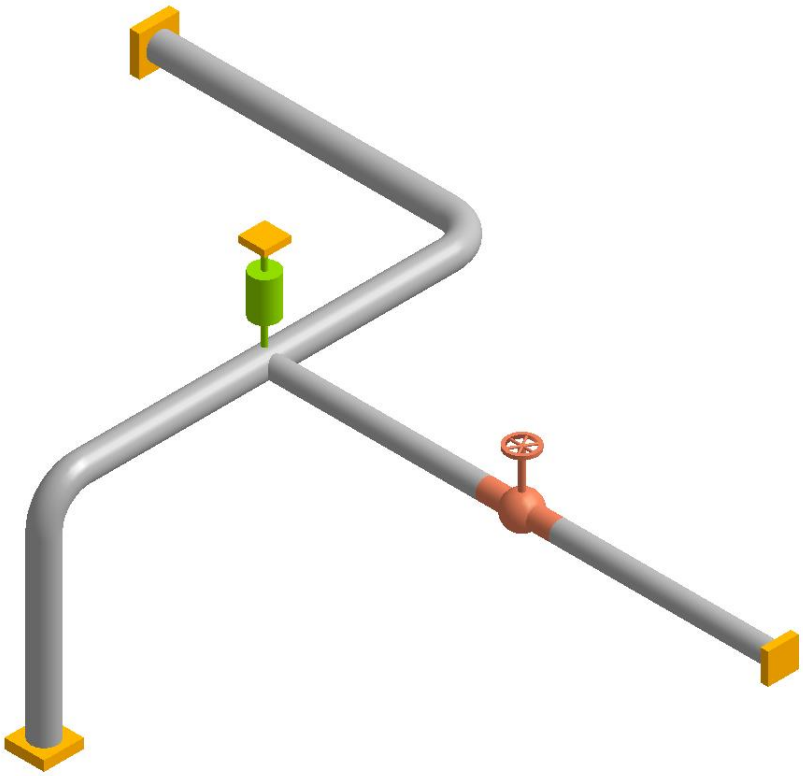
CAEPIPE™

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:

SST Systems, Inc.
5674 Stoneridge Drive, Suite 107
Pleasanton, CA 94588, USA

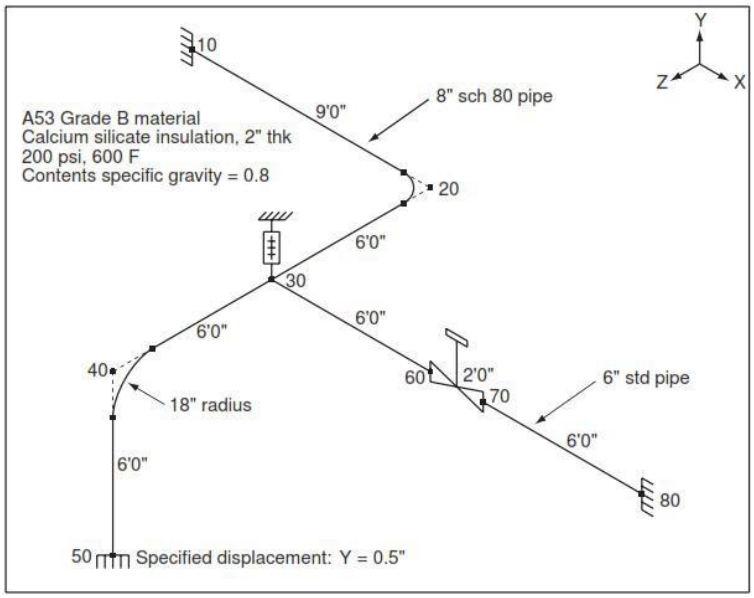
Tel: (408) 452 8111
Fax: (408) 452 8388

email: info@sstusa.com

www.sstusa.com

Tutorial for Modeling and Results Review – Problem 1

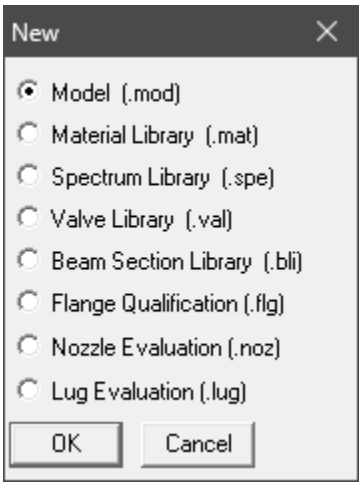
The best way to learn CAEPIPE is to try it yourself. In this tutorial we will create a simple model to help you understand the use of CAEPIPE. The details of the model are shown below:



You will learn how to:

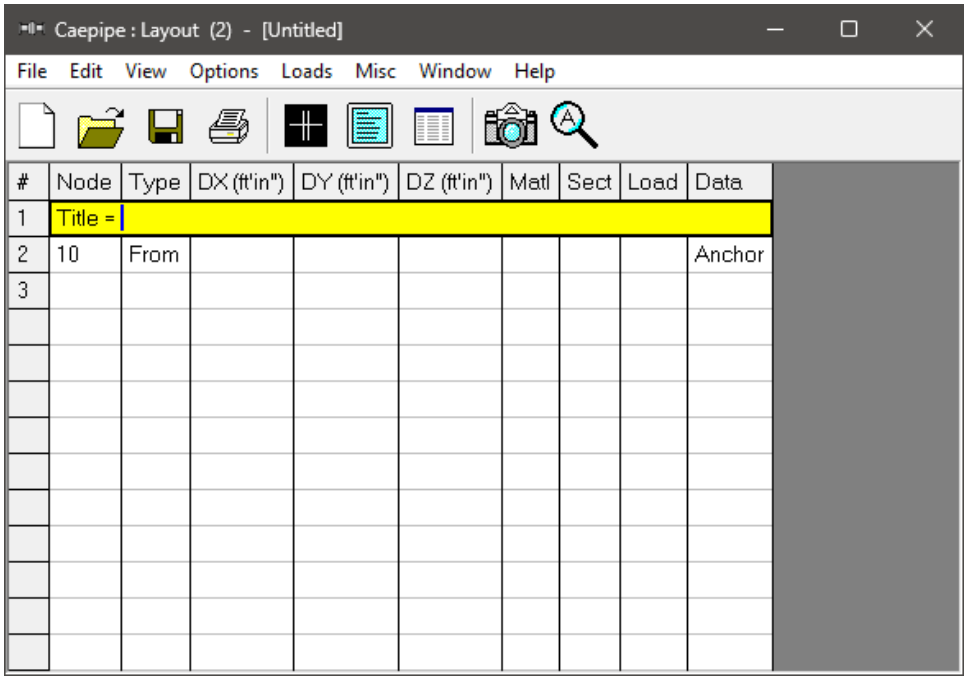
1. Enter Title
2. Select Analysis options (piping code etc.)
3. Define Material, Section and Loads for the model
4. Input Model Layout
5. Select Load Cases for Analysis
6. Analyze
7. View Results

Start CAEPIPE. Click on the option "File > New" from the layout window. The "New file" dialog opens.

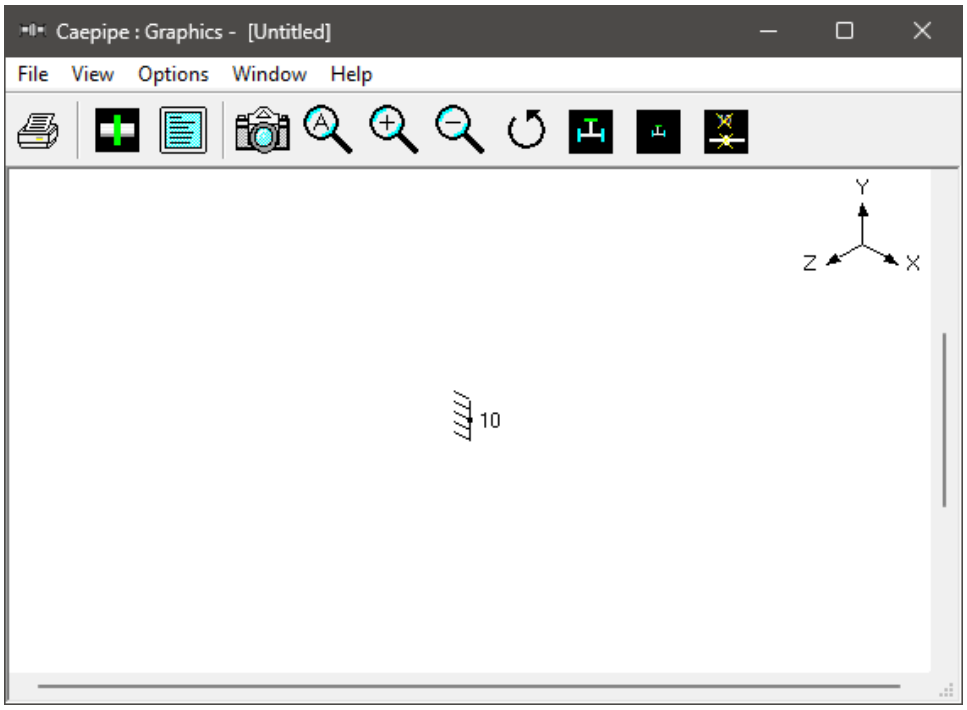


From the "New file" dialog, select the type of the new file as "Model (.mod)" file. This opens two independent windows: "Layout" and "Graphics".

Layout window



Graphics window



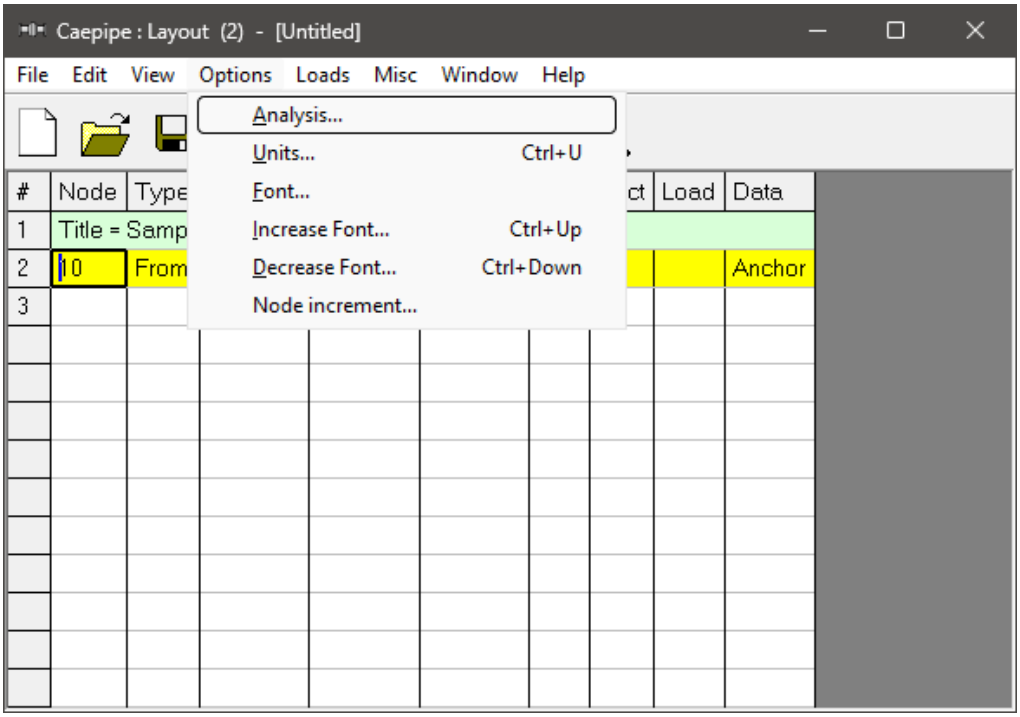
Adjust the size of the windows to fit your desktop such that you can view both comfortably at the same time.

1. Enter Title

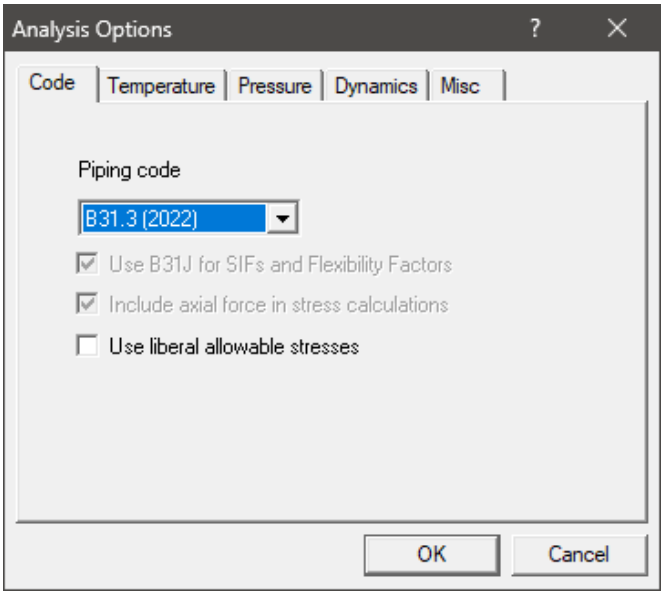
Type "Sample Problem" as the title in the first row that contains "Title =". Press Enter.

2. Select Analysis options (piping code etc.)

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



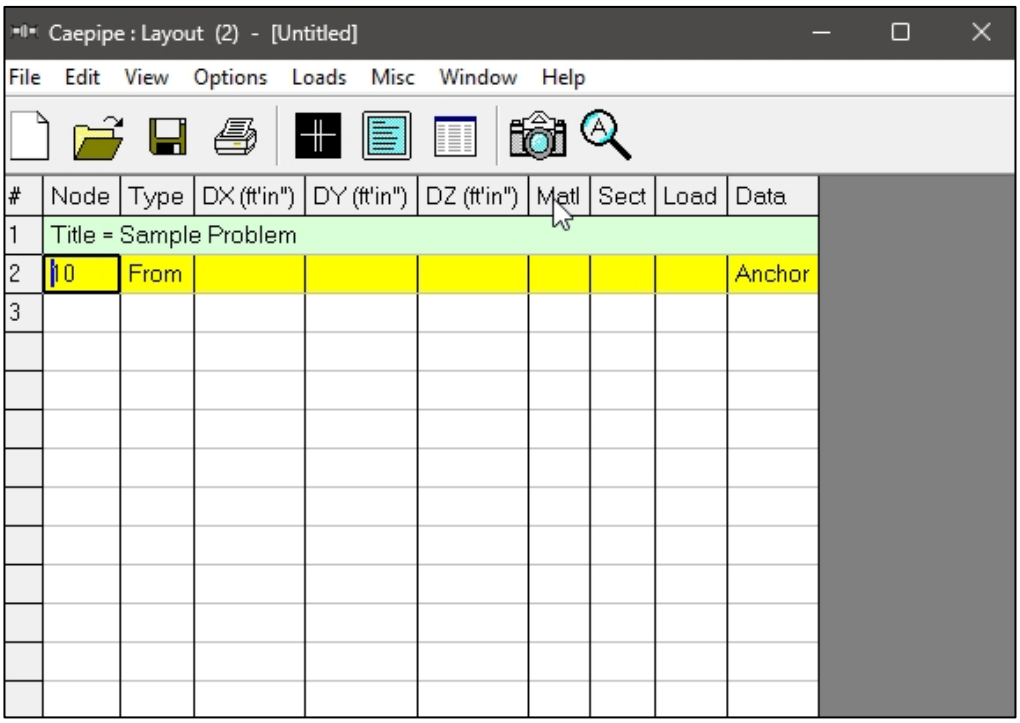
This opens the "Analysis" Options dialog.



On the Code property page, select "B31.3 (2022)" for Piping code. Then click on "OK" to close "Analysis Options" dialog.

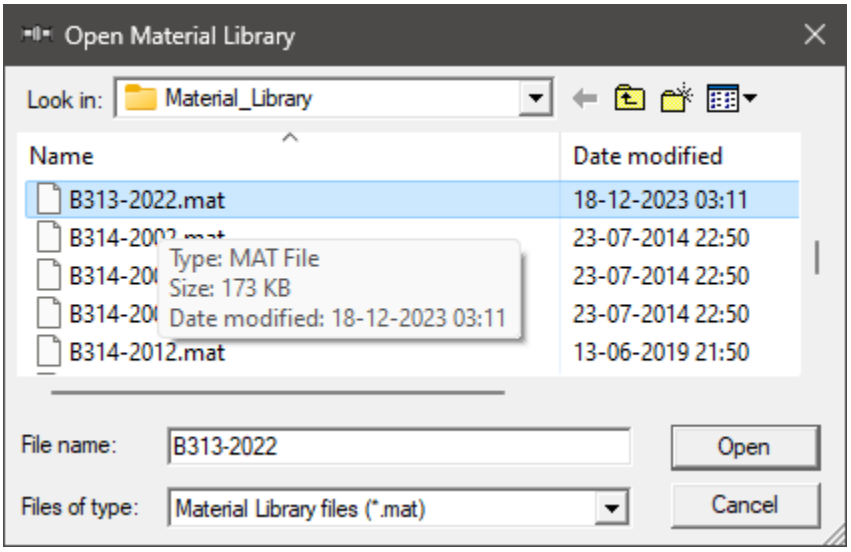
3. Define Material, Sections and Load Material

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

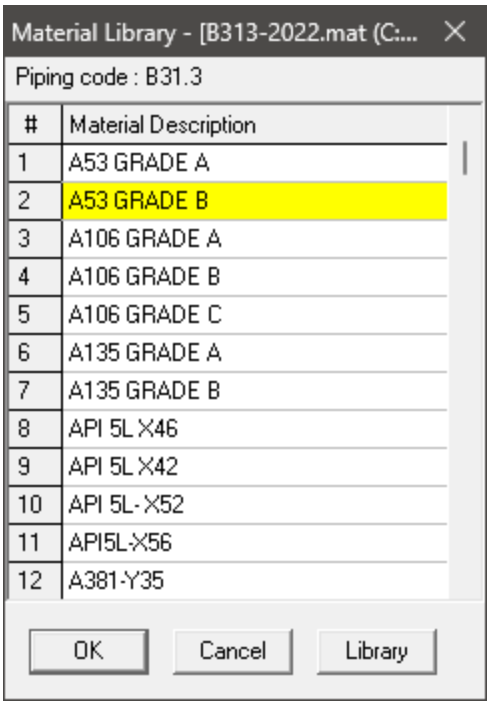


This opens up the "Materials" list in a separate "List" window. Position and resize the list window as you desire. Click on "Library" button on the "Toolbar" (or choose File > Library).

