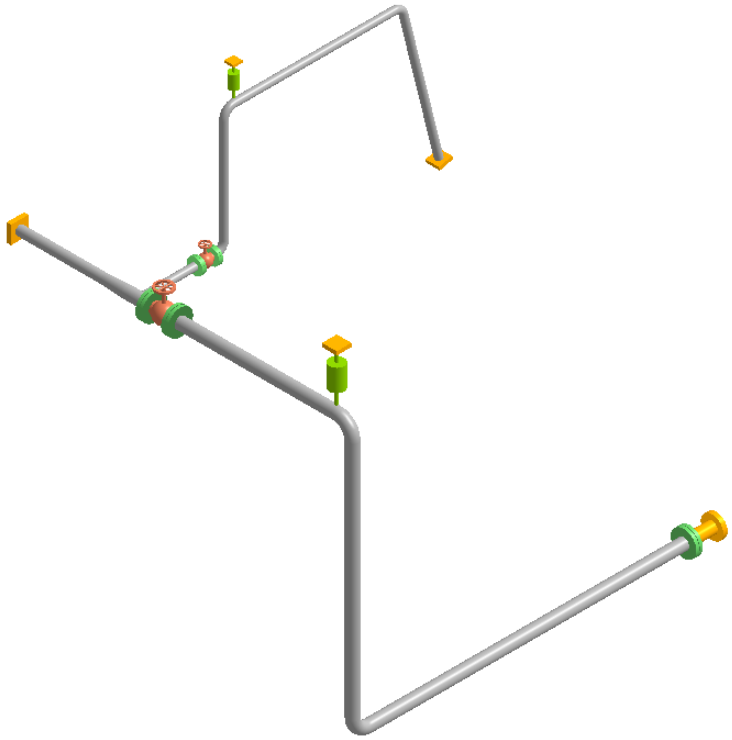
CAEPIPE™

Tutorial for Modeling and Results Review

Problem 2



SST SYSTEMS, INC.

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

Disclaimer

Please read the following carefully:

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SST Systems, Inc.
1798 Technology Drive, Suite 236
San Jose, CA 95110, USA

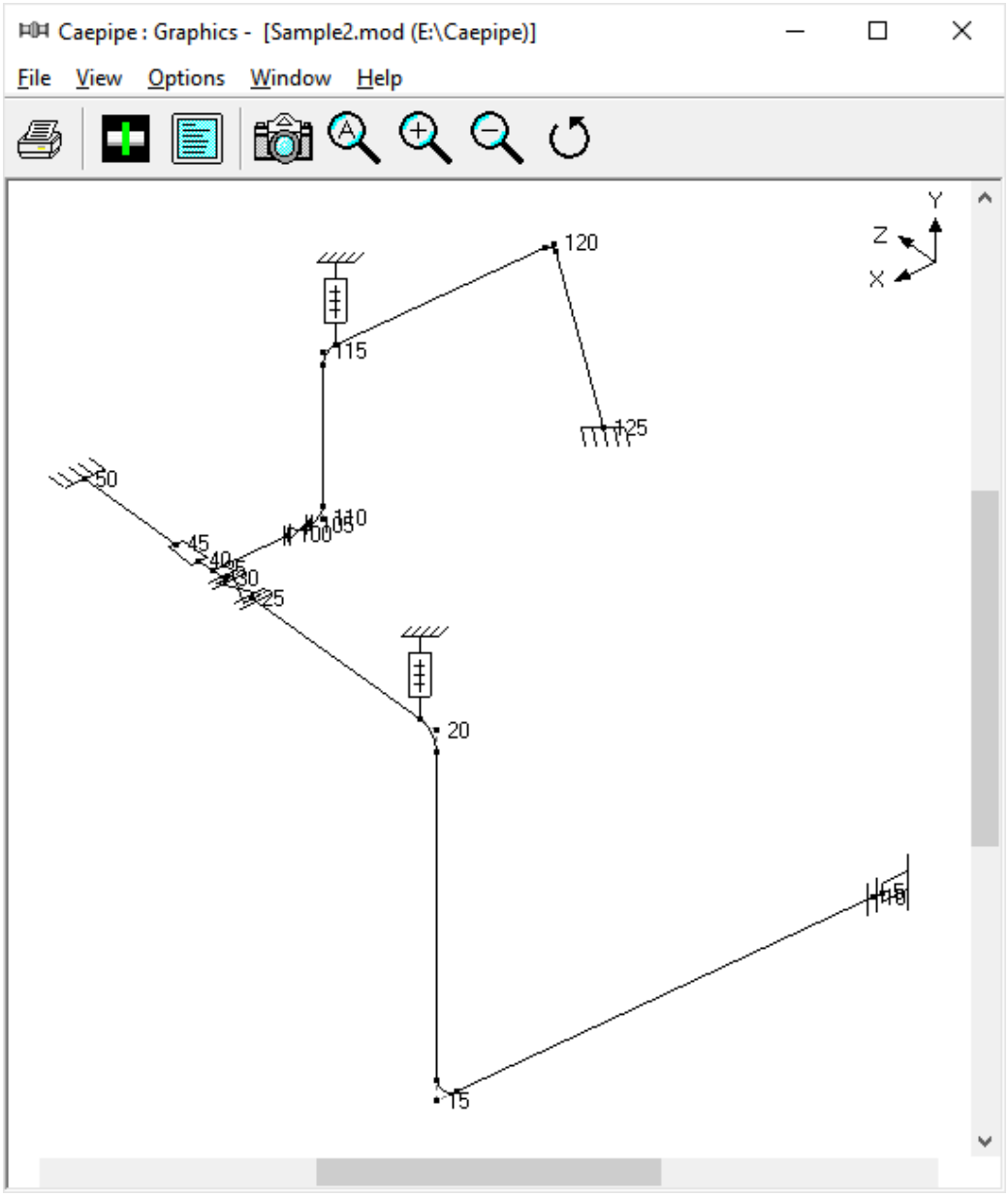
Tel: (408) 452 8111
Fax: (408) 452 8388

email: info@sstusa.com

www.sstusa.com

Modeling and Results Review – Problem 2

Let us model a slightly more advanced piping system now that you have familiarized yourself with the basic use of CAEPIPE via Tutorial 1. The details of the model (in SI units) 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 (different loads for different segments)
5. Select Load Cases for Analysis
6. Analyze
7. View Results

