2075	902	17900	0.05	16060	29475	0.54
40A	200	902	17900	0.05	19059	29475	0.65
40B	2075	1054	17900	0.06	10375	29475	0.35
40B	200	1054	17900	0.06	9362	29475	0.32
50	2075	924	17900	0.05	51451	29475	1.75
30	200	2035	17900	0.11	38098	29475	1.29
60	1513	2204	17900	0.12	17805	29475	0.60
70	200	2133	17900	0.12	12046	29475	0.41
80	1513	2537	17900	0.14	27595	29475	0.94

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	0.608	0.620	1287	1445	12

Support load summary for anchor at node 10

							Displacements (global)		
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	X (inch)	Y (inch)	Z (inch)
Sustained	-14	-397	26	-375	-174	-1156	0.000	0.000	0.000
Operating1	-29243	1485	-14077	-6953	59111	16505	0.000	0.000	0.000
Maximum	-14	1485	26	-375	59111	16505	0.000	0.000	0.000
Minimum	-29243	-397	-14077	-6953	-174	-1156	0.000	0.000	0.000
Allowables	0	0	0	0	0	0	0.000	0.000	0.000

Support load summary for anchor at node 50

							Displacements (global)		
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)	X (inch)	Y (inch)	Z (inch)
Sustained	-42	-201	-27	126	107	-90	0.000	0.000	0.000

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)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Operating1	-18158	-4327	12813	49283	13548	91086	0.000	0.500	0.000
Maximum	-42	-201	12813	49283	13548	91086	0.000	0.500	0.000
Minimum	-18158	-4327	-27	126	107	-90	0.000	0.000	0.000
Allowables	0	0	0	0	0	0	0.000	0.000	0.000

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)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Sustained	55	-378	1	-23	17	965	0.000	0.000	0.000
Operating1	47401	1709	1264	-1601	5218	-11457	0.000	0.000	0.000
Maximum	47401	1709	1264	-23	5218	965	0.000	0.000	0.000
Minimum	55	-378	1	-1601	17	-11457	0.000	0.000	0.000
Allowables	0	0	0	0	0	0	0.000	0.000	0.000

Support load summary for hanger at node 30

Load combination	Load (lb)	Displacements (global) X (inch)	Y (inch)	Z (inch)
Sustained	-1444	0.000	0.004	0.002
Operating1	-1287	-0.617	0.608	-0.055
Maximum	-1287	0.000	0.608	0.002
Minimum	-1444	-0.617	0.004	-0.055

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	-1156
50		-42	-201	-27	126	107	-90
80		55	-378	1	-23	17	965

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (lb)	No.of	Total (lb)
30		Grinnell	-1444	1	-1444

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

Node	Axial (lb)	y Shear (lb)	z Shear (lb)	Torque (ft-lb)	Inplane(ft-lb) Moment	SIF	Outplane(ft-lb) Moment	SIF	SL (psi)
10	-14	-397	26	-375	-1156		-174		1446
20A	-14	132	26	-375	-100		35		932
20A	-14	26	-132	-375	-35	1.75	-100	1.46	938
20B	26	14	-236	-270	-75	1.75	177	1.46	980
20B	26	236	14	-270	177		75		968
30	26	567	14	-270	-1831		144		1769
30	27	-550	-42	340	-1808		143		1760
40A	27	-252	-42	340	-3		-44		902
40A	27	252	42	340	3	1.33	44	1.11	902
40B	97	-27	42	107	-250	1.33	-277	1.11	1054
40B	97	-42	-27	107	-277		250		1054
50	-201	-42	-27	107	-90		126		924
30	-55	-327	-1	23	-610		1		2035
60	-55	-119	-1	23	730		-7		2204
70	-55	170	-1	23	679		-10		2133
80	-55	378	-1	23	-965		-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	-55	-94	-1	23	-7	755
70		-55	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	1156
20A	-14	132	26	-375	35	-100
20A	14	-132	-26	375	-35	100
20B	-14	236	26	-177	75	-270
20B	14	-236	-26	177	-75	270
30	-14	567	26	1831	144	-270
30	-42	550	-27	-1808	-143	-340
40A	42	-252	27	3	-44	340
40A	-42	252	-27	-3	44	-340
40B	42	-97	27	-250	-107	277
40B	-42	97	-27	250	107	-277
50	42	201	27	-126	-107	90
30	55	327	1	-23	-1	610
60	-55	-119	-1	23	-7	730
70	55	-170	1	-23	10	-679
80	-55	378	-1	23	-17	-965

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	55	94	1	-23	7	-755
70		-55	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	-0.0058
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	0.0023
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		-29229	1882	-14103	-6578	59285	17661
50		-18116	-4126	12841	49157	13441	91175
80		47345	2087	1262	-1578	5201	-12423

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)	Torque (ft-lb)	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	SE (psi)
10	-29229	1882	-14103	-6578	17661		59285		32730
20A	-29229	1882	-14103	-6578	2608		-53541		28711
20A	-29229	-14103	-1882	-6578	53541	1.75	2608	1.46	48350
20B	-14103	29229	-1882	727	38415	1.75	4696	1.46	34221
20B	-14103	1882	29229	727	4696		-38415		20053
30	-14103	1882	29229	727	-4712		107729		53892
30	-12841	4126	-18116	17523	-3134		95257		48427
40A	-12841	4126	-18116	17523	-21700		13733		16060
40A	-12841	-4126	18116	17523	21700	1.33	-13733	1.11	19059
40B	-4126	12841	18116	13441	8627	1.33	9652	1.11	10375
40B	-4126	-18116	12841	13441	9652		-8627		9362
50	-4126	-18116	12841	13441	91175		49157		51451
30	-47345	-2087	-1262	1578	-16796		12472		38098
60	-47345	-2087	-1262	1578	-4274		4898		17805
70	-47345	-2087	-1262	1578	-100		2373		12046
80	-47345	-2087	-1262	1578	12423		-5201		27595