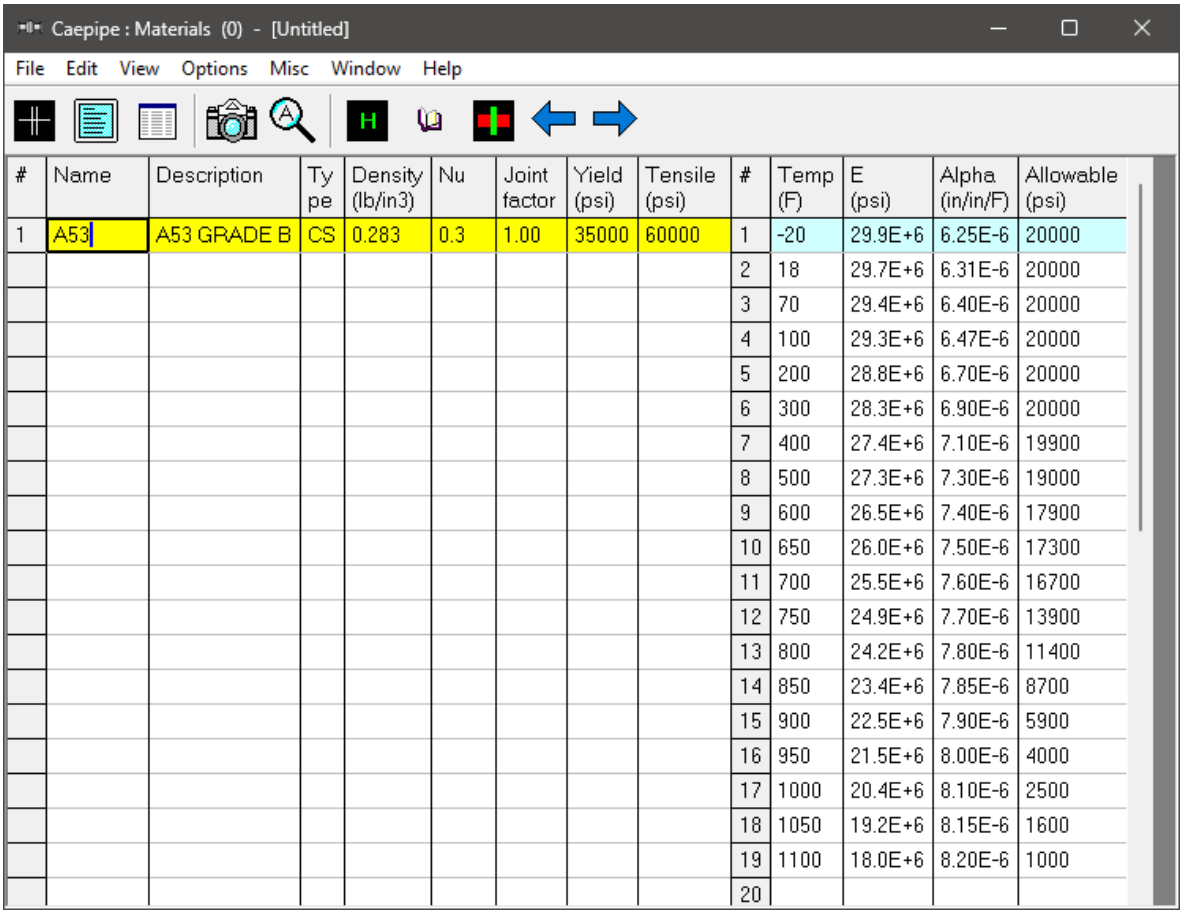
The "Open Material Library" dialog is shown



Select "B313-2022.mat" as the library file to open by double clicking on it. The available materials in the library are shown.



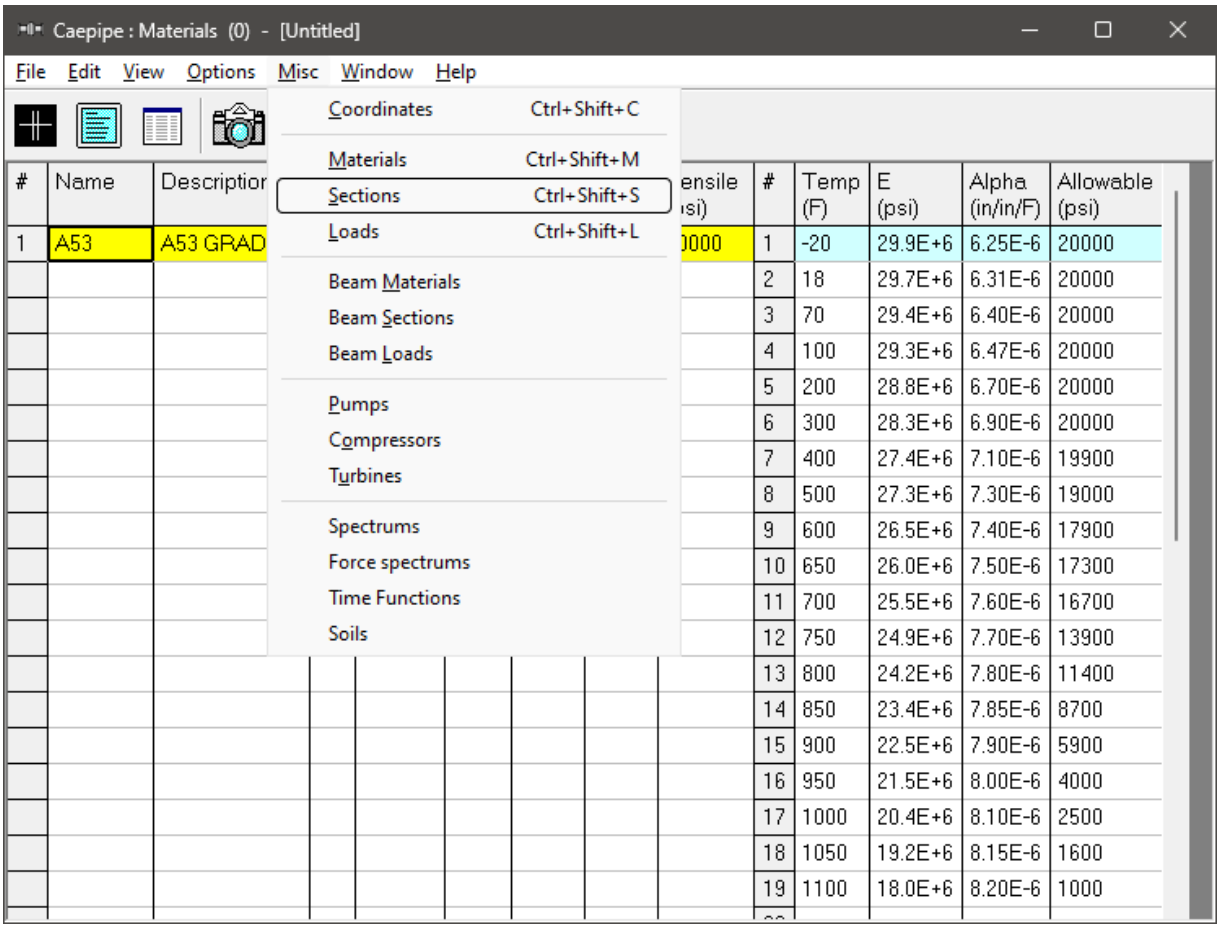
Double click on "A53 Grade B" material to select it. The properties for this material are transferred to the material in the List window. Type "A53" for material name and then press "Enter".



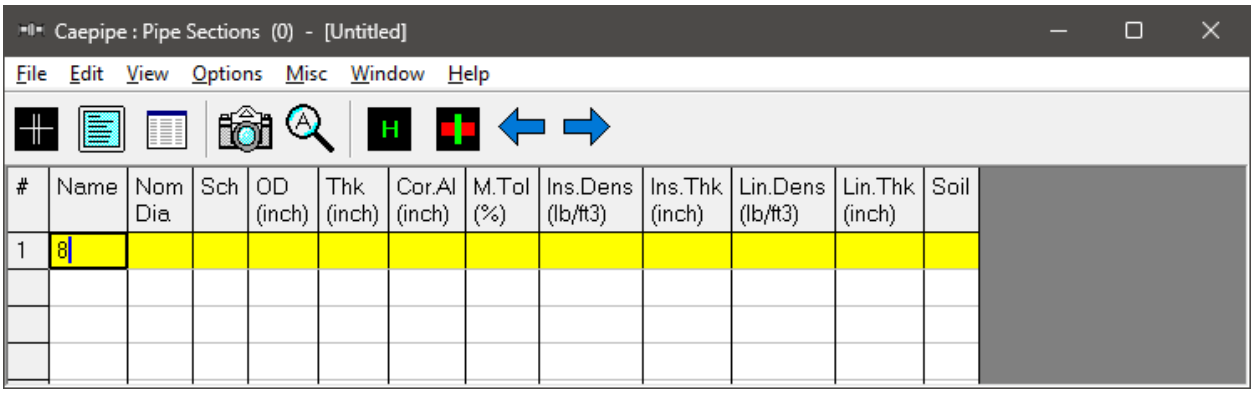
#	Name	Description	Type	Density (lb/in3)	Nu	Joint factor	Yield (psi)	Tensile (psi)	#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	A53	A53 GRADE B	CS	0.283	0.3	1.00	35000	60000	1	-20	29.9E+6	6.25E-6	20000
									2	18	29.7E+6	6.31E-6	20000
									3	70	29.4E+6	6.40E-6	20000
									4	100	29.3E+6	6.47E-6	20000
									5	200	28.8E+6	6.70E-6	20000
									6	300	28.3E+6	6.90E-6	20000
									7	400	27.4E+6	7.10E-6	19900
									8	500	27.3E+6	7.30E-6	19000
									9	600	26.5E+6	7.40E-6	17900
									10	650	26.0E+6	7.50E-6	17300
									11	700	25.5E+6	7.60E-6	16700
									12	750	24.9E+6	7.70E-6	13900
									13	800	24.2E+6	7.80E-6	11400
									14	850	23.4E+6	7.85E-6	8700
									15	900	22.5E+6	7.90E-6	5900
									16	950	21.5E+6	8.00E-6	4000
									17	1000	20.4E+6	8.10E-6	2500
									18	1050	19.2E+6	8.15E-6	1600
									19	1100	18.0E+6	8.20E-6	1000
									20				

Sections

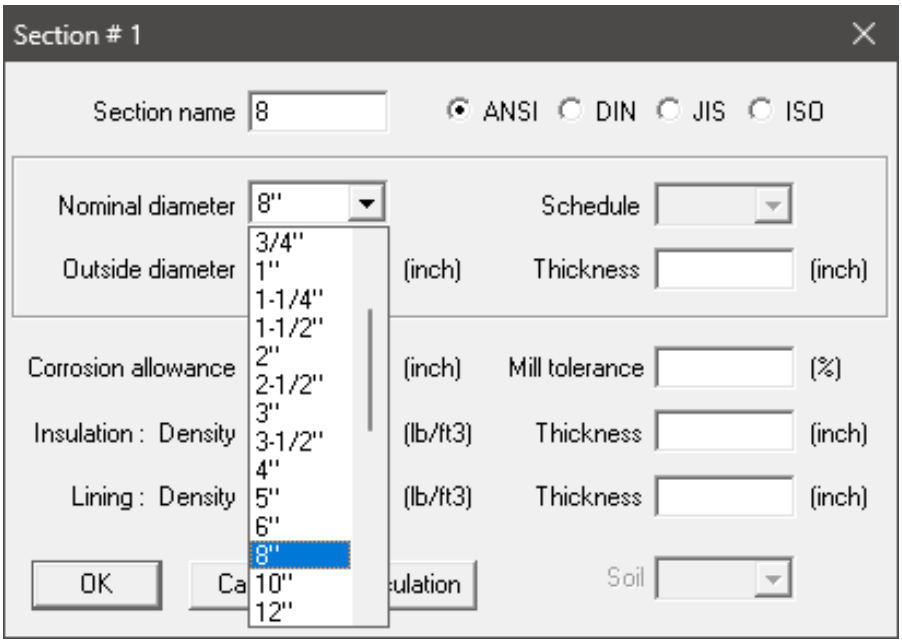
Select "Sections" from the "Misc" menu of the List window (or press "Ctrl+Shift+S").



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.

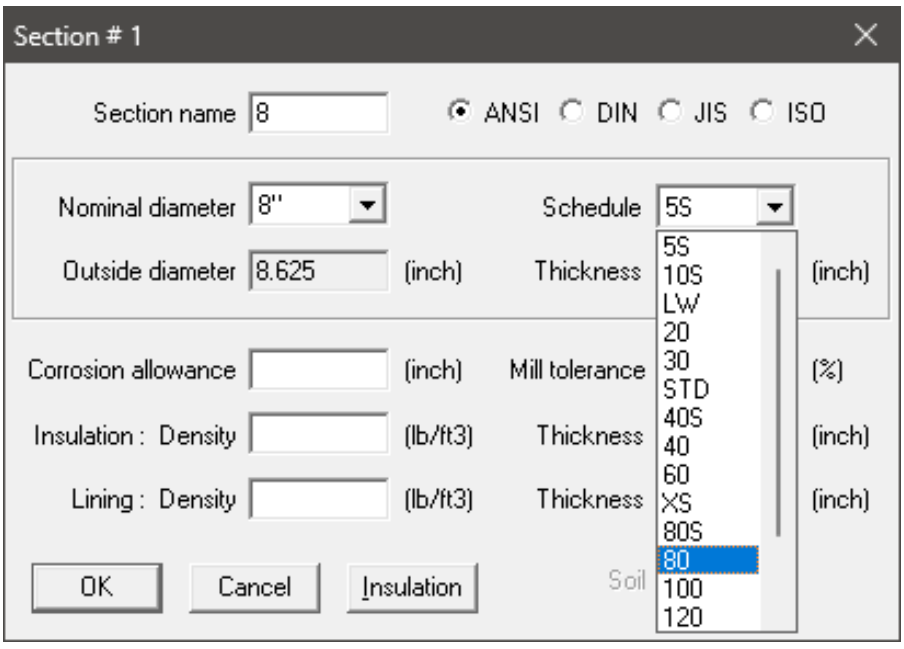


The Section Properties dialog ("Section #1") is shown with the section name 8.



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.

Insulation Densities

Insulation Material	Density (lb/ft3)
Amosite Asbestos	16
Calcium Silicate	15
Careytemp	10
Cellular Glass	9
Fiberglass	7
High Temperature	24
Kaylo 10	12.5
Mineral Wool	8.5
Perlite	13
Poly Urethane	2.2
Styro Foam	1.8
Super-X	25

OK Cancel

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.

Caepipe : Pipe Sections (1) - [Untitled]

File Edit View Options Misc Window Help

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	8	8"	80	8.625	0.5			15	2			
2												

Now repeat the process for the second section.

Caepipe : Pipe Sections (2) - [Untitled]

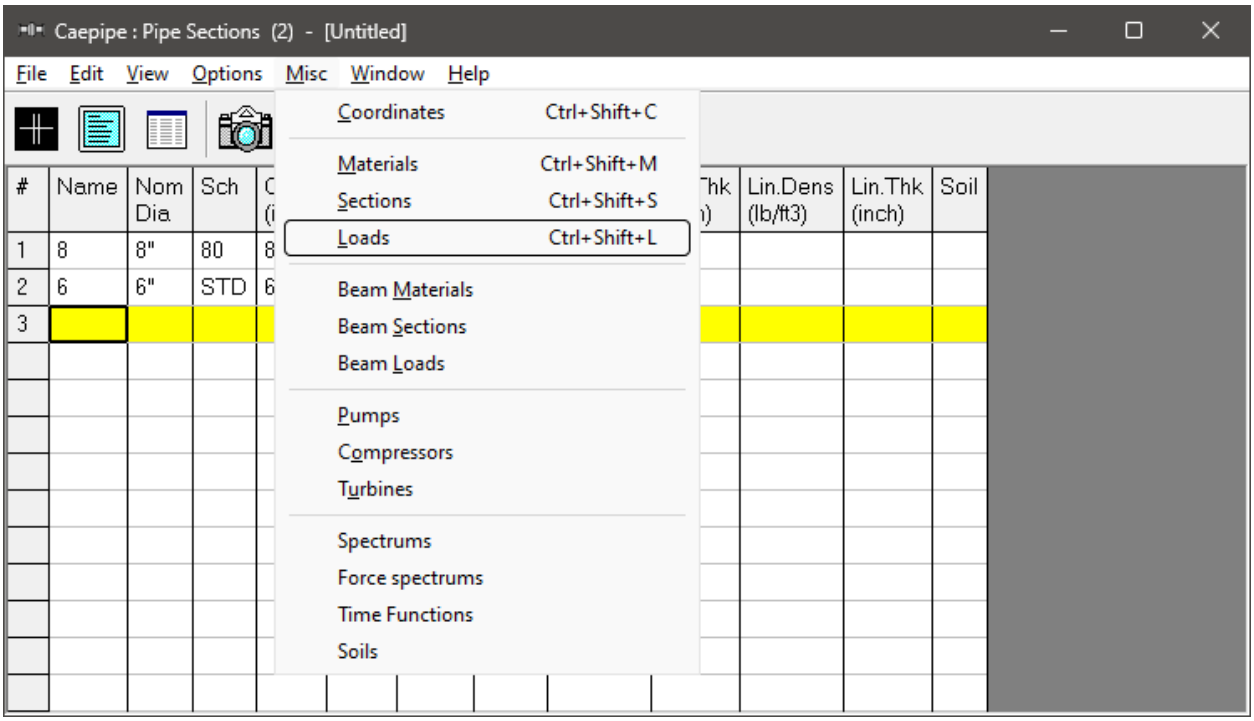
File Edit View Options Misc Window Help

#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	8	8"	80	8.625	0.5			15	2			
2	6	6"	STD	6.625	0.28			15	2			
3												

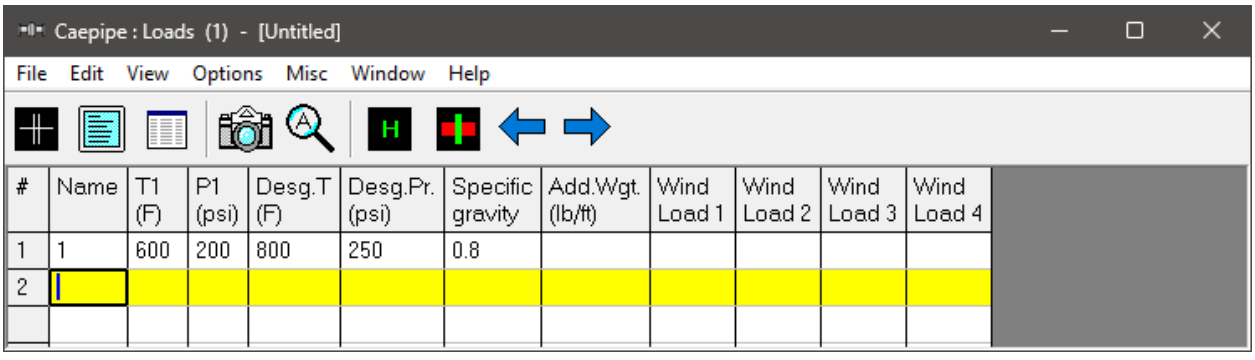
In row # 2, type 6 for section "Name" and press Enter. The "Section Properties" dialog is shown with the section name "6". Select 6" for "Nominal diameter", STD for "Schedule" and 2" Calcium Silicate for "Insulation". Press "Enter" or click on "OK" to enter the second section.

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).



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.12.10", there is an additional load case for Design Pressure and Design Temperature that computes 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.