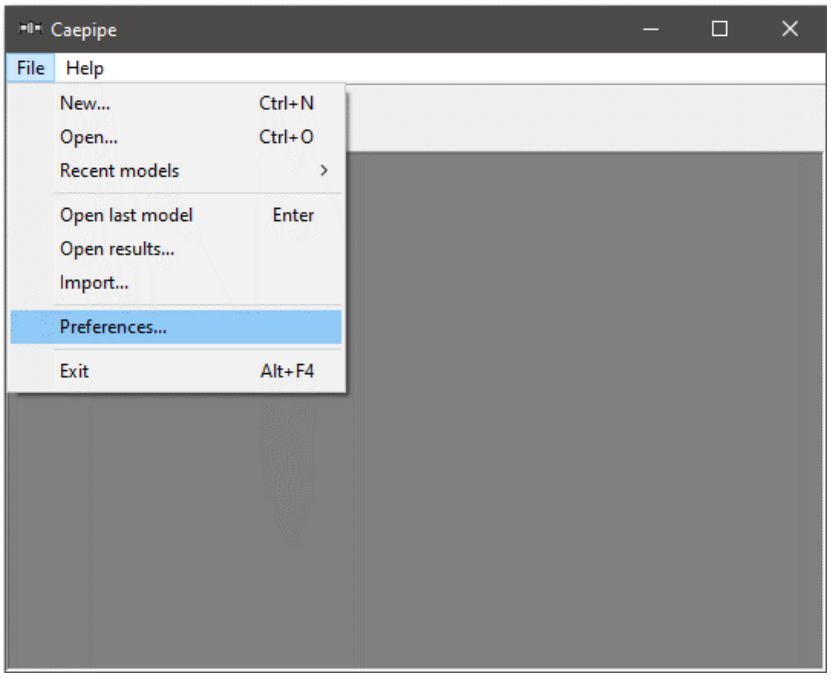
Modeling and Results Review – Problem 2

Model Description

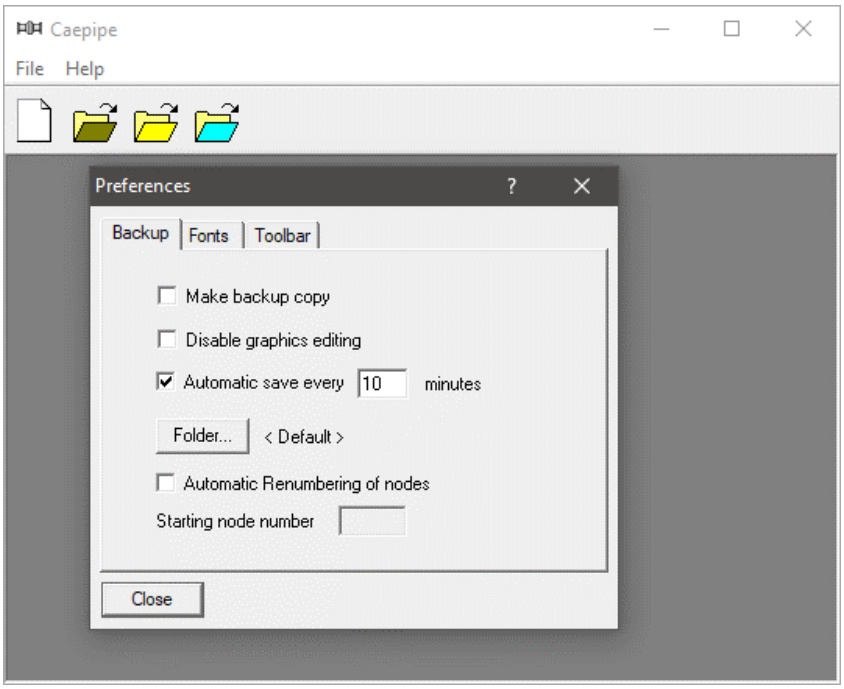
Details of the Layout, Material, Sections, Loads and Connection details are summarized for reference:

1. **Axes Chosen:** Global X = East, Global Y = Up and Global Z = South
2. **Piping Code:** ASME B31.1 (2020)
3. **Section Properties:**
    a. Main Line: 10" Schedule STD
    b. Branch Line: 6" Schedule STD
4. **Insulation throughout the Piping system**:
    a. **Density**: 176.2 kg/m3
    b. **Thickness**: 65 mm
5. **Material**: A 312 TP 316
6. **Temperature**:
    a. For Main Line and Branch Line up to Valve End Node 105:
    Operating Temperature = 185 Deg. C and Design Temperature = 230 Deg. C
    b. For Branch Line after Valve Node 105:
    Operating Temperature = 260 Deg. C and Design Temperature = 300 Deg. C
7. **Pressure**:
    a. For Main Line and Branch Line up to Valve End Node 105:
    Operating Pressure = 10 bar and Design Pressure = 15 bar
    b. For Branch Line after Valve Node 105:
    Operating Pressure = 32 bar and Design Pressure = 48 bar
8. **Operating Fluid and Specific Gravity**: Steam, 0.1
9. **Connection Details**:
    a. Node 5 connecting to Nozzle of a Cylindrical Vessel
    b. Node 50 connecting to Nozzle of a API 610 Horizontal Pump
10. **Wind Velocity**: 100 km/hr
11. **Static Seismic g's**: X=0.3, Y=0.2 and Z=0.3

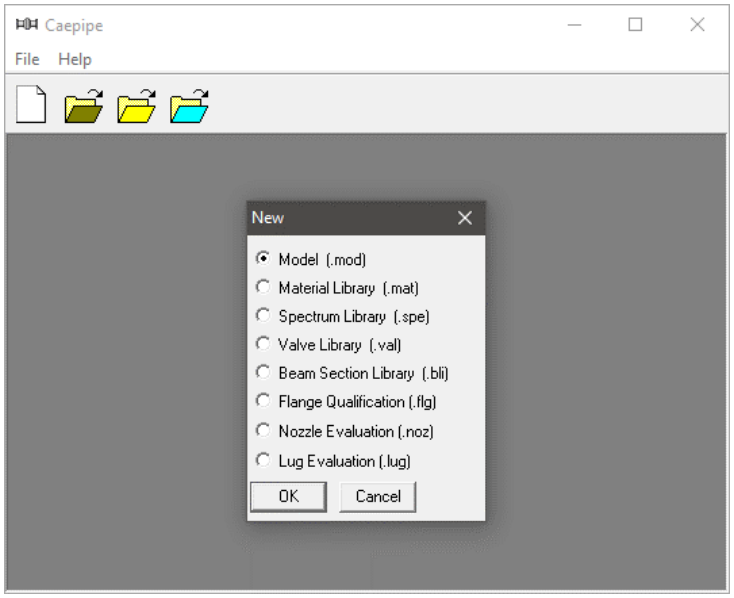
Start CAEPIPE. From the File pull down menu select Preferences.