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	-47345	-2087	-1262	1578	4898	-4274
70		-47345	-2087	-1262	1578	2373	-100

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	29229	-1882	14103	6578	-59285	-17661
20A	-29229	1882	-14103	-6578	-53541	2608
20A	29229	-1882	14103	6578	53541	-2608
20B	-29229	1882	-14103	-4696	-38415	727
20B	29229	-1882	14103	4696	38415	-727
30	-29229	1882	-14103	4712	107729	727
30	-18116	-4126	12841	-3134	-95257	-17523
40A	18116	4126	-12841	21700	13733	17523
40A	-18116	-4126	12841	-21700	-13733	-17523
40B	18116	4126	-12841	8627	-13441	-9652
40B	-18116	-4126	12841	-8627	13441	9652
50	18116	4126	-12841	-49157	-13441	-91175
30	47345	2087	1262	-1578	-12472	16796
60	-47345	-2087	-1262	1578	4898	-4274
70	47345	2087	1262	-1578	-2373	100
80	-47345	-2087	-1262	1578	-5201	12423

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	47345	2087	1262	-1578	-4898	4274
70		-47345	-2087	-1262	1578	2373	-100

Displacements: Expansion (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

Displacements: Expansion (T1)

Node	Displacements (global) X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
20A	0.370	0.227	-0.404	-0.1813	0.0609	0.2149
20B	0.291	0.324	-0.291	-0.2556	-0.9122	0.2599
30	-0.618	0.604	-0.057	-0.2555	-0.4529	0.2724
40A	-0.648	0.795	0.153	-0.1074	0.1971	0.5441
40B	-0.373	0.712	0.178	0.2418	0.2084	0.6014
50	0.000	0.500	0.000	0.0000	0.0000	0.0001
60	-0.355	0.467	0.136	-0.1330	0.0660	-0.3570
70	-0.263	0.314	0.103	-0.1225	0.0845	-0.3681
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		-29243	1485	-14077	-6953	59111	16505
50		-18158	-4327	12813	49283	13548	91086
80		47401	1709	1264	-1601	5218	-11457

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)	Torque (ft-lb)	Inplane(ft-lb) Moment	Inplane(ft-lb) SIF	Outplane(ft-lb) Moment	Outplane(ft-lb) SIF	Sopr (psi)
10	-29243	1485	-14077	-6953	16505		59111		28806
20A	-29243	2014	-14077	-6953	2508		-53506		25012
20A	-29243	-14077	-2014	-6953	53506	1.75	2508	1.46	44617
20B	-14077	29243	-2118	456	38340	1.75	4873	1.46	32823
20B	-14077	2118	29243	456	4873		-38340		18680
30	-14077	2449	29243	456	-6543		107873		52663
30	-12813	3576	-18158	17863	-4942		95400		47432
40A	-12813	3873	-18158	17863	-21703		13689		15163
40A	-12813	-3873	18158	17863	21703	1.33	-13689	1.11	18095
40B	-4029	12813	18158	13548	8377	1.33	9374	1.11	10541
40B	-4029	-18158	12813	13548	9374		-8377		9594
50	-4327	-18158	12813	13548	91086		49283		51652
30	-47401	-2414	-1264	1601	-17406		12473		23021
60	-47401	-2207	-1264	1601	-3544		4891		1516
70	-47401	-1917	-1264	1601	579		2364		3195
80	-47401	-1709	-1264	1601	11457		-5218		10616

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	-47401	-2182	-1264	1601	4891	-3519
70		-47401	-1942	-1264	1601	2364	604

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	29243	-1485	14077	6953	-59111	-16505
20A	-29243	2014	-14077	-6953	-53506	2508

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)
20A	29243	-2014	14077	6953	53506	-2508
20B	-29243	2118	-14077	-4873	-38340	456
20B	29243	-2118	14077	4873	38340	-456
30	-29243	2449	-14077	6543	107873	456
30	-18158	-3576	12813	-4942	-95400	-17863
40A	18158	3873	-12813	21703	13689	17863
40A	-18158	-3873	12813	-21703	-13689	-17863
40B	18158	4029	-12813	8377	-13548	-9374
40B	-18158	-4029	12813	-8377	13548	9374
50	18158	4327	-12813	-49283	-13548	-91086
30	47401	2414	1264	-1601	-12473	17406
60	-47401	-2207	-1264	1601	4891	-3544
70	47401	1917	1264	-1601	-2364	-579
80	-47401	-1709	-1264	1601	-5218	11457

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	47401	2182	1264	-1601	-4891	3519
70		-47401	-1942	-1264	1601	2364	604

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	0.370	0.219	-0.402	-0.1917	0.0595	0.2091
20B	0.290	0.317	-0.289	-0.2686	-0.9127	0.2532
30	-0.617	0.608	-0.055	-0.2593	-0.4519	0.2611
40A	-0.647	0.797	0.155	-0.1017	0.1988	0.5381
40B	-0.372	0.712	0.179	0.2440	0.2101	0.5992
50	0.000	0.500	0.000	0.0000	0.0000	0.0001
60	-0.355	0.455	0.136	-0.1350	0.0668	-0.3586
70	-0.263	0.302	0.104	-0.1244	0.0853	-0.3658
80	0.000	0.000	0.000	0.0000	0.0000	0.0000

Weight & Center of gravity

Empty weight = 1601.2 (lb)
Insulation weight = 267.8 (lb)
Content weight = 550.32 (lb)
Lining weight = 0 (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