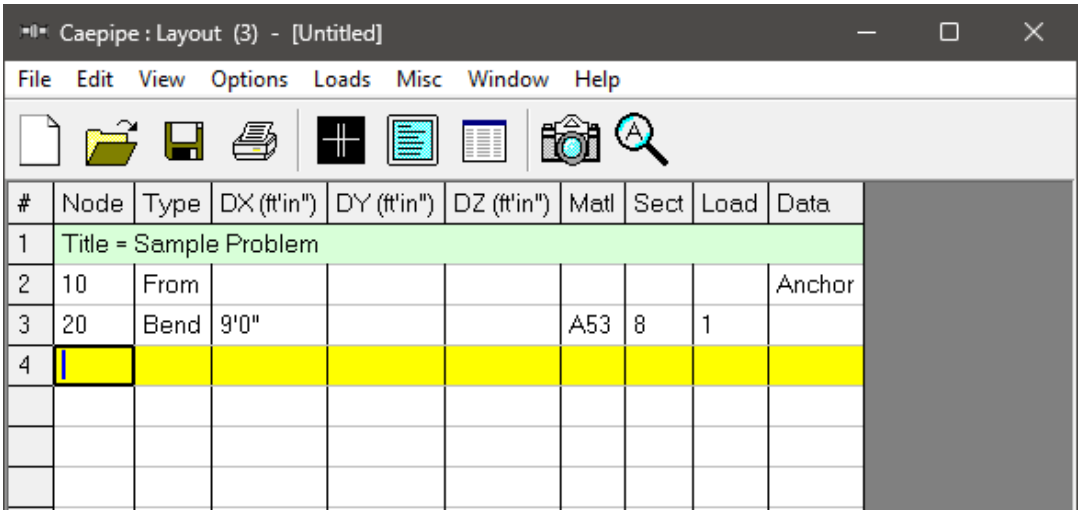
NOTE

- 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.

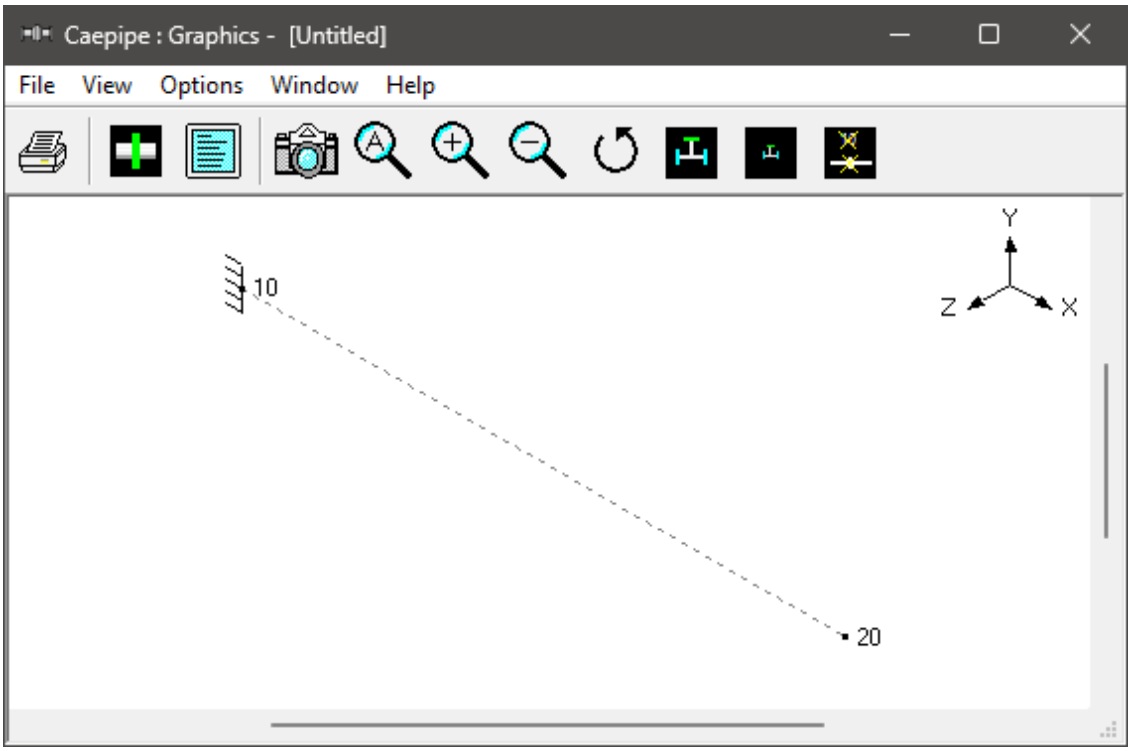
First the 8" header

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).

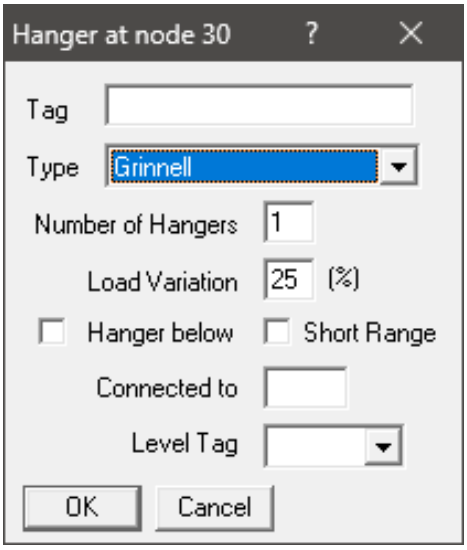


You will see the model in the graphics window as it is entered. You can press "F2" to switch between text and graphics windows.

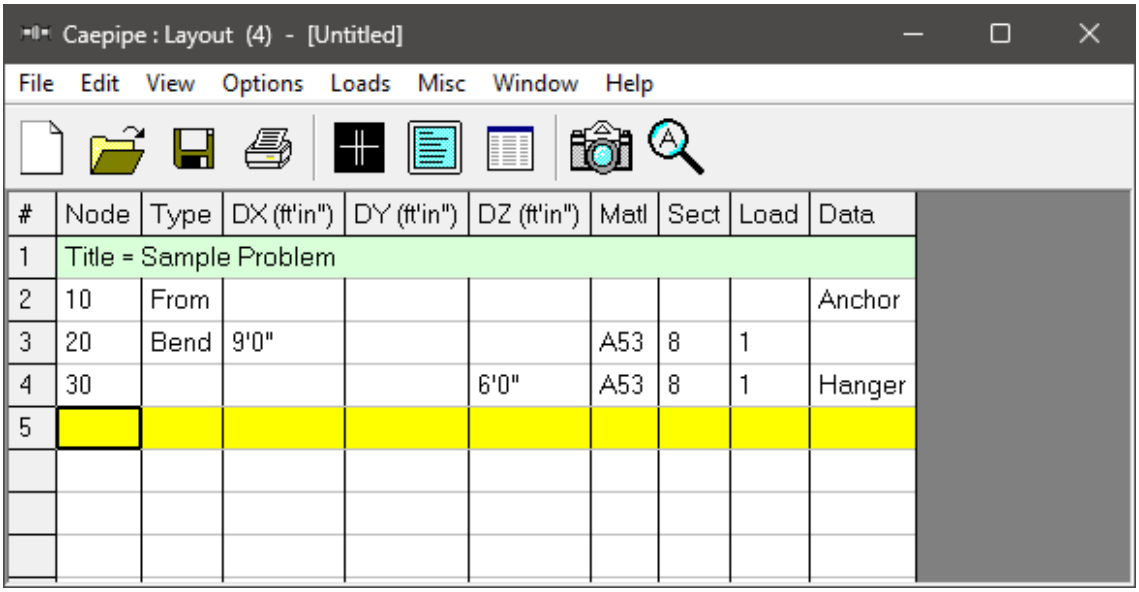


In row #4, Tab to the "Type" column. The next "Node" 30, is automatically assigned.

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.

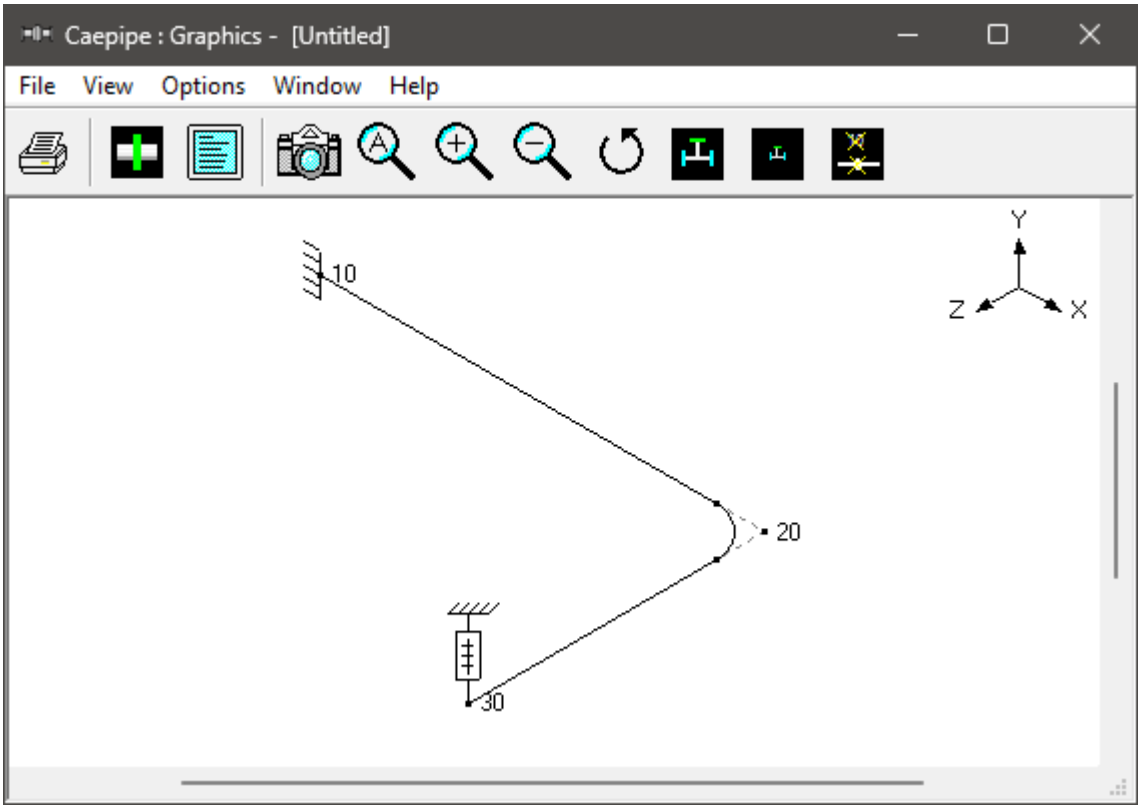


Press "Enter" or click on "OK" to input the hanger. The material, section and load are automatically inserted (based on the previous row's material, section and load), and the cursor moves to the next row.

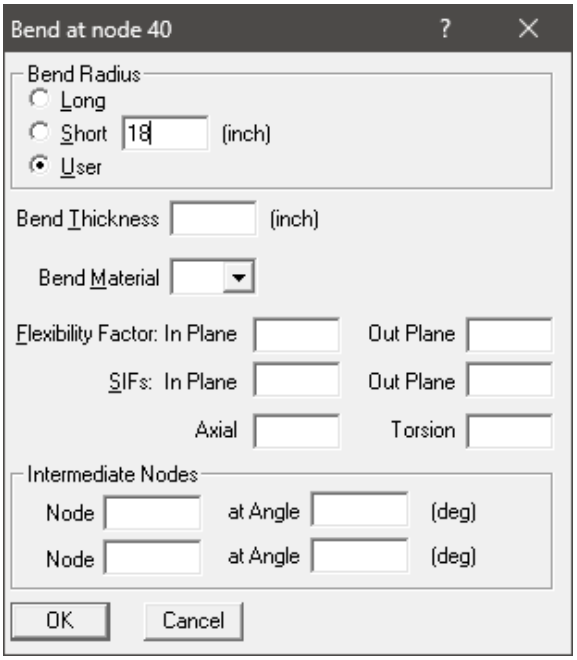


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5									

The Graphics window will look like this.



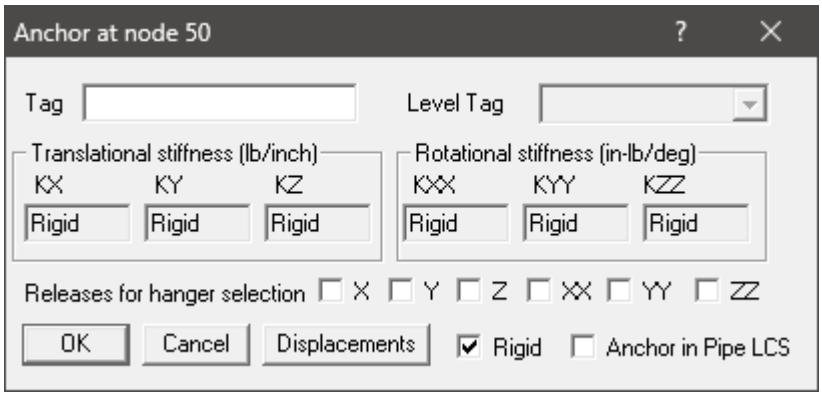
In row #5, Tab to the "Type" column. The next "Node" 40, is automatically assigned. In the "Type" column, type "b" (for "Bend") and press Tab. This bend has a non-standard (user defined) bend radius. Therefore, the bend radius needs to be modified from the default long radius. Double click on the "Bend" in the "Type" column or press "Ctrl+T" to bring up the "Bend" dialog box. Click on "User" (Bend Radius > User) 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"). Anchor, material, section and load fields are automatically inserted, and the cursor moves to the next row.

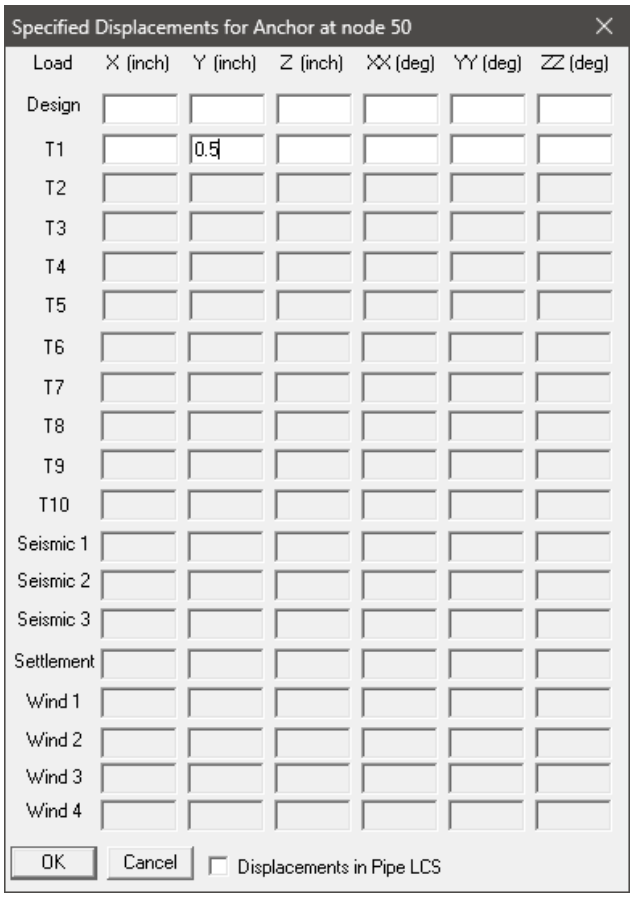
Let us specify a thermal anchor movement for the "Anchor" we just put in at node 50. Double click on the "Anchor" at node 50 in row #6. The "Anchor" dialog comes up.



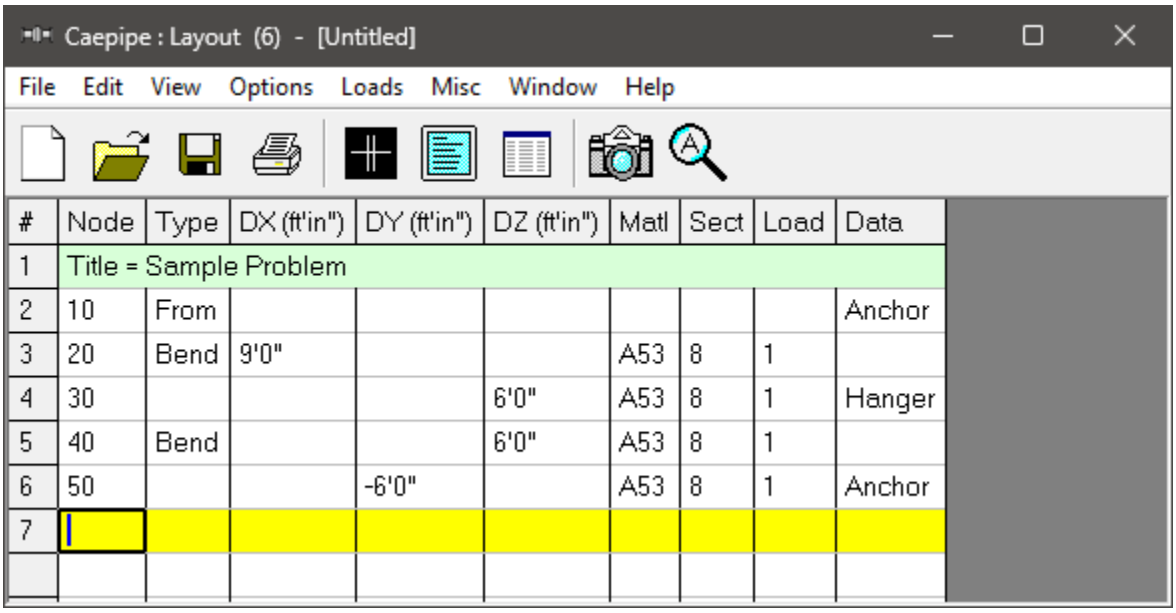
Note:

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.

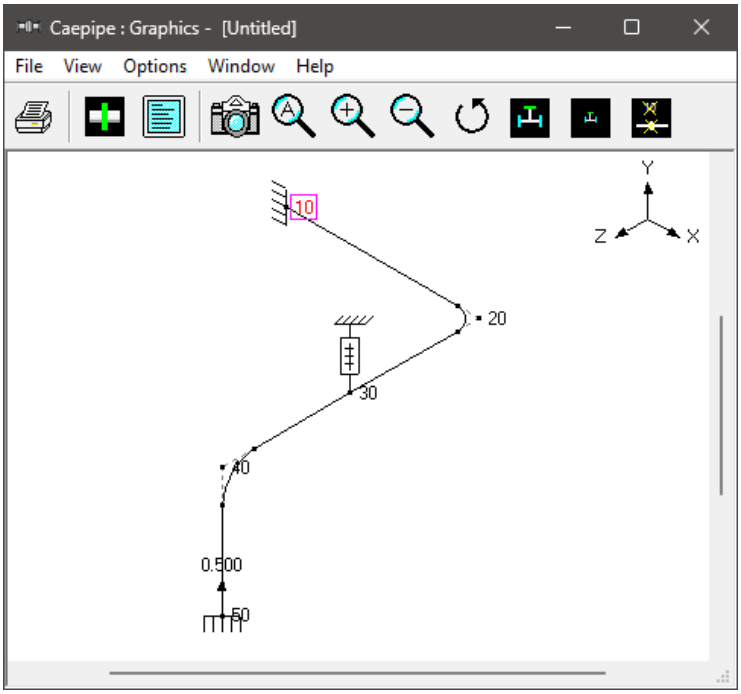


Press "Enter" to exit the "Specified Displacements" dialog. Press "Enter" again to exit the "Anchor" dialog. In the "Layout" window, press "Enter" to move to the next row.