Make sure that the Automatic save feature is enabled and the Automatic Renumbering of nodes feature is disabled.

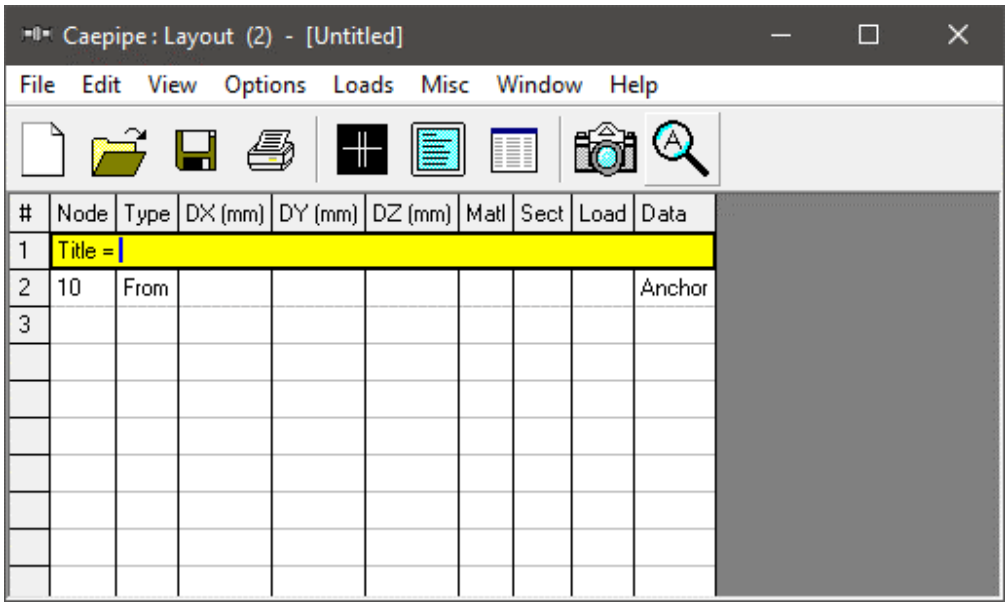


Start CAEPIPE. Then click on the New file button.

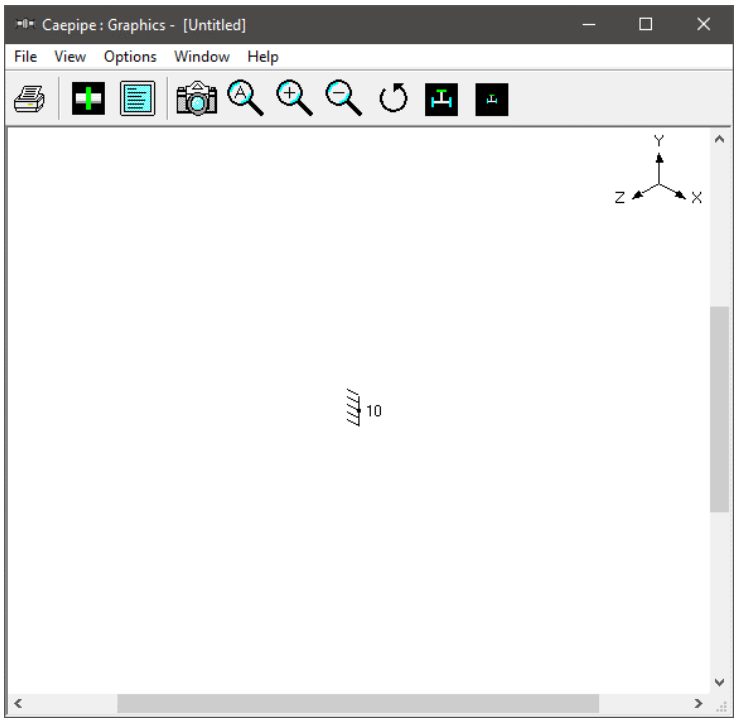


From the New file dialog, select the type of the new file as Model (.mod) file. This opens two independent windows: Layout and Graphics.

Layout window



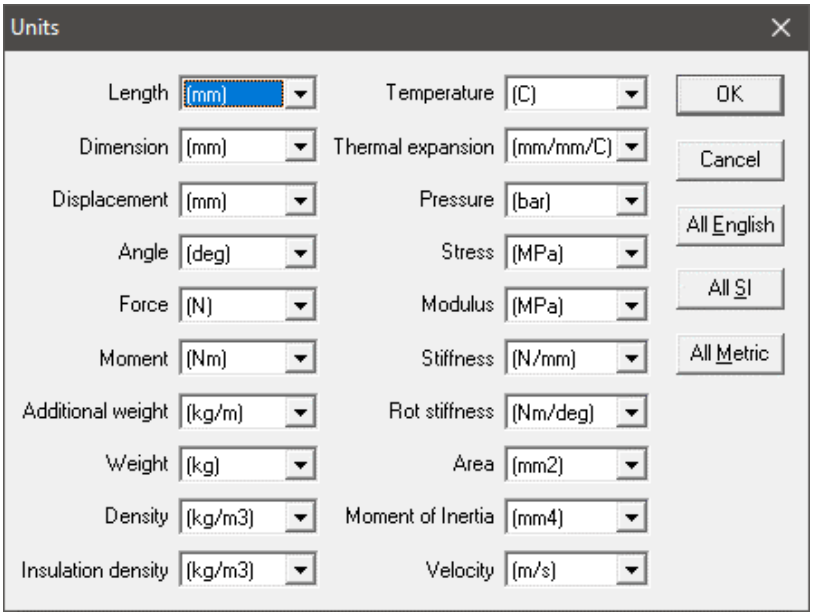
Graphics window



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

Change Units

As this is a SI/Metric model, change the units appropriately. From the layout window, click on Options menu > Units (alternately, press the hotkey Ctrl+U). Click on "All SI" button followed by OK. The layout window will show the offsets (DX/DY/DZ) in mm units.