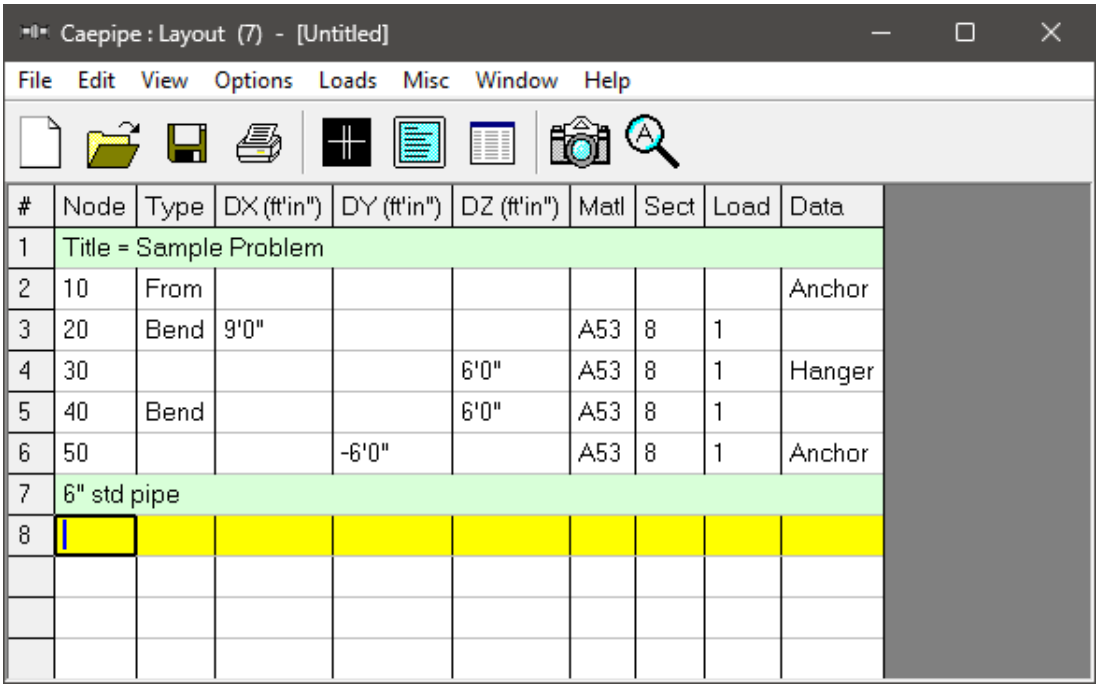
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7									

 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

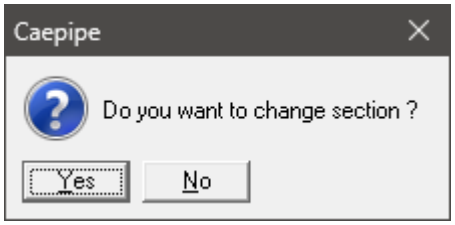
Let us input a comment saying that this is a 6" std pipe. On an empty row, if the first character in the Node field is input as "c", that row becomes a comment row. On row #7, type "c" to create the comment and then type: " 6" std pipe" and then press "Enter" to go to the next row.



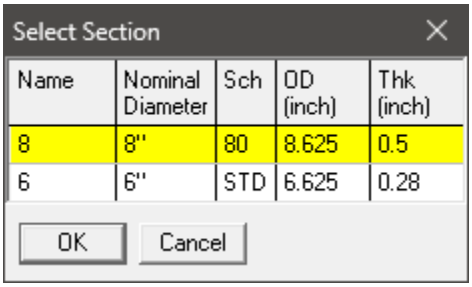
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8									

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".

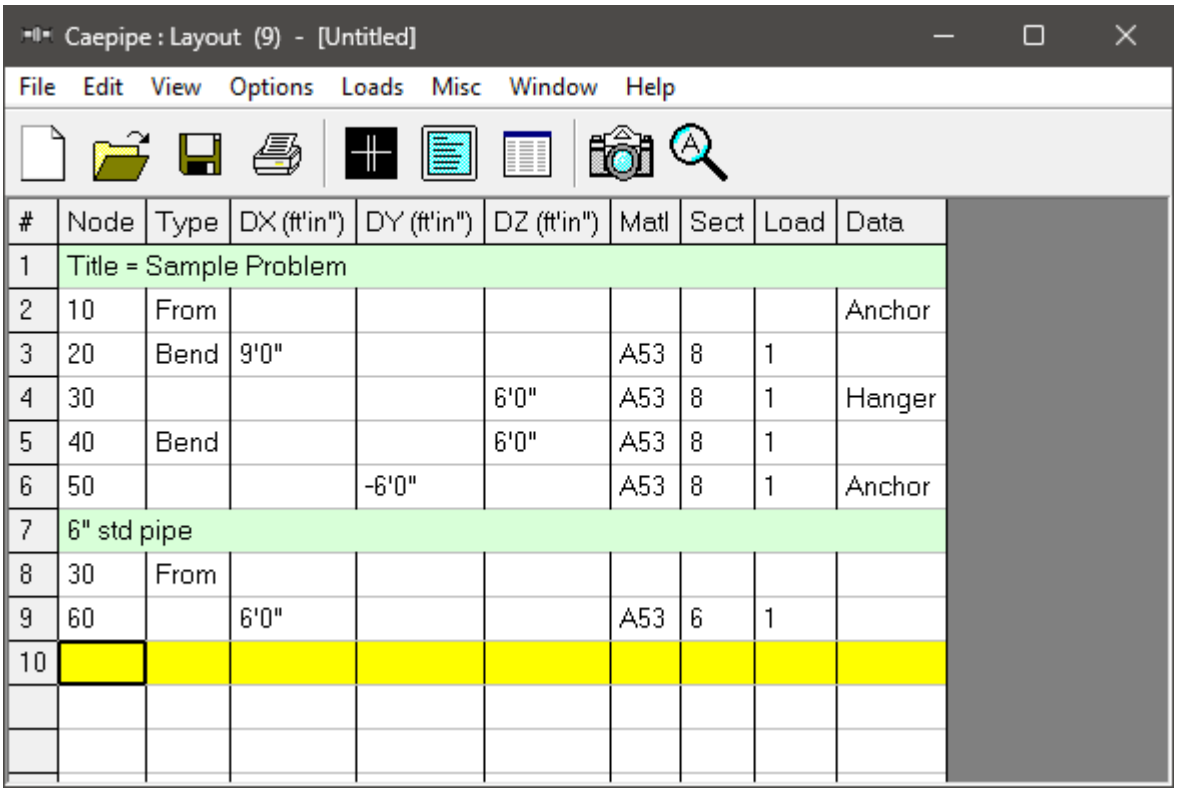
CAEPIPE inserts the previous material, and automatically detects the new branch and asks if you want to change section.



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

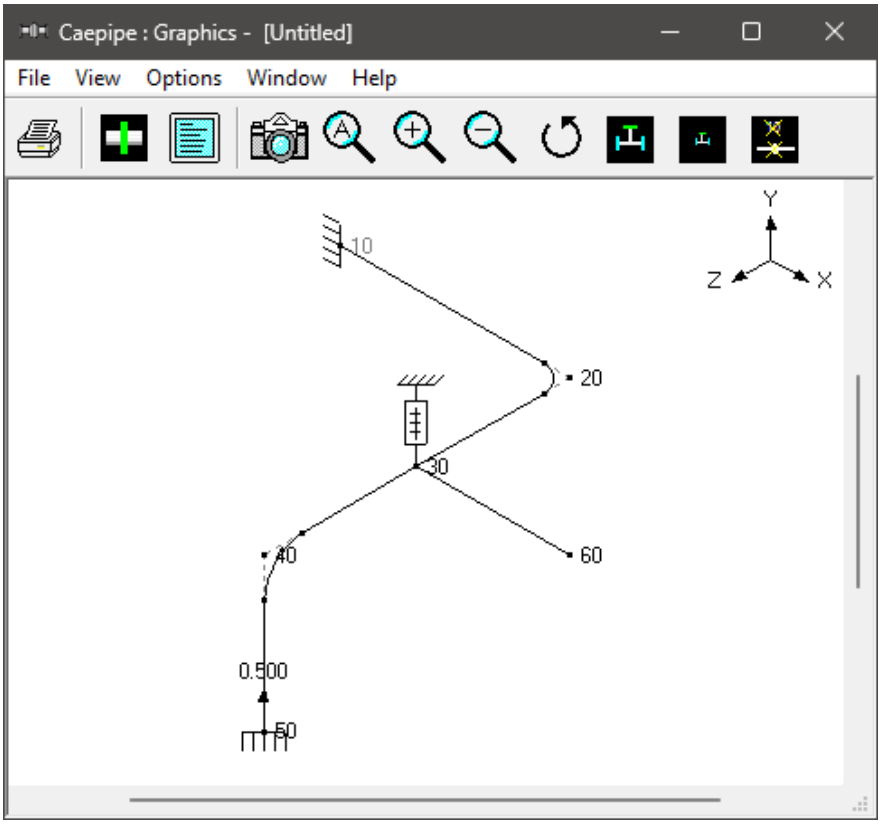


Select the 6" section by double clicking on it. The section (6) is entered in the "Section" column in the "Layout" window. Press "Enter" to go to the next row. The load is again automatically inserted from the previous load.

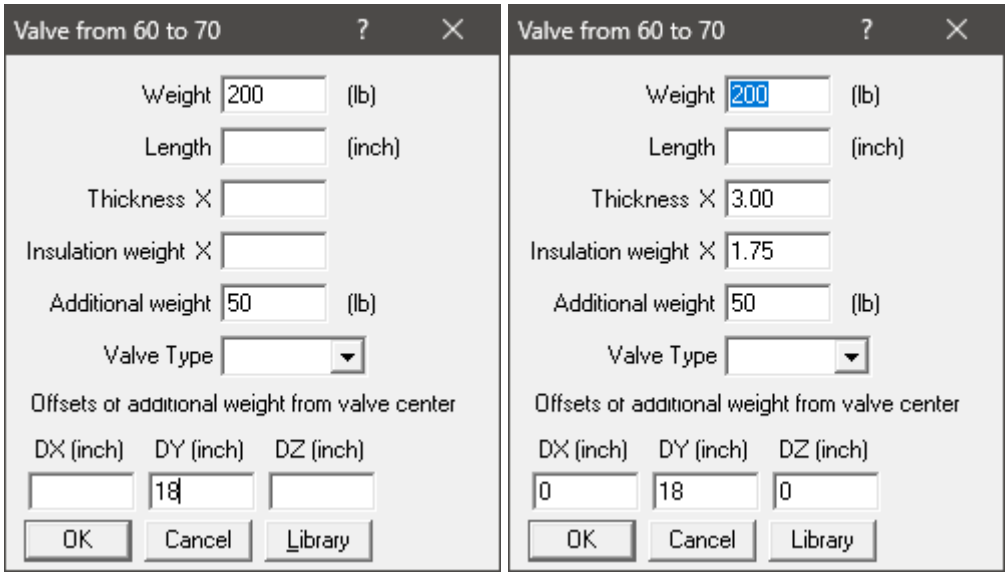


#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10									

The graphics window will look like this.



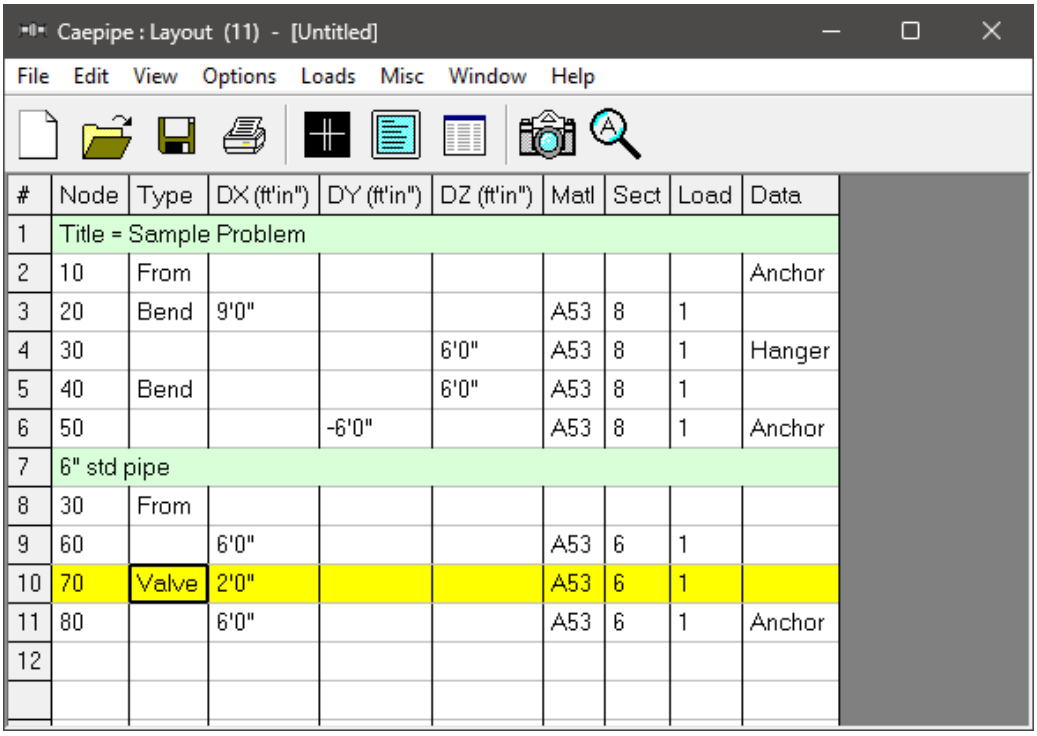
In the next row (#10), Tab to the "Type" column. The next "Node" 70, is automatically assigned. In the "Type" column, type "v" (for "Valve"). This brings up the "Valve" dialog box.



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. The "Thickness X" and "Insulation weight X" are automatically added as 3.00 and 1.75 by CAEPIPE as shown.

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.

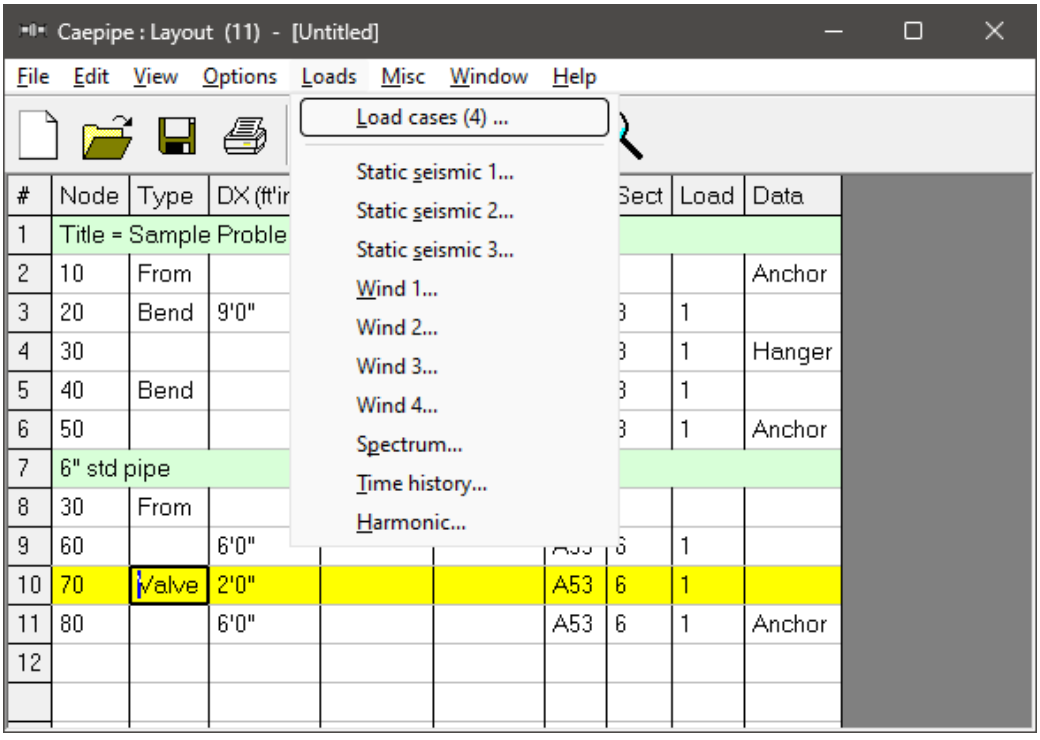
In the next row (#11), Tab to "DX". The next "Node" 80 is automatically assigned. In the "DX" column, type 6. Tab to "Data" or press "Ctrl+Shift+D" to move to the data column, then type "a" (for "Anchor"). Material, section and load are automatically inserted like before, and the cursor moves to the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



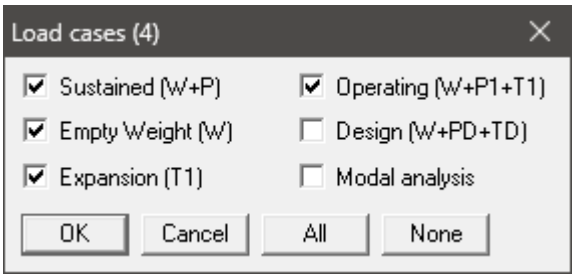
#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Sample Problem								
2	10	From							Anchor
3	20	Bend	9'0"			A53	8	1	
4	30				6'0"	A53	8	1	Hanger
5	40	Bend			6'0"	A53	8	1	
6	50			-6'0"		A53	8	1	Anchor
7	6" std pipe								
8	30	From							
9	60		6'0"			A53	6	1	
10	70	Valve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

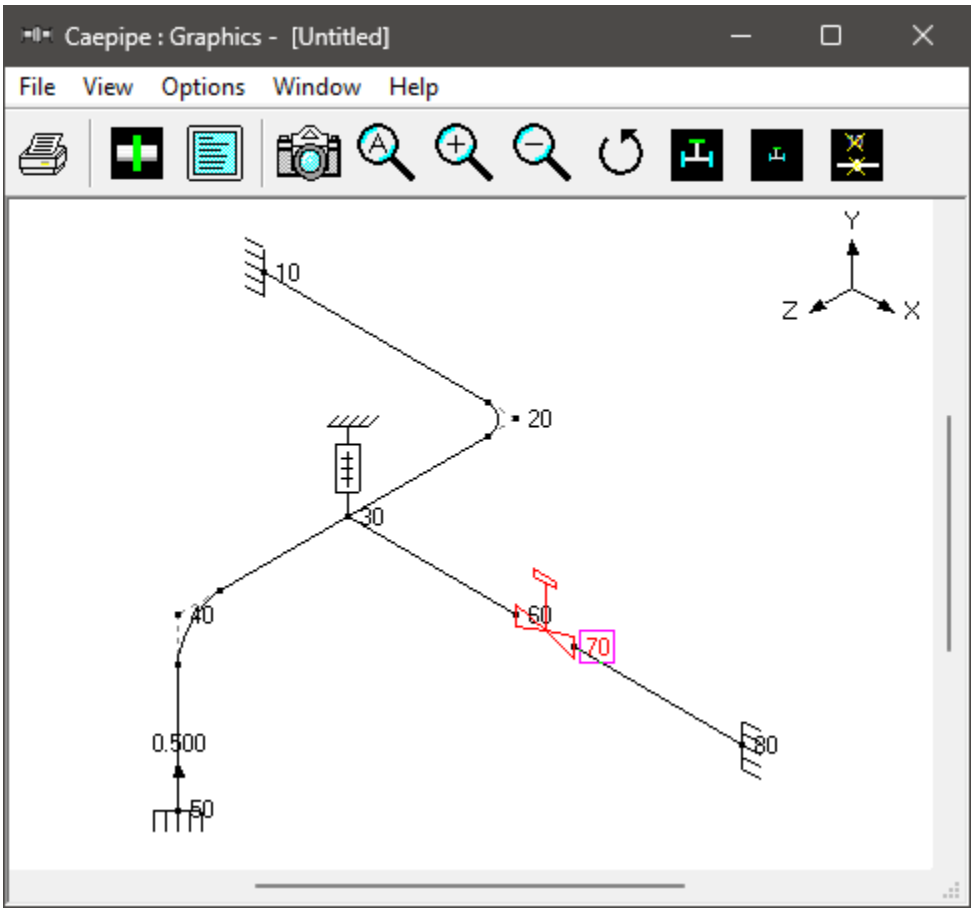


The "Load cases" dialog is shown.