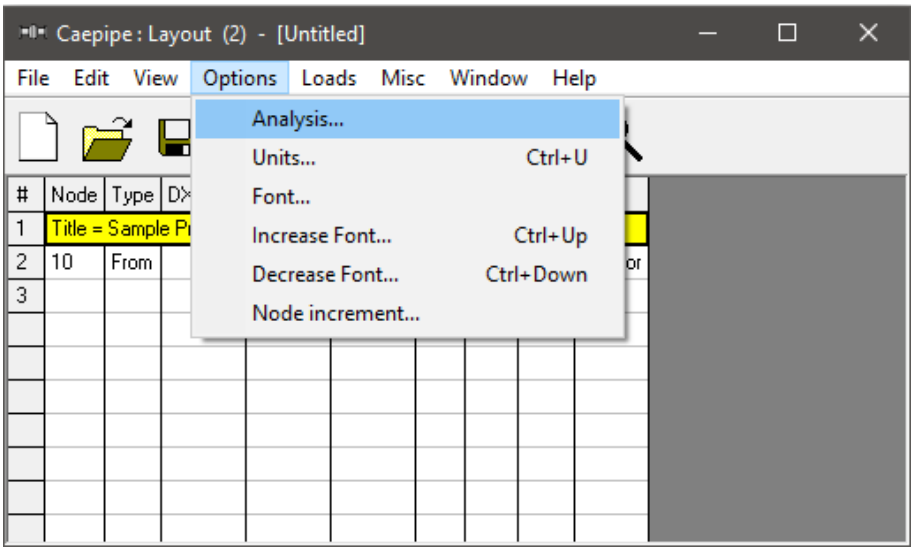


1. Enter Title

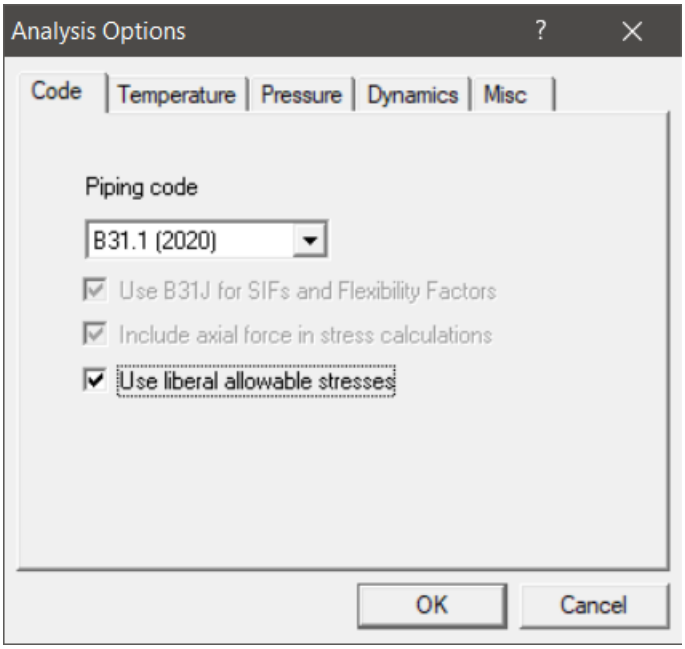
Type "Sample Problem 2" as the title in the first row that contains "Title = ". Press Enter.

2. Select Analysis options (piping code etc.)

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



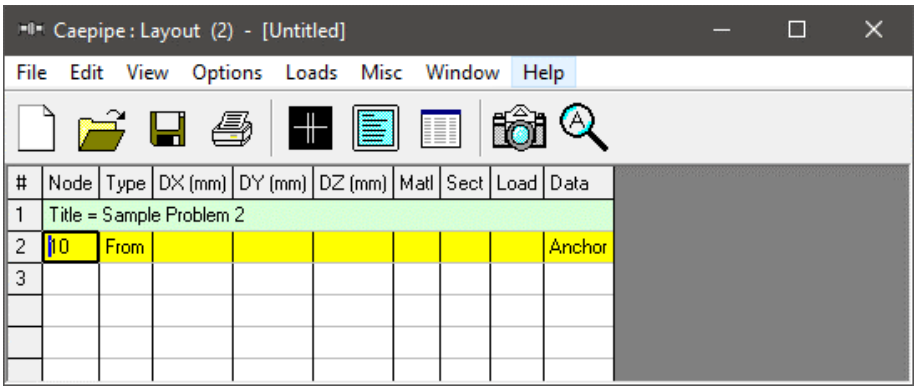
This opens the Analysis Options dialog.



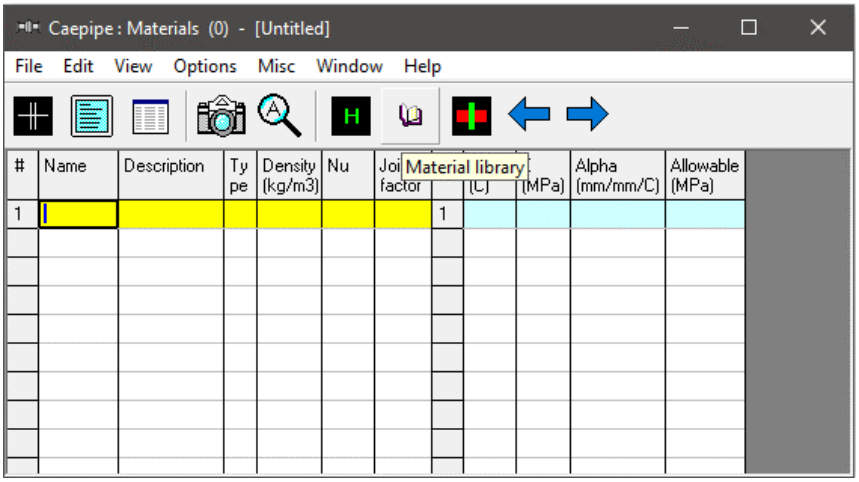
On the Code property page, select B31.1 (2020) for Piping code. Turn ON the option "Use liberal allowable stresses". Then click on OK to close Analysis Options dialog.

3. Define Material, Sections and Loads

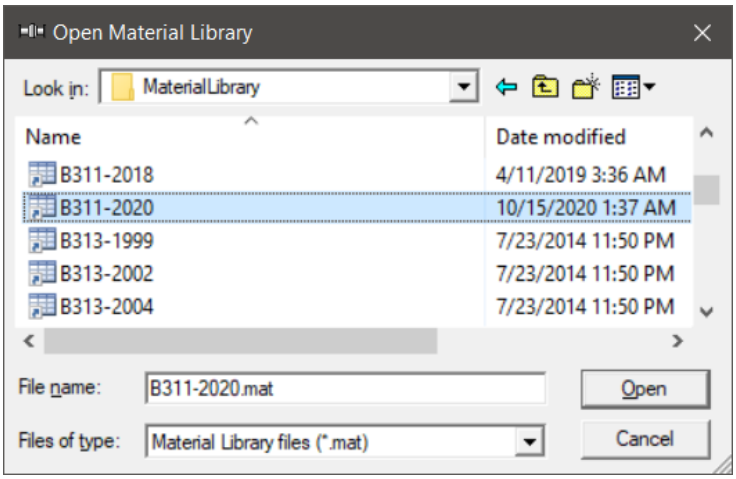
Click on "Matl" in the header in the Layout window (or press Ctrl+Shift+M)



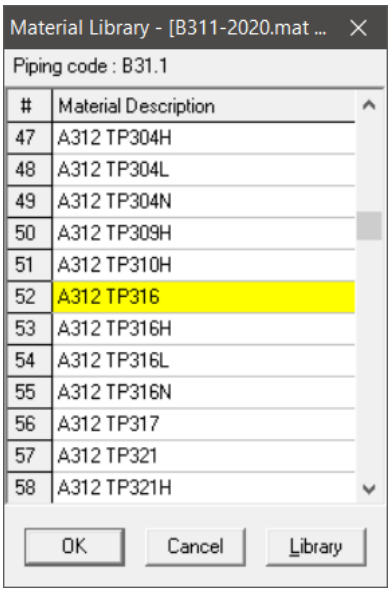
This opens up the Materials list in a separate List window. Position and resize the list window as you desire. Click on Library button on the Toolbar (or choose File > Library).



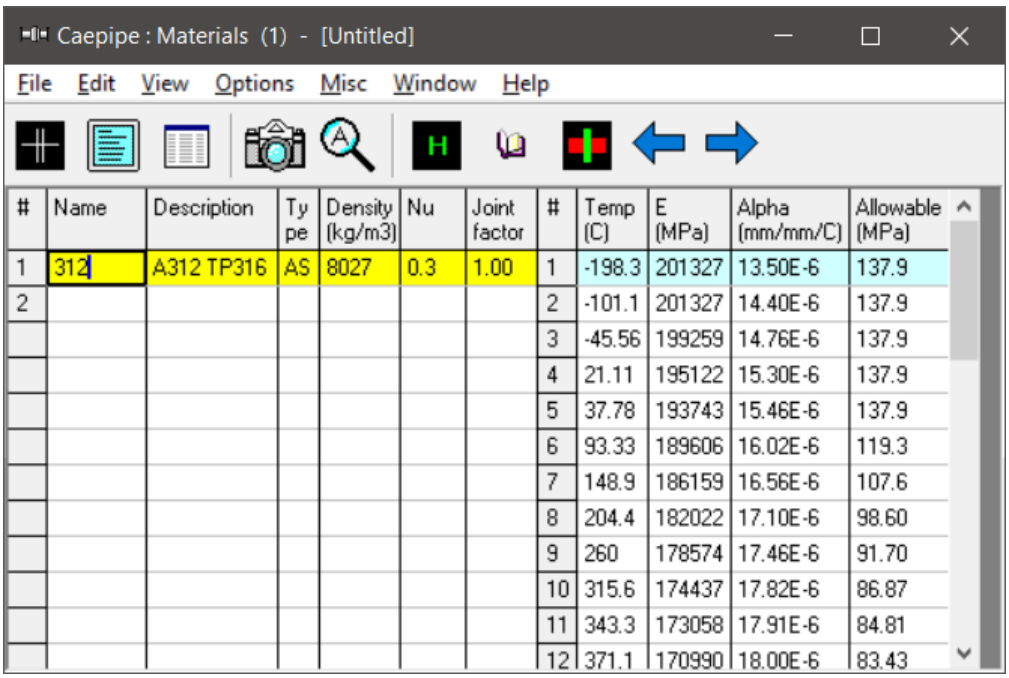
The Open Material Library dialog is shown. *If you don't see the folder shown below, then navigate to the Material Library folder under the CAEPIPE installed folder (usually C:\CAEPIPIE\xxxx, xxxx = version number).*



Select B311-2020.mat as the library file by double clicking on it. The available materials in the library are shown. Scroll down to A312 TP 316. Double click on it or click on OK to select it.

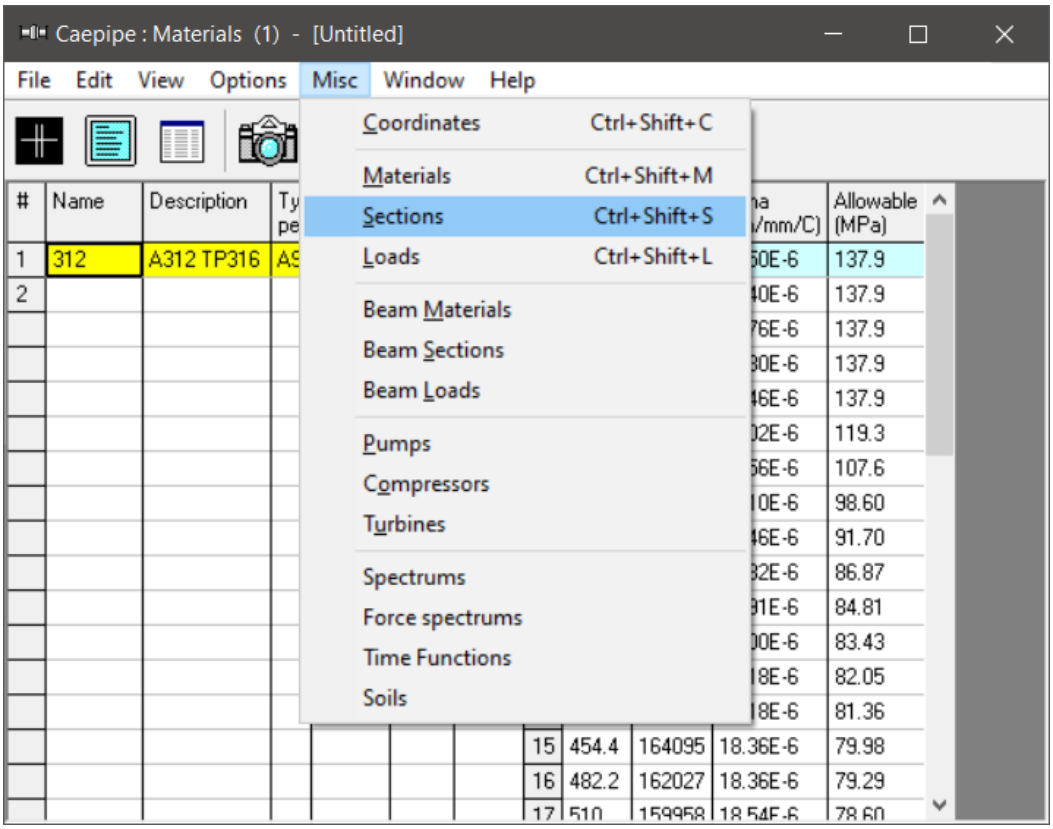


The properties for this selected material are transferred to the material in the List window. Type "312" for material name and then **press Enter**.