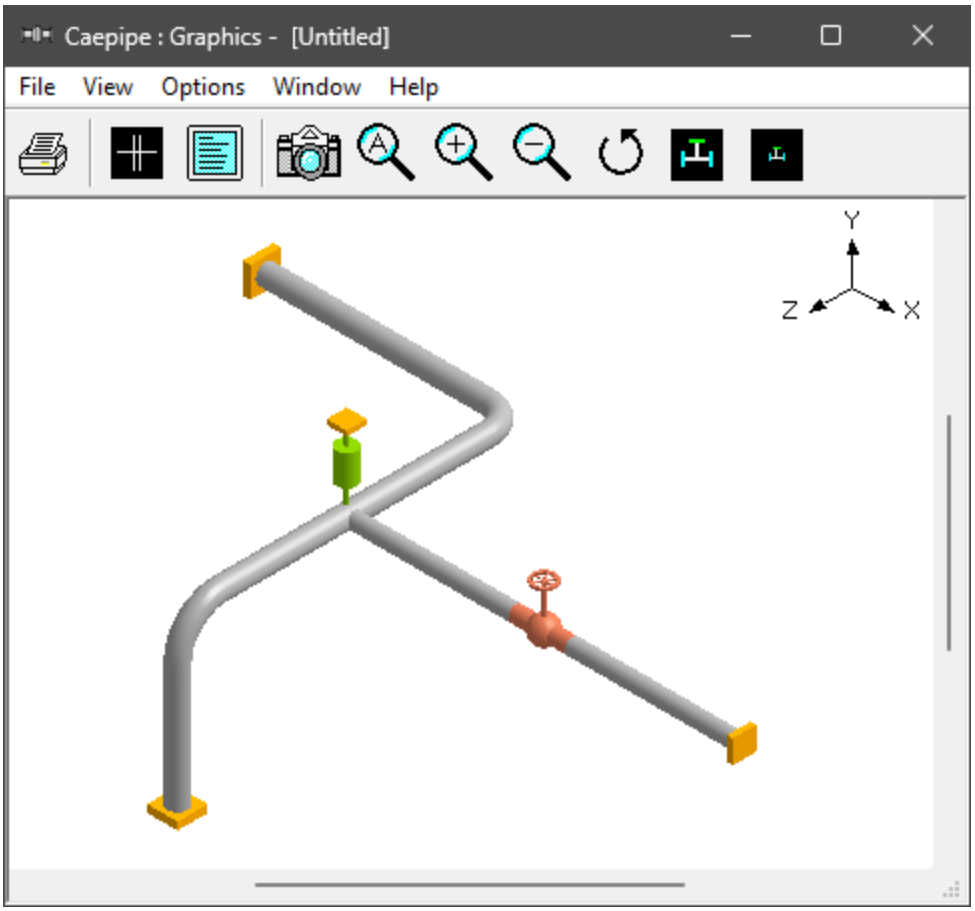


By default, "Sustained" (W+P), "Empty Weight" (W), "Expansion" (T1) and "Operating" (W+P1+T1) load cases are already selected. "Design" (W+PD+TD) load case when selected for the "Analysis", CAEPIPE will compute and show results for "Displacements", "Element Forces & Moments", "Support Loads" and "Support 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.



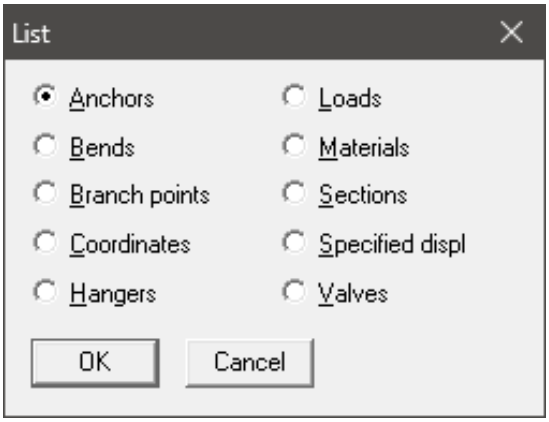
 To see a 3D rendered view of the model, click on the "Render" button (or press "Ctrl+R") in the graphics window.



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

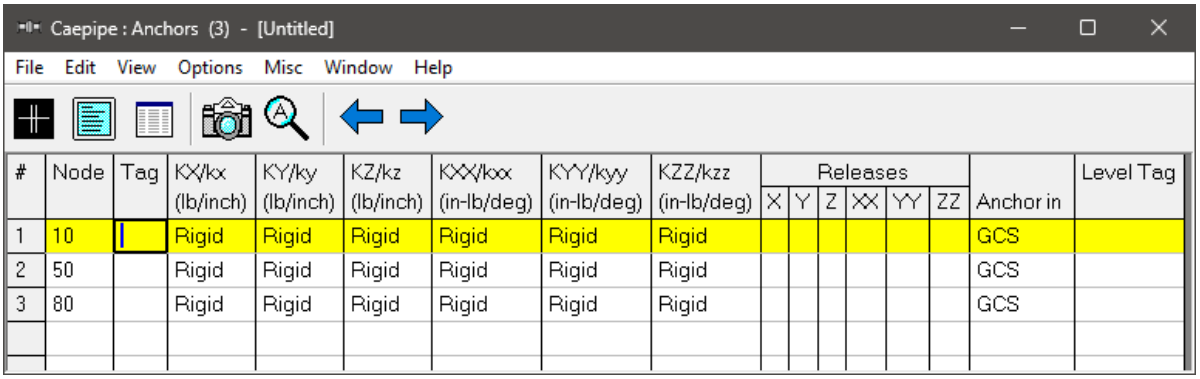
List

 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.

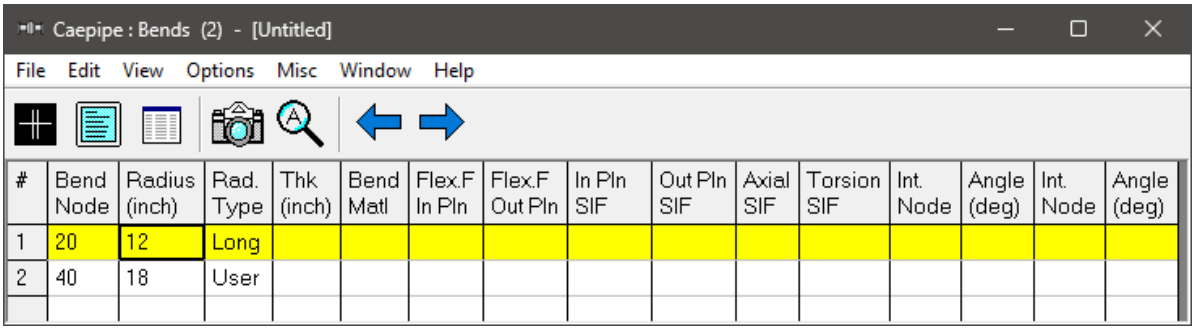
A list of all the anchors in the sample model is shown below:



#	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 X	Y	Z	XX	YY	ZZ	Anchor in	Level Tag
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.

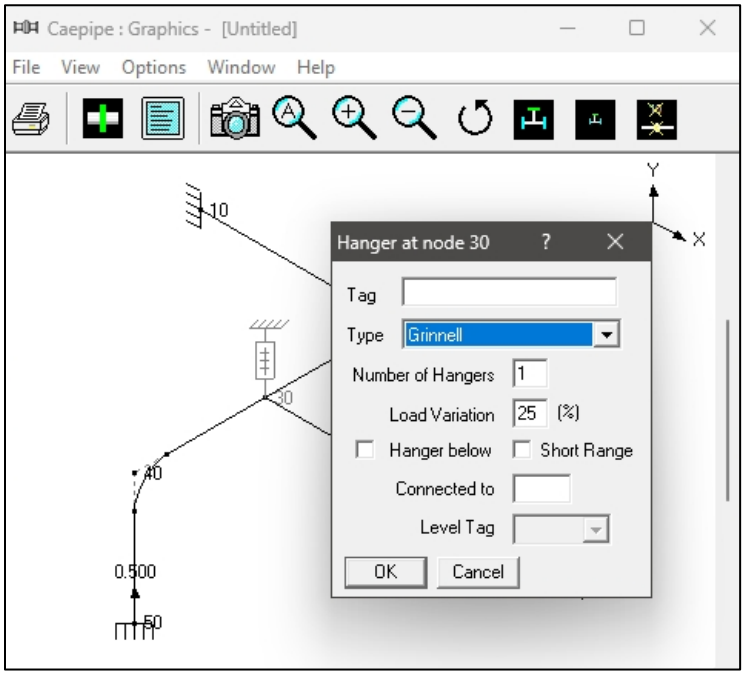
A list of all the bends in the sample model is shown below:



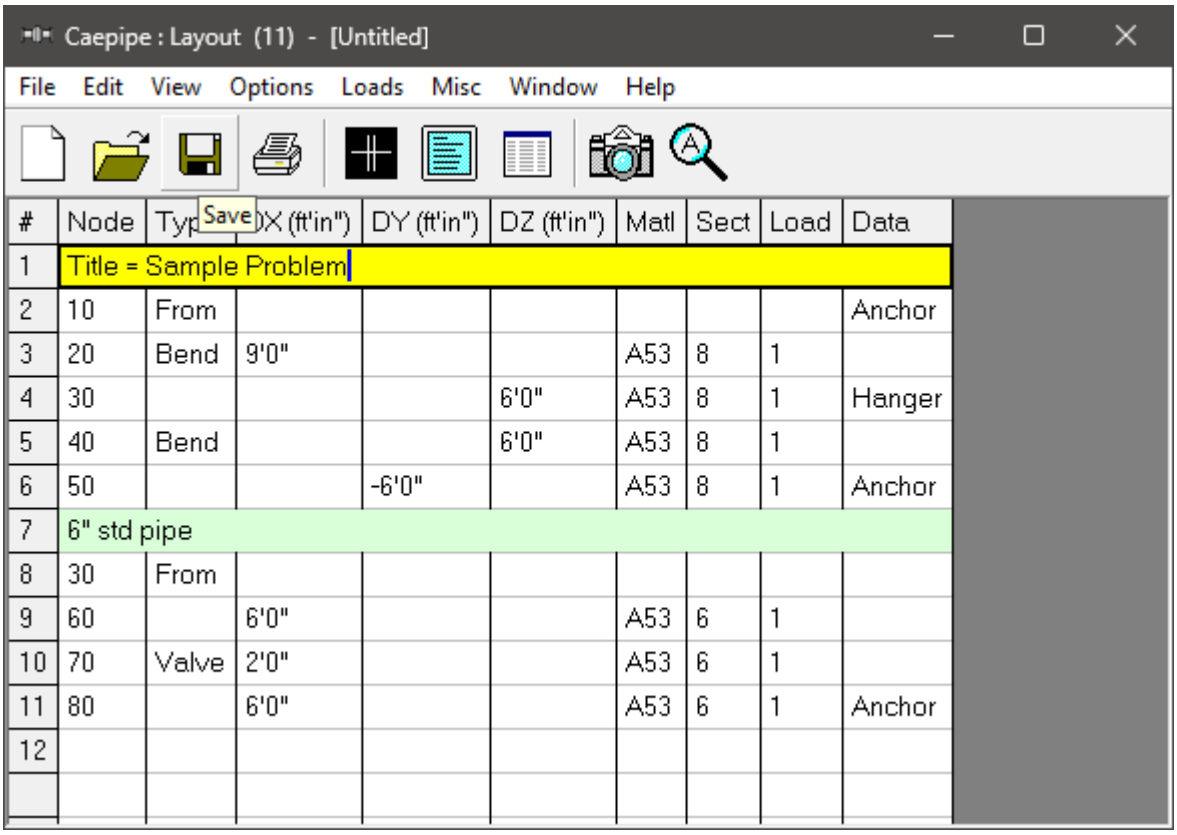
#	Bend Node	Radius (inch)	Rad. Type	Thk (inch)	Bend Matl	Flex.F In Pln	Flex.F Out Pln	In Pln SIF	Out Pln SIF	Axial SIF	Torsion SIF	Int. Node	Angle (deg)	Int. Node	Angle (deg)
1	20	12	Long												
2	40	18	User												

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.

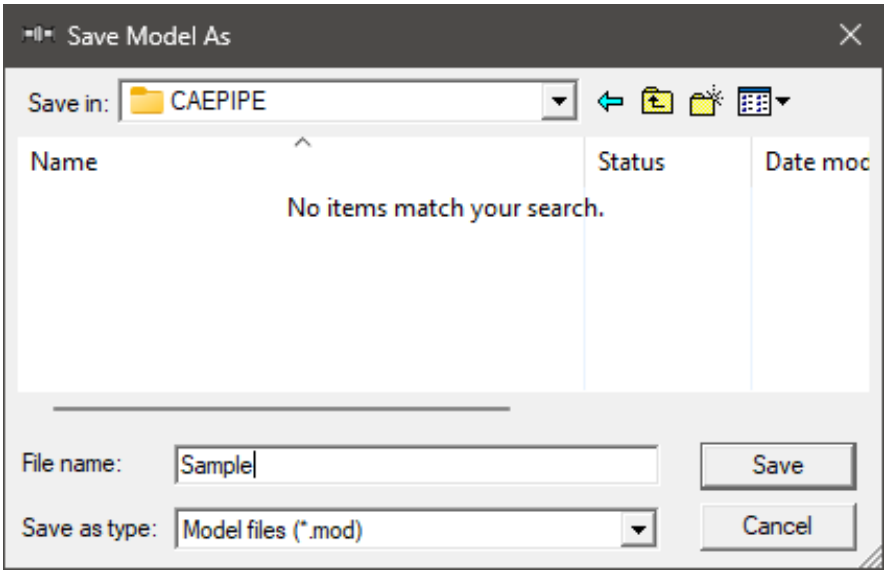


 Save the model by clicking on the Save button.



#	Node	Typ	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									

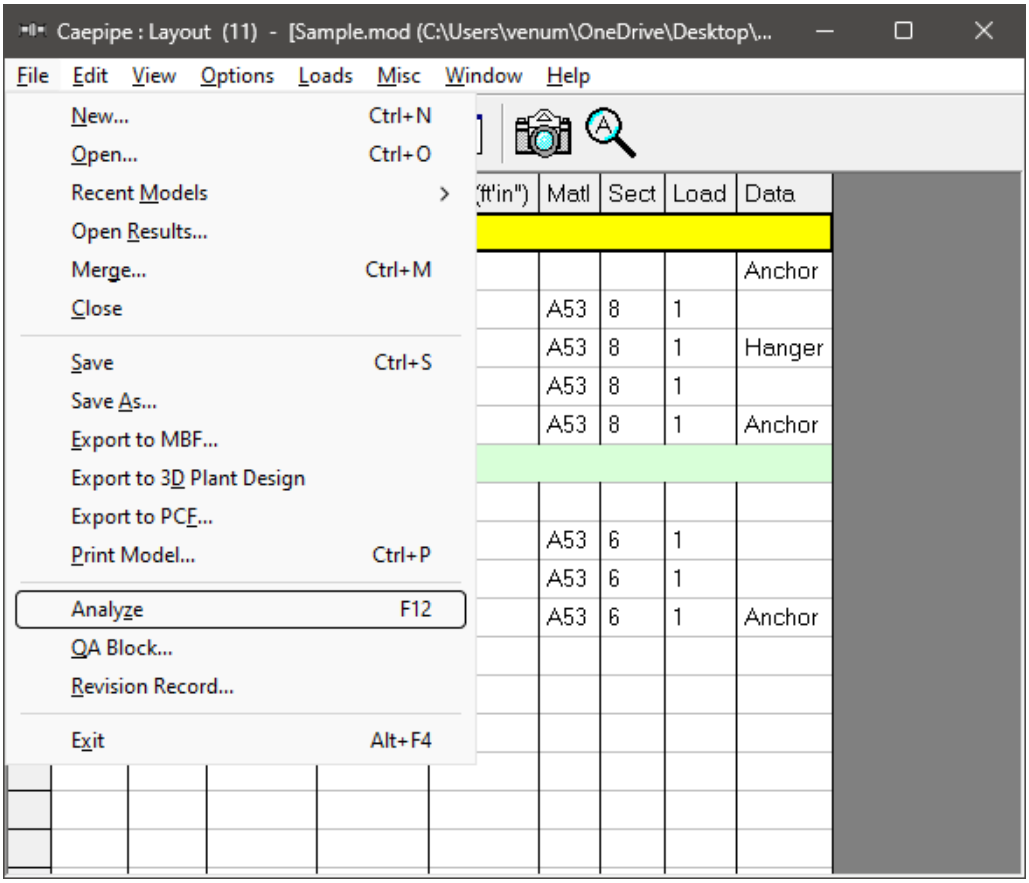
The "Save Model As" dialog is shown.