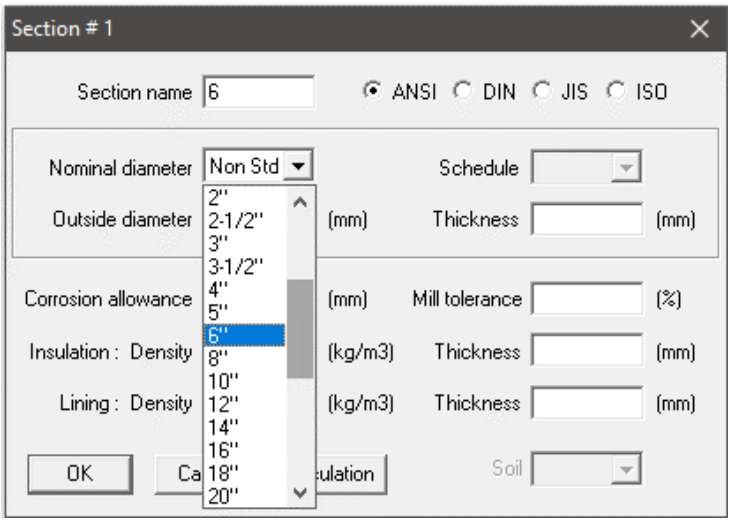


Sections

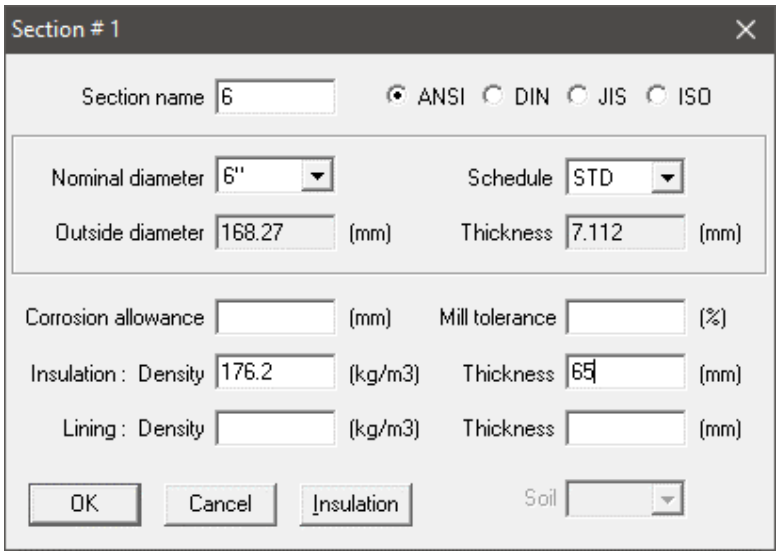
Select Sections from the Misc menu of the List window (or press Ctrl+Shift+S).



A list of Sections is shown. This system has three sections: 6", 8" and 10". To enter the first section, type '6' for Section name and press Enter. The Section Properties dialog is shown with the section name 6.



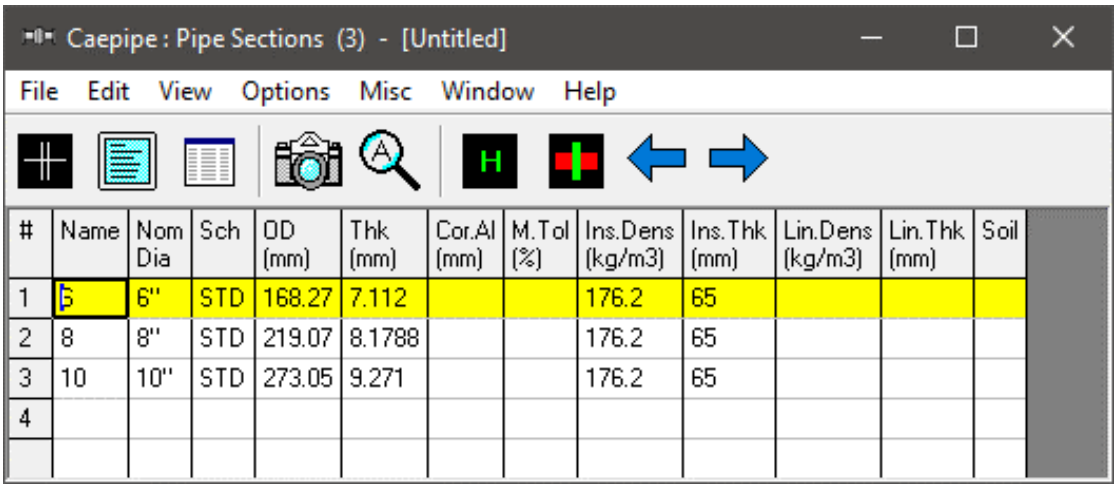
Click on the down arrow of the dropdown combo box for Nominal diameter and select 6" for Nominal diameter. Select/Enter other properties (STD thickness, Insulation density [Alt+I may be used for a list of insulation materials or you may enter your own density, in this case, 176.2 kg/cu.m] and thickness).



After entering all properties, press Enter or click on OK to enter the first section.

Now repeat the process for the 8" pipe section.

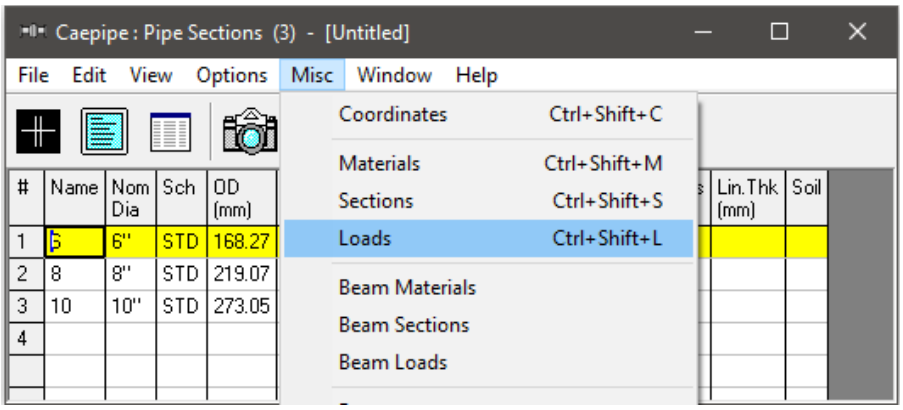
In row # 2, Type 8 for Section name and press Enter. The Section Properties dialog is shown with the section name 8. Select 8" for Nominal diameter, STD for Schedule, and same insulation properties as before for Insulation. Press Enter or click on OK to enter the second section. Do similarly for the 10" pipe section.



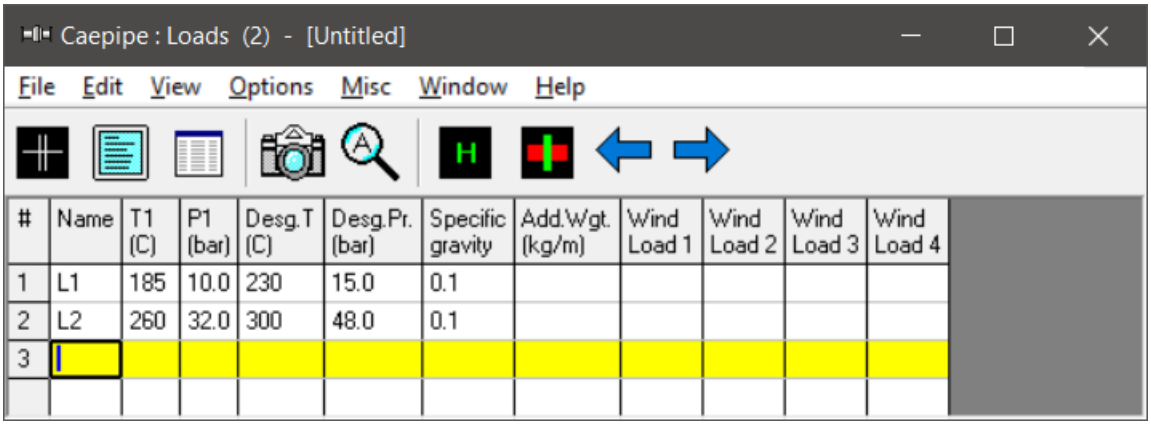
#	Name	Nom Dia	Sch	OD (mm)	Thk (mm)	Cor.Al (mm)	M.Tol (%)	Ins.Dens (kg/m3)	Ins.Thk (mm)	Lin.Dens (kg/m3)	Lin.Thk (mm)	Soil
1	6	6"	STD	168.27	7.112			176.2	65			
2	8	8"	STD	219.07	8.1788			176.2	65			
3	10	10"	STD	273.05	9.271			176.2	65			
4												

Load

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



The Loads list is shown. To enter the first load, Type 'L1' for Name, Tab to T1 and type 185, Tab to P1 and type 10 bar, tab to Desg.T and type 230, Tab to Desg.Pr. and type 15 and Tab to Specific gravity and type 0.1. 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). Similarly, enter the second load set "L2" {260°C, 32 bar, 300°C, 48 bar and Sp. Gravity = 0.1}.



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 10" main line first, followed by the 8" segment.

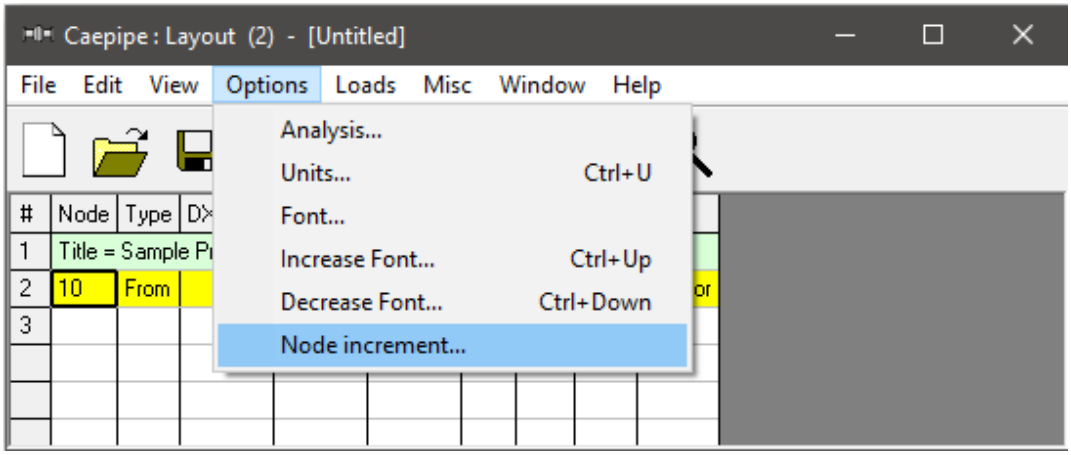
CONVENTIONS

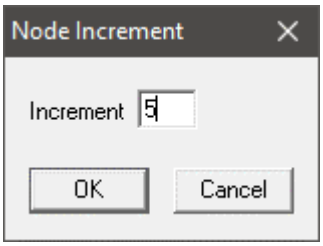
- In the following text, the word 'type' should be distinguished from the words 'Type column' or simply 'Type' (upper case 'T'). The former ('type') will mean press the keys on the keyboard. The latter word 'Type' will refer to the Type column in the Layout spreadsheet. Of course, occurrence of Type at the beginning of a sentence will mean "type" the keys.
- Also, the instruction "type B for Bend" does not necessarily mean the upper case 'B'. The lower case 'b' can also be typed.

- For items in the Data column (such as Anchor or Hanger), the cursor needs to be in the Data column. To move the cursor quickly to that column, press Ctrl+Shift+D from any column or click in the Data column. Or press the Tab key 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. Simultaneous feedback is one of the chief design intents in CAEPIPE.
- For mouse clicks, when you read the word "click on xxx," this means left-click on your mouse. For the context menu, if referred to, right-click.

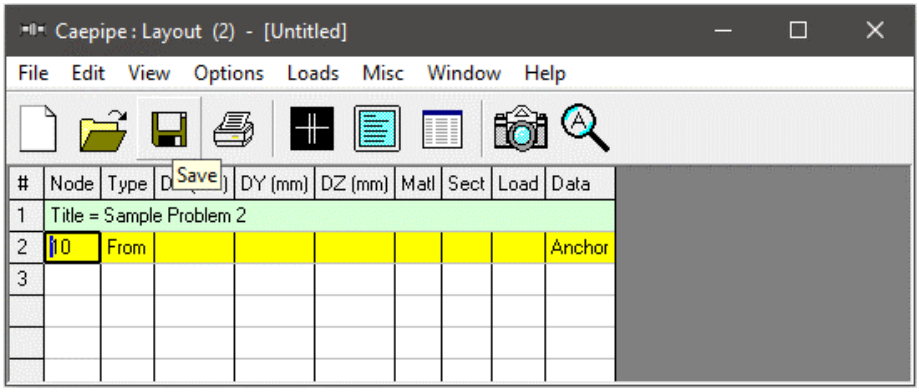
Change Node Increment

You might have noticed in the model drawing that the node numbering scheme has an increment of 5. CAEPIPE has a feature that allows you to specify a node increment. Select Options menu > Node increment…type 5 for value. Click on OK.