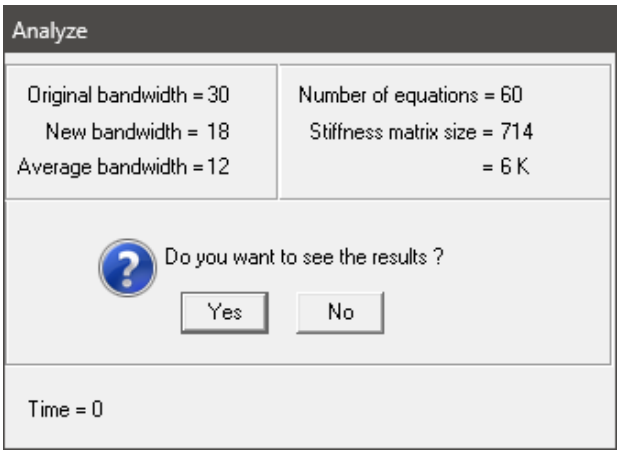


Type the File name as "Sample" and press Enter to save the model. We are done with modelling. Let us analyze now.

6. Analyze

Click on "Analyze" under the File menu.

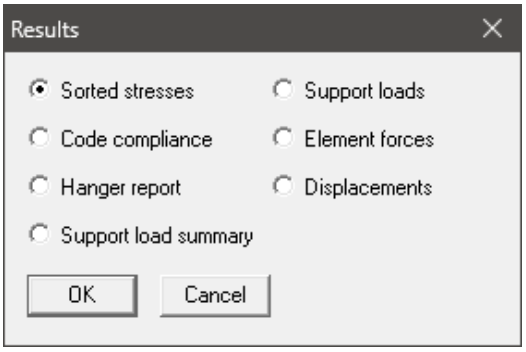


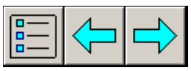


After the analysis, you are asked if you want to see the results. Select "Yes".

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.



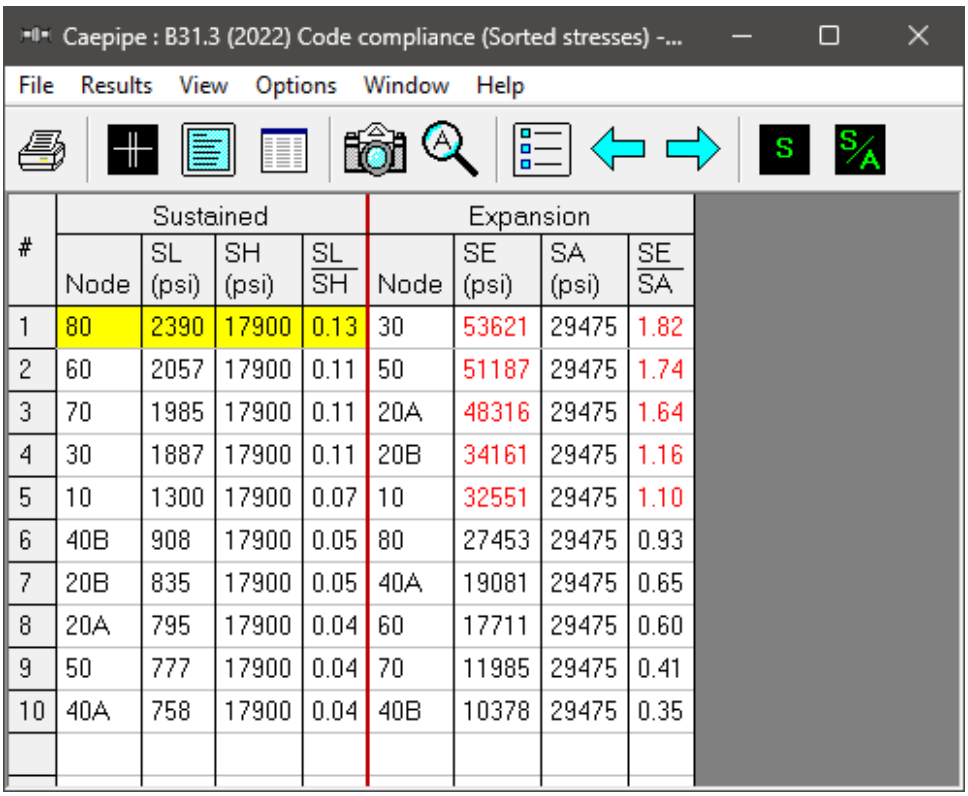


Select an item of interest by clicking on it. When you are viewing the results, use Tab (or "Next Result" button) to view the next result and "Shift+Tab" (or "Previous Result" button) to view the previous result. The "Results" dialog can be brought up by clicking on the "Results" button (or press "Ctrl+R").

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

Sorted Stresses

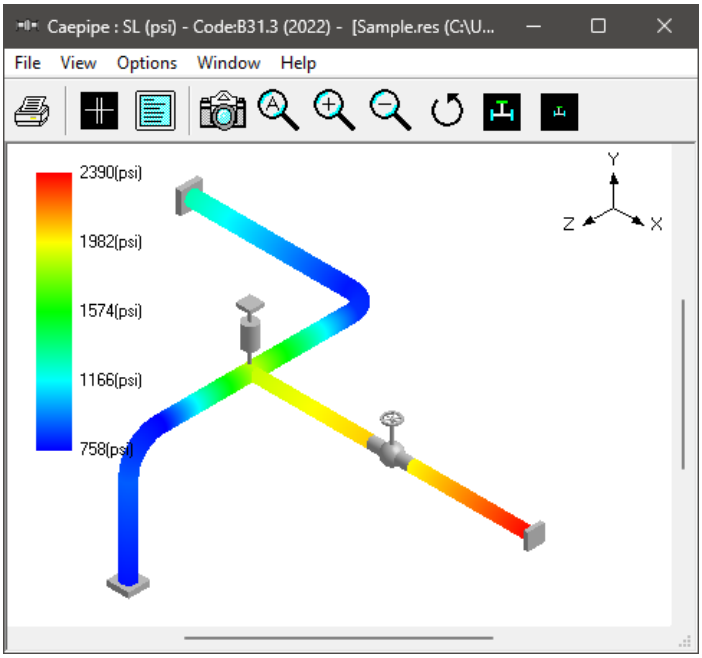
The computed stresses ("sustained", "expansion" and "occasional") are sorted in descending order by stress ratios.



#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
1	80	2390	17900	0.13	30	53621	29475	1.82
2	60	2057	17900	0.11	50	51187	29475	1.74
3	70	1985	17900	0.11	20A	48316	29475	1.64
4	30	1887	17900	0.11	20B	34161	29475	1.16
5	10	1300	17900	0.07	10	32551	29475	1.10
6	40B	908	17900	0.05	80	27453	29475	0.93
7	20B	835	17900	0.05	40A	19081	29475	0.65
8	20A	795	17900	0.04	60	17711	29475	0.60
9	50	777	17900	0.04	70	11985	29475	0.41
10	40A	758	17900	0.04	40B	10378	29475	0.35

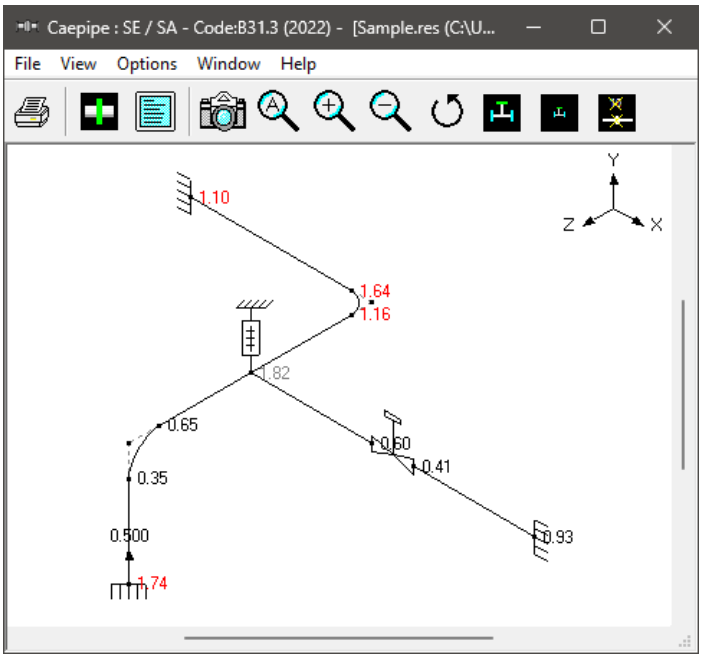
When the stress ratio exceeds 1.00, the stress and the stress ratio are shown in red. In this particular case, the high thermal stresses may be reduced by replacing the anchor at "Node" 80 by a guide. This allows the 6" pipe to expand more freely and reduce the thermal stresses. The maximum thermal stress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

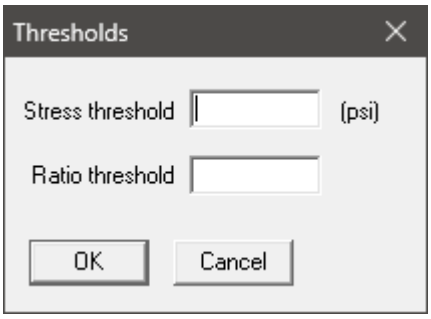


The stress ratios may similarly be rendered by using the "Show Stress Ratios" button (or choose "View > Show Stress Ratios").

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

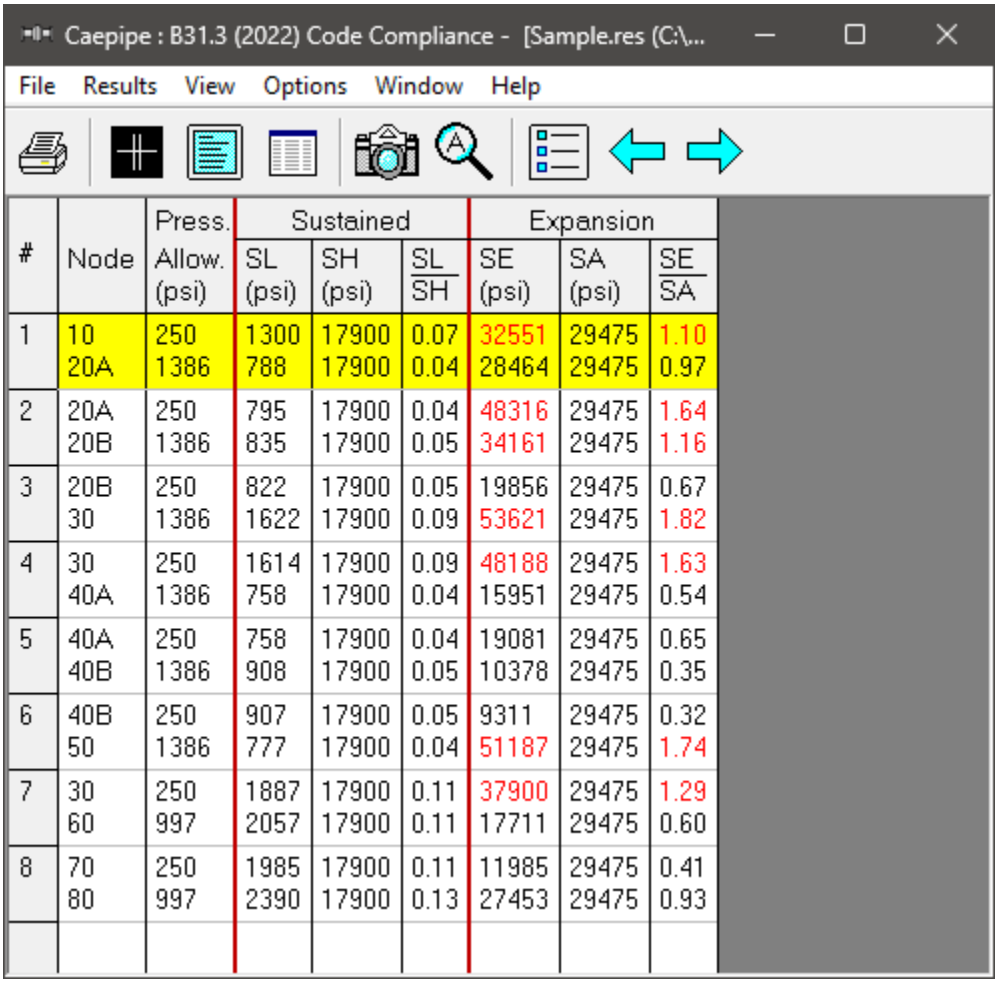


While plotting stresses or stress ratios, thresholds may be specified (choose "View > Thresholds"). Only the stresses or stress ratios exceeding the thresholds are plotted.



Code compliance

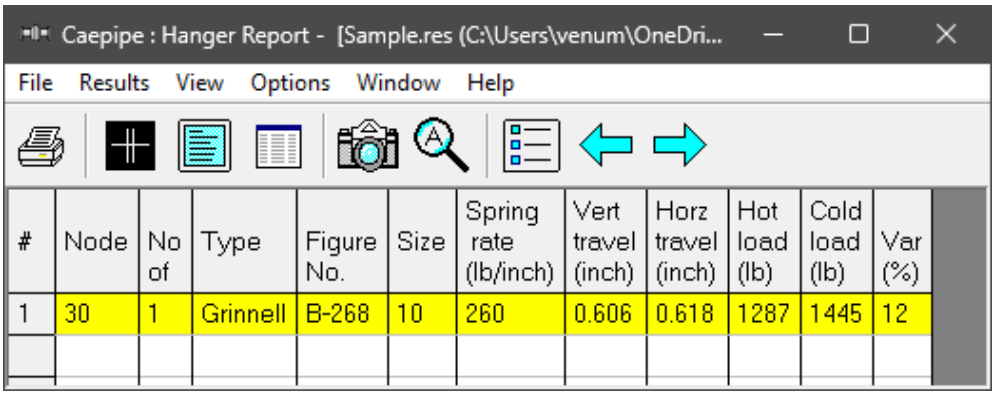
The element stresses and stress ratios calculated according to the piping code are shown under "Code Compliance". Design pressure and CAEPIPE calculated "Allowable pressures" are shown in 2nd column.



#	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	1300 788	17900 17900	0.07 0.04	32551 28464	29475 29475	1.10 0.97
2	20A 20B	250 1386	795 835	17900 17900	0.04 0.05	48316 34161	29475 29475	1.64 1.16
3	20B 30	250 1386	822 1622	17900 17900	0.05 0.09	19856 53621	29475 29475	0.67 1.82
4	30 40A	250 1386	1614 758	17900 17900	0.09 0.04	48188 15951	29475 29475	1.63 0.54
5	40A 40B	250 1386	758 908	17900 17900	0.04 0.05	19081 10378	29475 29475	0.65 0.35
6	40B 50	250 1386	907 777	17900 17900	0.05 0.04	9311 51187	29475 29475	0.32 1.74
7	30 60	250 997	1887 2057	17900 17900	0.11 0.11	37900 17711	29475 29475	1.29 0.60
8	70 80	250 997	1985 2390	17900 17900	0.11 0.13	11985 27453	29475 29475	0.41 0.93

Hanger report

The hanger report is shown below.



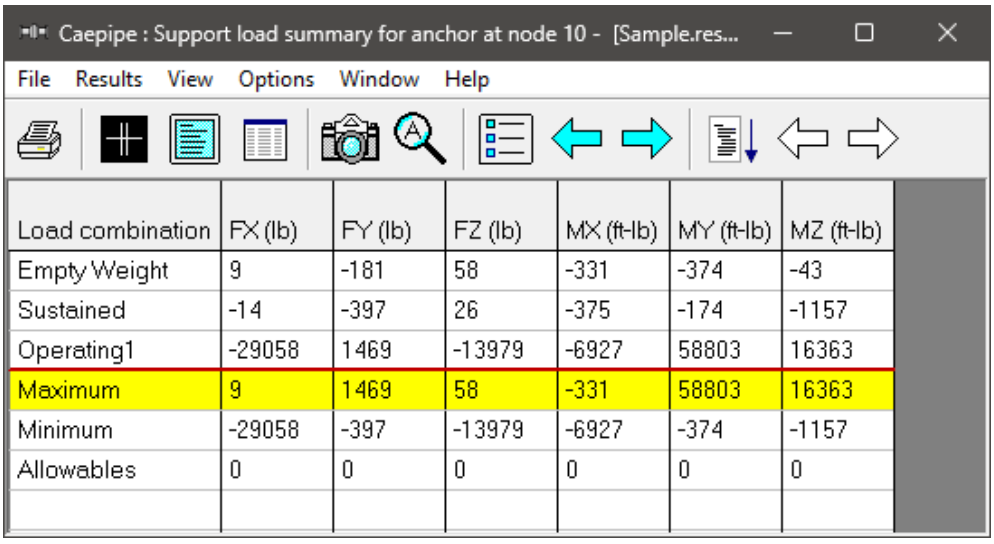
#	Node	No of	Type	Figure No.	Size	Spring rate (lb/inch)	Vert travel (inch)	Horz travel (inch)	Hot load (lb)	Cold load (lb)	Var (%)
1	30	1	Grinnell	B-268	10	260	0.606	0.618	1287	1445	12

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

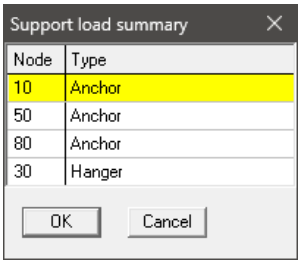
Support load summary

"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.



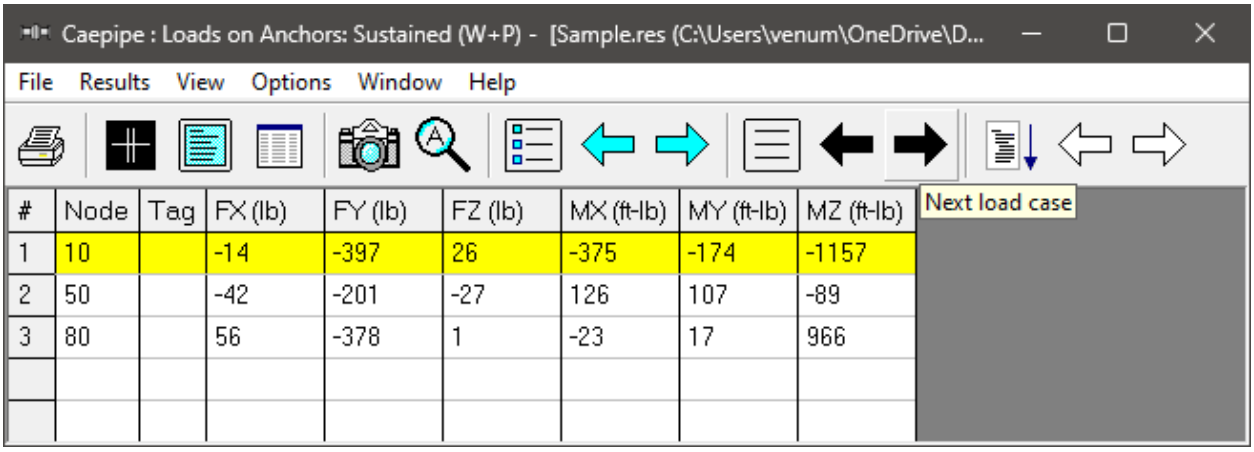
Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Empty Weight	9	-181	58	-331	-374	-43
Sustained	-14	-397	26	-375	-174	-1157
Operating1	-29058	1469	-13979	-6927	58803	16363
Maximum	9	1469	58	-331	58803	16363
Minimum	-29058	-397	-13979	-6927	-374	-1157
Allowables	0	0	0	0	0	0

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.

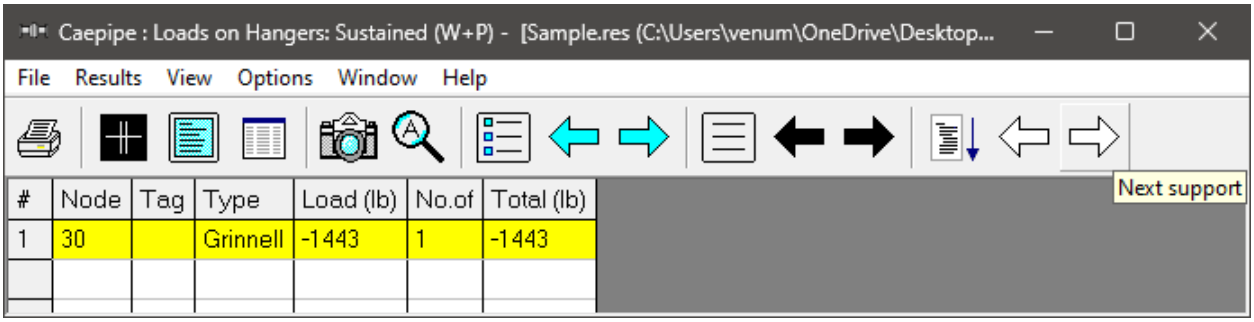


#	Node	Tag	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10		-14	-397	26	-375	-174	-1157
2	50		-42	-201	-27	126	107	-89
3	80		56	-378	1	-23	17	966

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.).

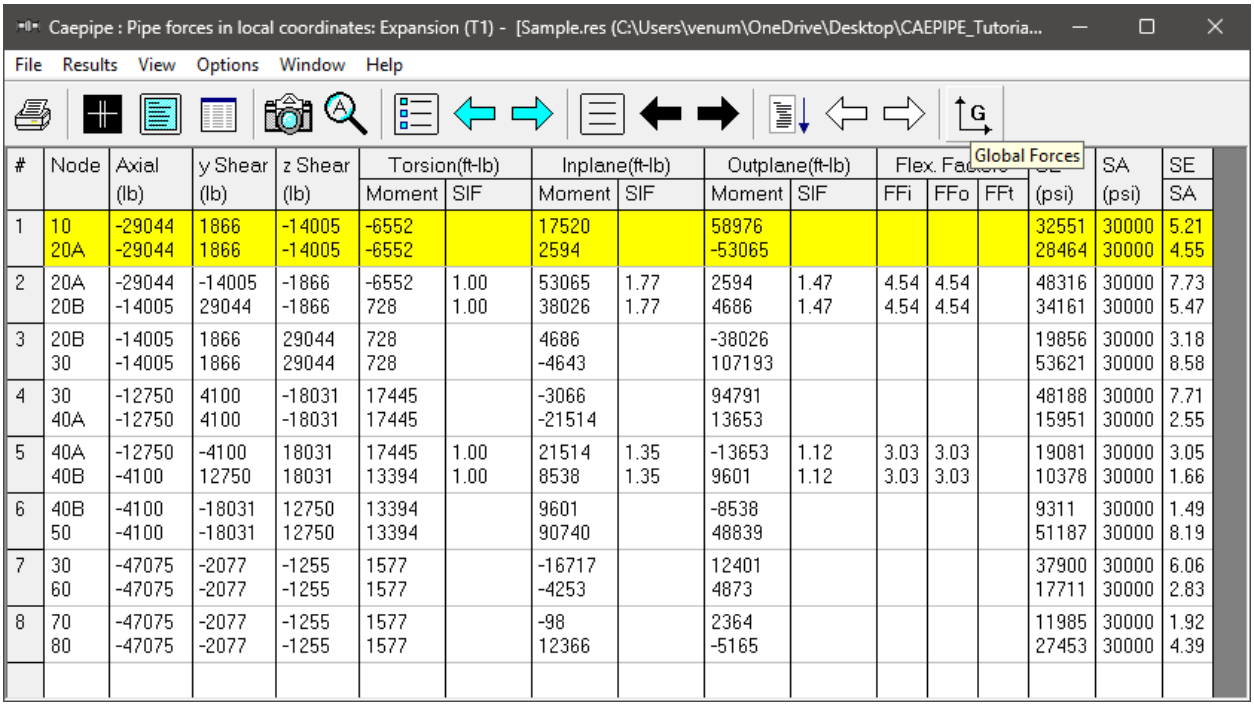
For example, the loads on hangers (i.e. the loads acting at the hanger locations imposed by the piping system) for the "Expansion" case are shown below.



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

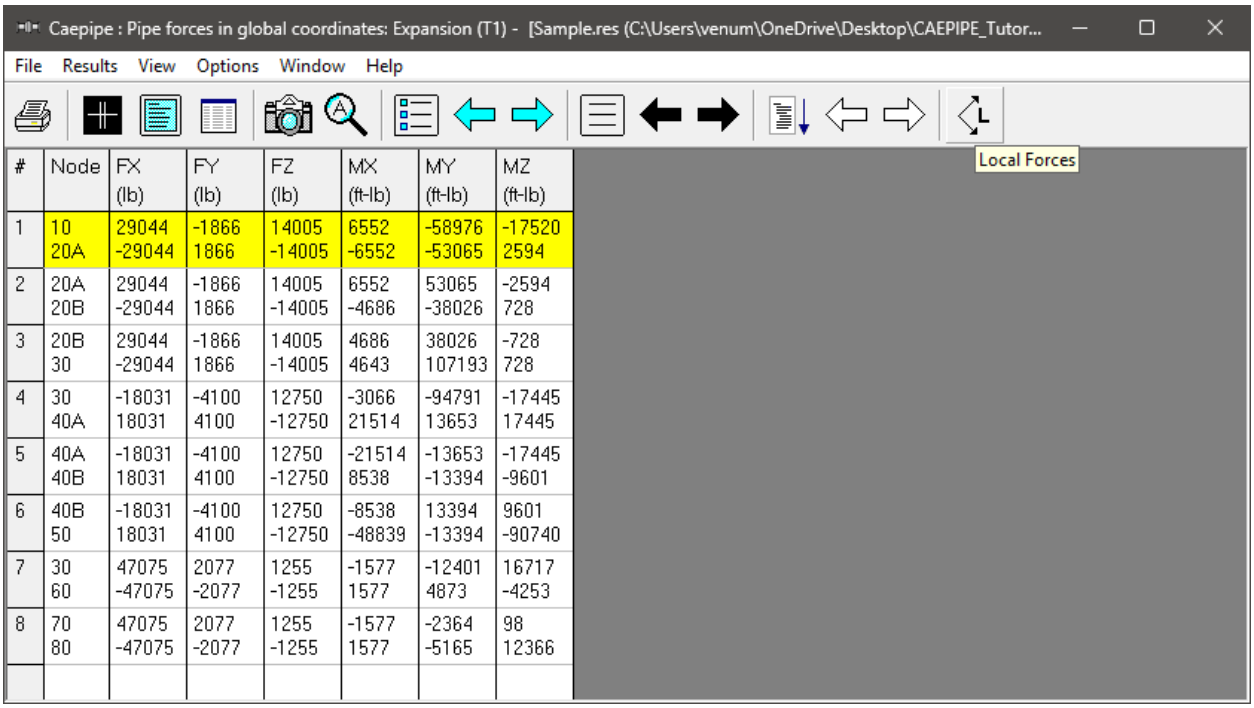
Element Forces

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. Fa... FFi	Flex. Fa... FFo	Flex. Fa... FFt	SA (psi)	SE (psi)	SE SA
1	10	-29044	1866	-14005	-6552		17520		58976					32551	30000	5.21
	20A	-29044	1866	-14005	-6552		2594		-53065					28464	30000	4.55
2	20A	-29044	-14005	-1866	-6552	1.00	53065	1.77	2594	1.47	4.54	4.54		48316	30000	7.73
	20B	-14005	29044	-1866	728	1.00	38026	1.77	4686	1.47	4.54	4.54		34161	30000	5.47
3	20B	-14005	1866	29044	728		4686		-38026					19856	30000	3.18
	30	-14005	1866	29044	728		-4643		107193					53621	30000	8.58
4	30	-12750	4100	-18031	17445		-3066		94791					48188	30000	7.71
	40A	-12750	4100	-18031	17445		-21514		13653					15951	30000	2.55
5	40A	-12750	-4100	18031	17445	1.00	21514	1.35	-13653	1.12	3.03	3.03		19081	30000	3.05
	40B	-4100	12750	18031	13394	1.00	8538	1.35	9601	1.12	3.03	3.03		10378	30000	1.66
6	40B	-4100	-18031	12750	13394		9601		-8538					9311	30000	1.49
	50	-4100	-18031	12750	13394		90740		48839					51187	30000	8.19
7	30	-47075	-2077	-1255	1577		-16717		12401					37900	30000	6.06
	60	-47075	-2077	-1255	1577		-4253		4873					17711	30000	2.83
8	70	-47075	-2077	-1255	1577		-98		2364					11985	30000	1.92
	80	-47075	-2077	-1255	1577		12366		-5165					27453	30000	4.39

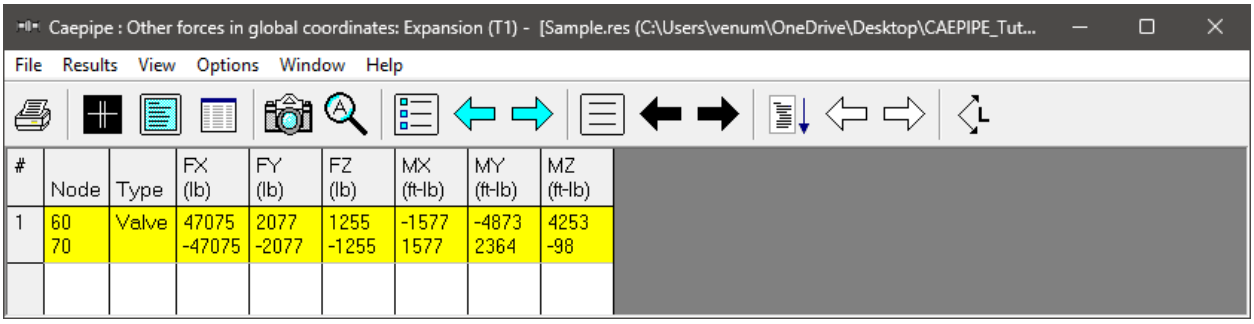
Use the "Global Forces" button (F7) to see the element forces in global coordinates.



#	Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	10	29044	-1866	14005	6552	-58976	-17520
	20A	-29044	1866	-14005	-6552	-53065	2594
2	20A	29044	-1866	14005	6552	53065	-2594
	20B	-29044	1866	-14005	-4686	-38026	728
3	20B	29044	-1866	14005	4686	38026	-728
	30	-29044	1866	-14005	4643	107193	728
4	30	-18031	-4100	12750	-3066	-94791	-17445
	40A	18031	4100	-12750	21514	13653	17445
5	40A	-18031	-4100	12750	-21514	-13653	-17445
	40B	18031	4100	-12750	8538	-13394	-9601
6	40B	-18031	-4100	12750	-8538	13394	9601
	50	18031	4100	-12750	-48839	-13394	-90740
7	30	47075	2077	1255	-1577	-12401	16717
	60	-47075	-2077	-1255	1577	4873	-4253
8	70	47075	2077	1255	-1577	-2364	98
	80	-47075	-2077	-1255	1577	-5165	12366

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

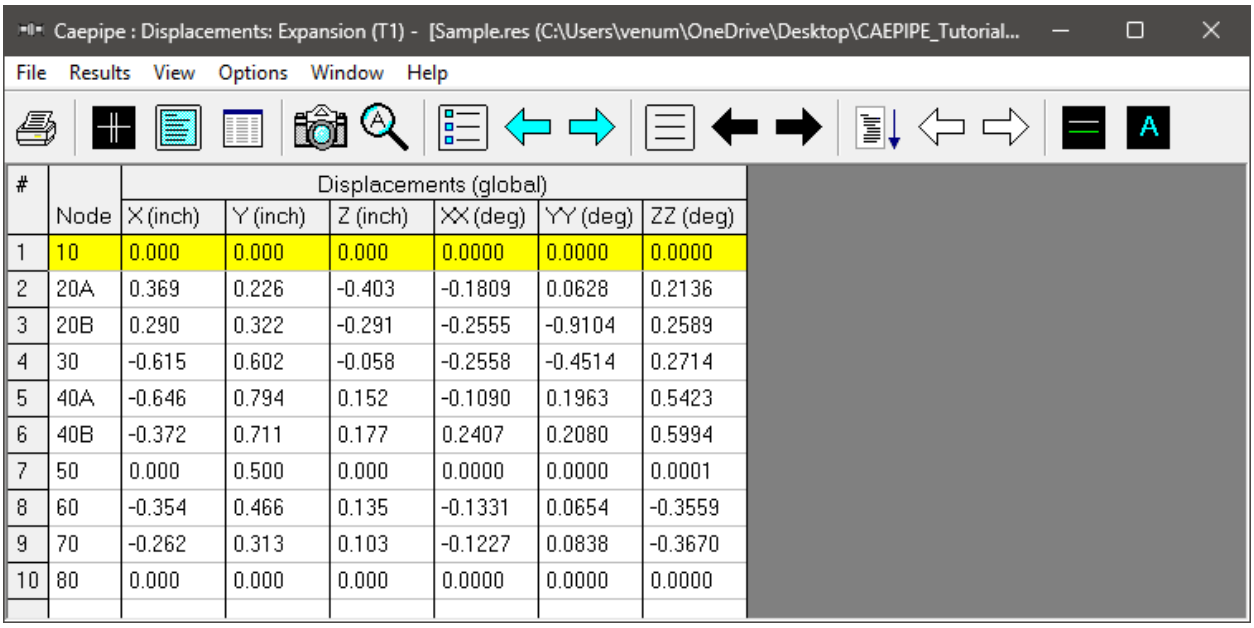
Use the "Other Forces" button (F6), "Next Force" button ("Ctrl+Right arrow") or "Previous Force" button ("Ctrl+Left arrow") to see other element forces (e.g. valves, bellows etc.).



#	Node	Type	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
1	60 70	Valve	47075 -47075	2077 -2077	1255 -1255	-1577 1577	-4873 2364	4253 -98

Displacements

The nodal displacements are shown.

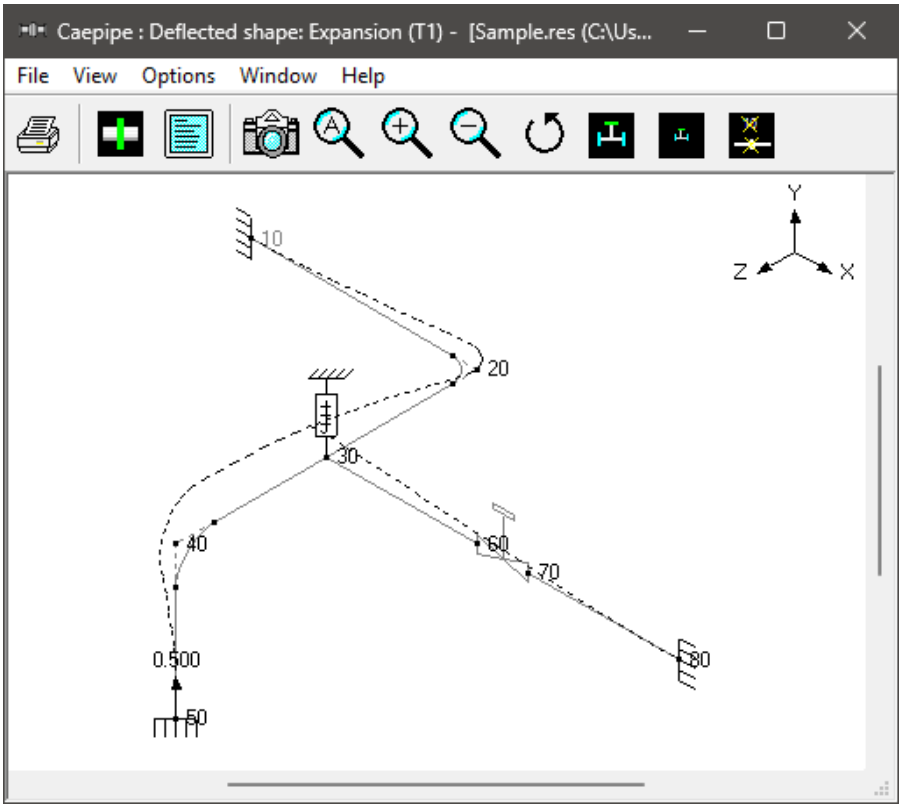


#	Node	Displacements (global)					
		X (inch)	Y (inch)	Z (inch)	XX (deg)	YY (deg)	ZZ (deg)
1	10	0.000	0.000	0.000	0.0000	0.0000	0.0000
2	20A	0.369	0.226	-0.403	-0.1809	0.0628	0.2136
3	20B	0.290	0.322	-0.291	-0.2555	-0.9104	0.2589
4	30	-0.615	0.602	-0.058	-0.2558	-0.4514	0.2714
5	40A	-0.646	0.794	0.152	-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

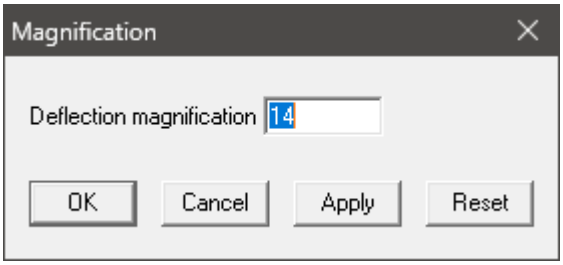
Use the "Load Cases" button, "Next load case" button (Right arrow) or "Previous load case" button (Left arrow) to see displacements for different load cases (e.g. Sustained, Expansion etc.).

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.



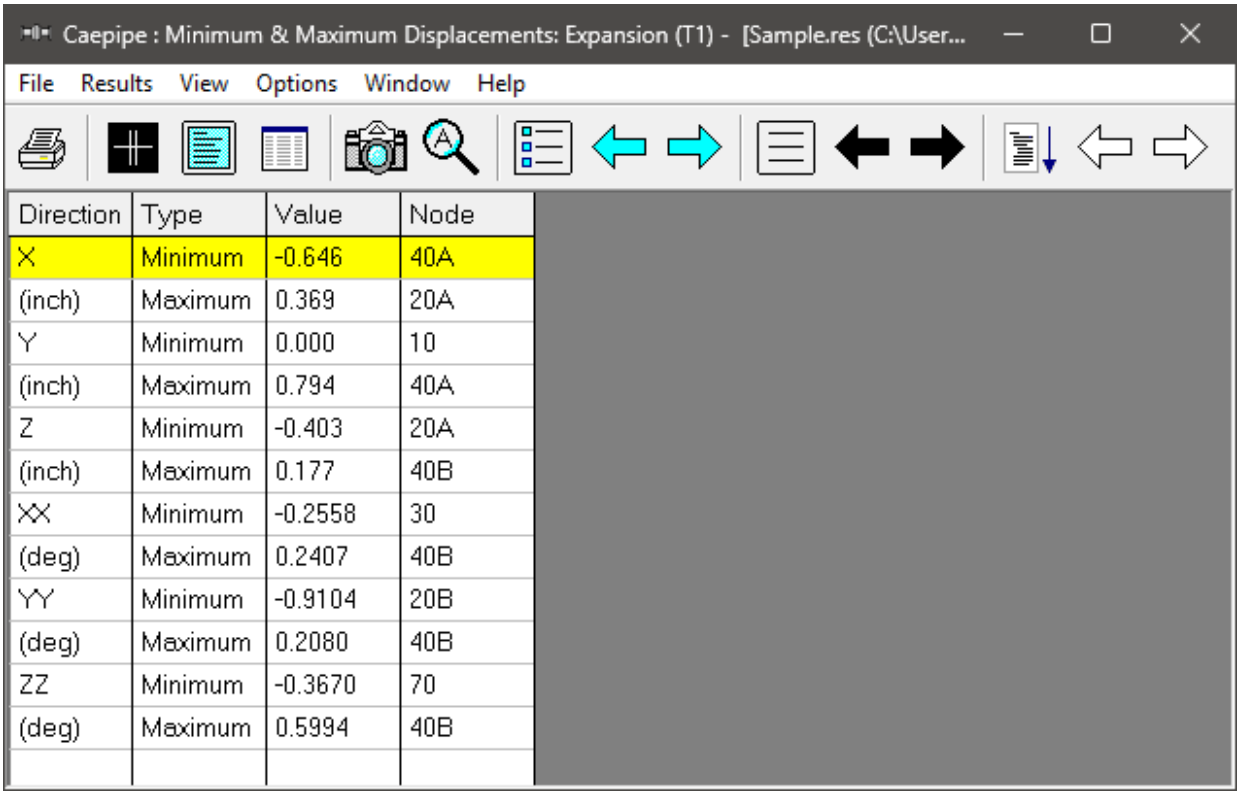
Choose "View > Magnification" to change the magnification of the deflected shape.



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.

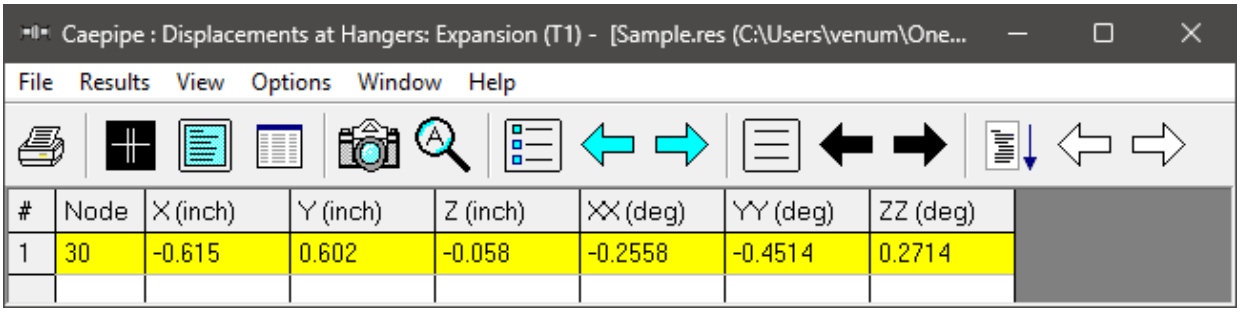
Use the "Other displacements" button (F6), "Next displacement" button ("Ctrl+Right arrow") or "Previous displacement" button ("Ctrl+Left arrow") to see other displacements (e.g. Min/Max, displacements at hangers, flex joints, limit stops etc.).

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

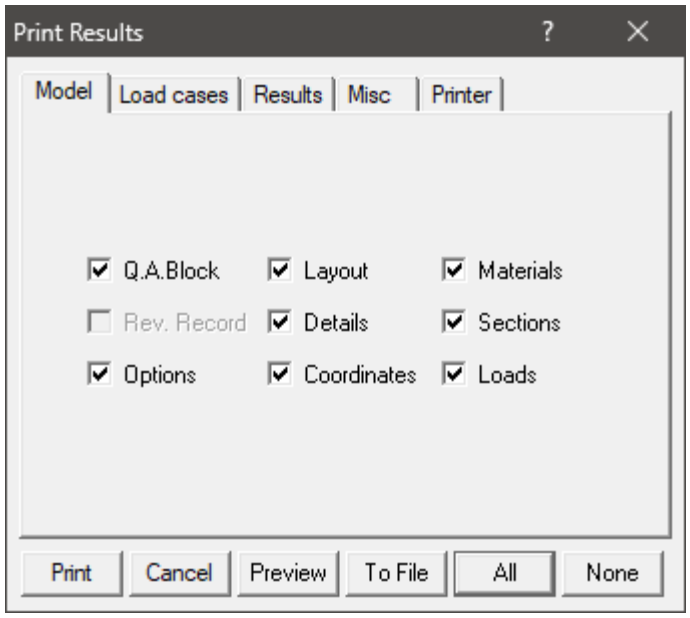
The displacements at hanger nodes are shown below.



#	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

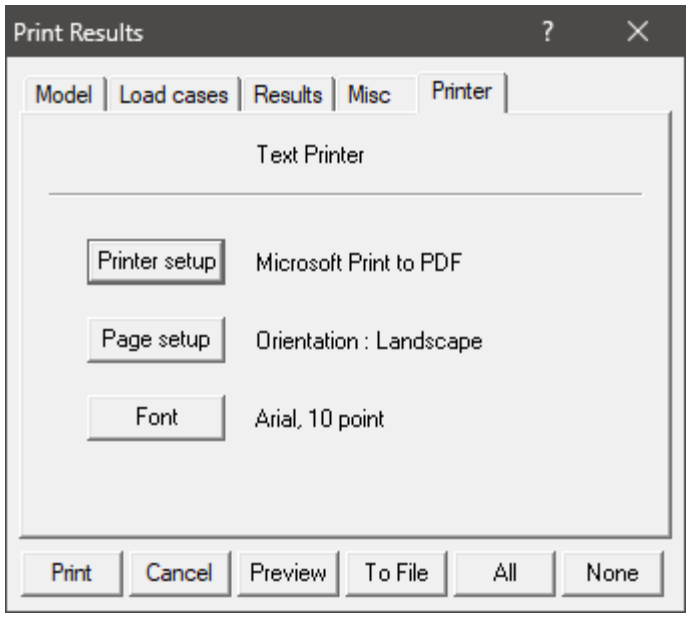
To print results and model data, click on the Print button (or press Ctrl+P). In the "Print Results" dialog, the items to print can be selected.



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 12.10

Client :

Project :

File Number :

Report Number :

Model Name : sample

Title : Sample Problem

Analyzed : Thu Jan 11 10:54:26 2024

Prepared by : _____ Date:

Checked by : _____ Date:

Tutorial for Modeling and Results Review – Problem 1

Table of Contents

Analysis Options

Code : Piping code = B31.3 (2022)
Include axial force in stress calculations
Do not use liberal allowable stresses
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^2 / (D^2 - d^2)
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	Level Tag
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 In Pln	Flex.F Out Pln	In Pln SIF	Out Pln SIF	Axial SIF	Torsion 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	Level Tag
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
50	Anchor	Desn							GCS
		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)
Tensile strength = 60000 (psi)

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
-20	29.9E+6	6.25E-6	20000
18	29.7E+6	6.31E-6	20000
70	29.4E+6	6.40E-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	27.4E+6	7.10E-6	19900
500	27.3E+6	7.30E-6	19000
600	26.5E+6	7.40E-6	17900
650	26.0E+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	23.4E+6	7.85E-6	8700
900	22.5E+6	7.90E-6	5900
950	21.5E+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 (2022) Code compliance (Sorted stresses)

Sustained				Expansion			
Node	SL (psi)	SH (psi)	SL / SH	Node	SE (psi)	SA (psi)	SE / SA
80	2390	17900	0.13	30	53621	29475	1.82
60	2057	17900	0.11	50	51187	29475	1.74
70	1985	17900	0.11	20A	48316	29475	1.64
30	1887	17900	0.11	20B	34161	29475	1.16
10	1300	17900	0.07	10	32551	29475	1.10

B31.3 (2022) Code compliance (Sorted stresses)

Sustained				Expansion			
Node	SL (psi)	SH (psi)	SL SH	Node	SE (psi)	SA (psi)	SE SA
40B	908	17900	0.05	80	27453	29475	0.93
20B	835	17900	0.05	40A	19081	29475	0.65
20A	795	17900	0.04	60	17711	29475	0.60
50	777	17900	0.04	70	11985	29475	0.41
40A	758	17900	0.04	40B	10378	29475	0.35

B31.3 (2022) Code Compliance

Node	Press. Allow. (psi)	Sustained SL (psi)	SH (psi)	SL SH	Expansion SE (psi)	SA (psi)	SE SA
10	250	1300	17900	0.07	32551	29475	1.10
20A	1386	788	17900	0.04	28464	29475	0.97
20A	250	795	17900	0.04	48316	29475	1.64
20B	1386	835	17900	0.05	34161	29475	1.16
20B	250	822	17900	0.05	19856	29475	0.67
30	1386	1622	17900	0.09	53621	29475	1.82
30	250	1614	17900	0.09	48188	29475	1.63
40A	1386	758	17900	0.04	15951	29475	0.54
40A	250	758	17900	0.04	19081	29475	0.65
40B	1386	908	17900	0.05	10378	29475	0.35
40B	250	907	17900	0.05	9311	29475	0.32
50	1386	777	17900	0.04	51187	29475	1.74
30	250	1887	17900	0.11	37900	29475	1.29
60	997	2057	17900	0.11	17711	29475	0.60
70	250	1985	17900	0.11	11985	29475	0.41
80	997	2390	17900	0.13	27453	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	-29058	1469	-13979	-6927	58803	16363
Maximum	9	1469	58	-331	58803	16363
Minimum	-29058	-397	-13979	-6927	-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	-18073	-4301	12723	48964	13501	90650
Maximum	-23	33	12723	48964	13501	90650
Minimum	-18073	-4301	-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	47130	1699	1256	-1601	5182	-11400
Maximum	47130	1699	1256	12	5182	966

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)
Minimum	14	-378	1	-1601	17	-11400
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	1.00	-94	1.77	-206	1.47	4.54	4.54	
20B	58	-9	-300	-456	1.00	-143	1.77	59	1.47	4.54	4.54	
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	1.00	-126	1.35	39	1.12	3.03	3.03	
40B	259	-64	23	74	1.00	-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	FY	FZ	MX	MY	MZ
	(lb)	(lb)	(lb)	(ft-lb)	(ft-lb)	(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

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
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)

	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	0.003	0.004	-0.0091	-0.0030	0.0031
20B	-0.000	0.006	0.004	-0.0101	-0.0005	0.0001
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	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SL
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)
10	-14	-397	26	-375		-1157		-174					1300
20A	-14	132	26	-375		-100		35					788
20A	-14	26	-132	-375	1.00	-35	1.77	-100	1.47	4.54	4.54		795
20B	26	14	-236	-270	1.00	-75	1.77	177	1.47	4.54	4.54		835
20B	26	236	14	-270		177		75					822
30	26	567	14	-270		-1831		144					1622
30	27	-550	-42	339		-1807		143					1614
40A	27	-252	-42	339		-4		-44					758
40A	27	252	42	339	1.00	4	1.35	44	1.12	3.03	3.03		758
40B	96	-27	42	107	1.00	-249	1.35	-277	1.12	3.03	3.03		908
40B	96	-42	-27	107		-277		249					907
50	-201	-42	-27	107		-89		126					777
30	-56	-327	-1	23		-610		1					1887
60	-56	-119	-1	23		730		-7					2057
70	-56	170	-1	23		679		-10					1985
80	-56	378	-1	23		-966		-17					2390

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
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	-0.0104	-0.0015	-0.0059
20B	-0.000	-0.007	0.002	-0.0130	-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		-29044	1866	-14005	-6552	58976	17520
50		-18031	-4100	12750	48839	13394	90740
80		47075	2077	1255	-1577	5165	-12366

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	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			SE	SA	SE
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)	(psi)	SA
10	-29044	1866	-14005	-6552		17520		58976					32551	30000	1.09
20A	-29044	1866	-14005	-6552		2594		-53065					28464	30000	0.95
20A	-29044	-14005	-1866	-6552	1.00	53065	1.77	2594	1.47	4.54	4.54		48316	30000	1.61
20B	-14005	29044	-1866	728	1.00	38026	1.77	4686	1.47	4.54	4.54		34161	30000	1.14

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)	SA (psi)	SE SA
20B	-14005	1866	29044	728		4686		-38026					19856	30000	0.66
30	-14005	1866	29044	728		-4643		107193					53621	30000	1.79
30	-12750	4100	-18031	17445		-3066		94791					48188	30000	1.61
40A	-12750	4100	-18031	17445		-21514		13653					15951	30000	0.53
40A	-12750	-4100	18031	17445	1.00	21514	1.35	-13653	1.12	3.03	3.03		19081	30000	0.64
40B	-4100	12750	18031	13394	1.00	8538	1.35	9601	1.12	3.03	3.03		10378	30000	0.35
40B	-4100	-18031	12750	13394		9601		-8538					9311	30000	0.31
50	-4100	-18031	12750	13394		90740		48839					51187	30000	1.71
30	-47075	-2077	-1255	1577		-16717		12401					37900	30000	1.26
60	-47075	-2077	-1255	1577		-4253		4873					17711	30000	0.59
70	-47075	-2077	-1255	1577		-98		2364					11985	30000	0.40
80	-47075	-2077	-1255	1577		12366		-5165					27453	30000	0.92

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	-47075	-2077	-1255	1577	4873	-4253
70		-47075	-2077	-1255	1577	2364	-98

Pipe forces in global coordinates: Expansion (T1)

Node	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
10	29044	-1866	14005	6552	-58976	-17520
20A	-29044	1866	-14005	-6552	-53065	2594
20A	29044	-1866	14005	6552	53065	-2594
20B	-29044	1866	-14005	-4686	-38026	728
20B	29044	-1866	14005	4686	38026	-728
30	-29044	1866	-14005	4643	107193	728
30	-18031	-4100	12750	-3066	-94791	-17445
40A	18031	4100	-12750	21514	13653	17445
40A	-18031	-4100	12750	-21514	-13653	-17445
40B	18031	4100	-12750	8538	-13394	-9601
40B	-18031	-4100	12750	-8538	13394	9601
50	18031	4100	-12750	-48839	-13394	-90740
30	47075	2077	1255	-1577	-12401	16717
60	-47075	-2077	-1255	1577	4873	-4253
70	47075	2077	1255	-1577	-2364	98
80	-47075	-2077	-1255	1577	-5165	12366

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	47075	2077	1255	-1577	-4873	4253
70		-47075	-2077	-1255	1577	2364	-98

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
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
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		-29058	1469	-13979	-6927	58803	16363
50		-18073	-4301	12723	48964	13501	90650
80		47130	1699	1256	-1601	5182	-11400

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	y Shear	z Shear	Torsion(ft-lb)		Inplane(ft-lb)		Outplane(ft-lb)		Flex. Factors			Sopr
	(lb)	(lb)	(lb)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	(psi)
10	-29058	1469	-13979	-6927		16363		58803					31622
20A	-29058	1998	-13979	-6927		2494		-53030					27757
20A	-29058	-13979	-1998	-6927	1.00	53030	1.77	2494	1.47	4.54	4.54		27757
20B	-13979	29058	-2102	458	1.00	37951	1.77	4863	1.47	4.54	4.54		19111
20B	-13979	2102	29058	458		4863		-37951					19111
30	-13979	2433	29058	458		-6474		107337					53019
30	-12723	3550	-18073	17785		-4873		94935					47617
40A	-12723	3848	-18073	17785		-21518		13608					15434
40A	-12723	-3848	18073	17785	1.00	21518	1.35	-13608	1.12	3.03	3.03		15434
40B	-4003	12723	18073	13501	1.00	8290	1.35	9324	1.12	3.03	3.03		9276
40B	-4003	-18073	12723	13501		9324		-8290					9276
50	-4301	-18073	12723	13501		90650		48964					51241
30	-47130	-2404	-1256	1601		-17327		12402					37574
60	-47130	-2197	-1256	1601		-3523		4866					16054
70	-47130	-1907	-1256	1601		581		2354					11067
80	-47130	-1699	-1256	1601		11400		-5182					25198

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	-47130	-2172	-1256	1601	4866	-3498
70		-47130	-1932	-1256	1601	2354	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	29058	-1469	13979	6927	-58803	-16363
20A	-29058	1998	-13979	-6927	-53030	2494
20A	29058	-1998	13979	6927	53030	-2494
20B	-29058	2102	-13979	-4863	-37951	458
20B	29058	-2102	13979	4863	37951	-458
30	-29058	2433	-13979	6474	107337	458
30	-18073	-3550	12723	-4873	-94935	-17785
40A	18073	3848	-12723	21518	13608	17785
40A	-18073	-3848	12723	-21518	-13608	-17785
40B	18073	4003	-12723	8290	-13501	-9324
40B	-18073	-4003	12723	-8290	13501	9324
50	18073	4301	-12723	-48964	-13501	-90650
30	47130	2404	1256	-1601	-12402	17327
60	-47130	-2197	-1256	1601	4866	-3523
70	47130	1907	1256	-1601	-2354	-581
80	-47130	-1699	-1256	1601	-5182	11400

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	47130	2172	1256	-1601	-4866	3498
70		-47130	-1932	-1256	1601	2354	606

Displacements: Operating (W+P1+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	0.217	-0.402	-0.1912	0.0613	0.2077
20B	0.290	0.315	-0.289	-0.2685	-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	0.5362
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
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)	Ins.Wt (lb)	Lin.Wt (lb)	Add.Wt (lb)
1	10	20A		96	8.625	0.5	0.283	0.029	0.009	2			346.74	126.57	55.632	0	0
2	20A	20B	Bend	18.85	8.625	0.5	0.283	0.029	0.009	2			68.082	24.851	10.923	0	0
3	20B	30		60	8.625	0.5	0.283	0.029	0.009	2			216.71	79.104	34.77	0	0
4	30	40A		54	8.625	0.5	0.283	0.029	0.009	2			195.04	71.193	31.293	0	0
5	40A	40B	Bend	28.274	8.625	0.5	0.283	0.029	0.009	2			102.12	37.277	16.385	0	0
6	40B	50		54	8.625	0.5	0.283	0.029	0.009	2			195.04	71.193	31.293	0	0
7	30	60		72	6.625	0.28	0.283	0.029	0.009	2			113.73	60.057	33.87	0	0
8	60	70	Valve	24	6.625	0.84	0.283	0.029	0.009	2			200	20.019	19.758	0	0
9	70	80		72	6.625	0.28	0.283	0.029	0.009	2			113.73	60.057	33.87	0	0