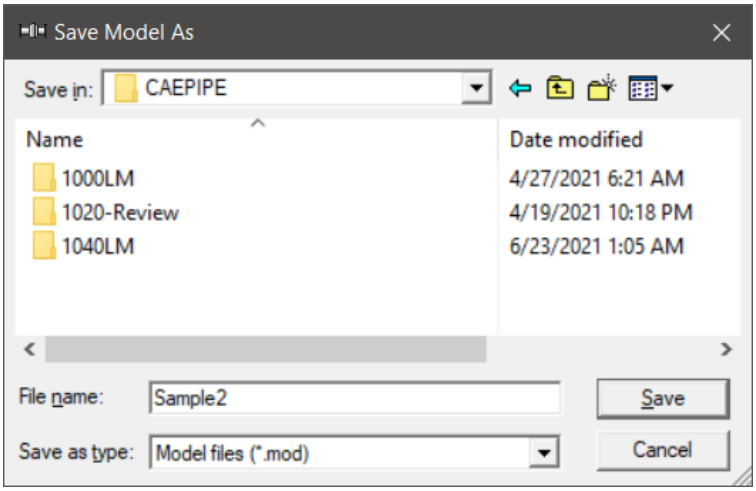




After defining the above parameters,  Save the model by clicking on the Save button.



The "Save Model As" dialog is shown.



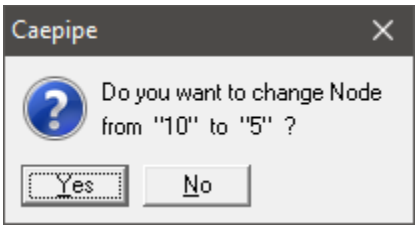
Type the File name as "Sample2" and press Enter to save the model.

First model the 10" Main line

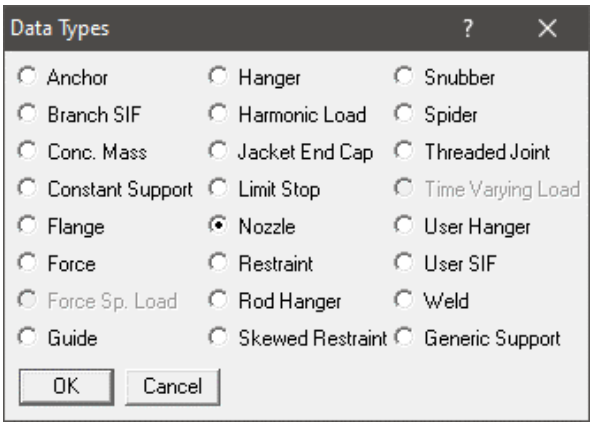
Following the Title at row #1, row #2 is already generated with Node 10 of Type "From" with an Anchor in the Data column.

Model information shows that the piping is connecting to a Nozzle of a Cylindrical Vessel with node number as 5. So, to account for the stiffness of the Nozzle protruding out of the Cylindrical Vessel, the nozzle portion is modeled as a pipe in this model. The junction of this Pipe (Nozzle) and the Shell is modeled as "Nozzle".

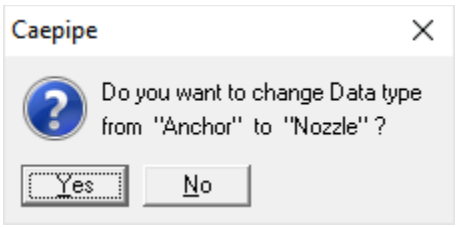
To change the Node number and to replace "Anchor" with "Nozzle", click on 10, press Backspace to erase 10, type 5. Press Tab to advance. Confirm the node number change when asked (by clicking on Yes, or simply pressing the Spacebar key on the keyboard).



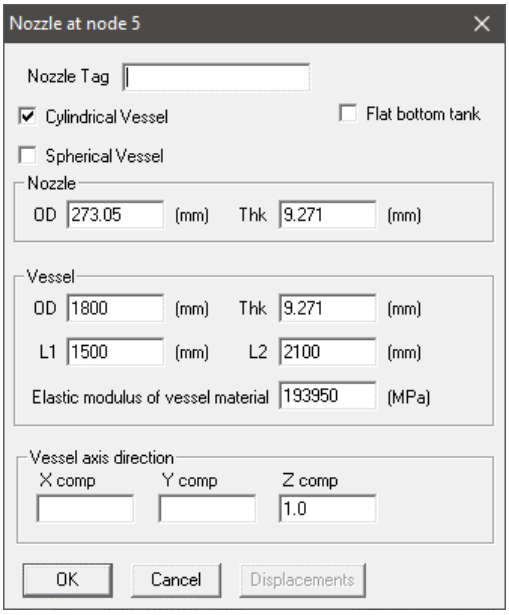
To replace the "Anchor" with "Nozzle", highlight the data type "Anchor" at row #2 using mouse left button and then click on "Data" in the header in the Layout window. From the "Data types" dialog box shown, select the new data type as "Nozzle".

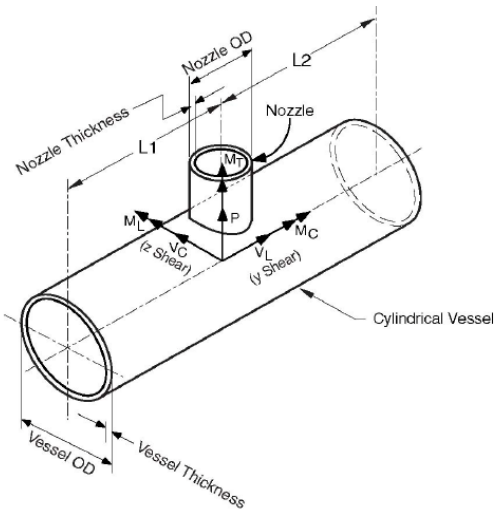


CAEPIPE will prompt as shown below. Press "Yes" to proceed.



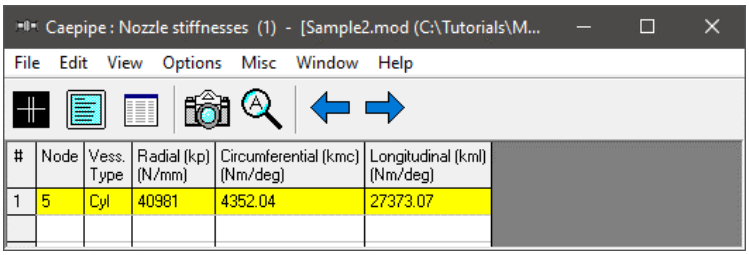
Enter the Nozzle and Vessel parameters as shown below and press "OK".



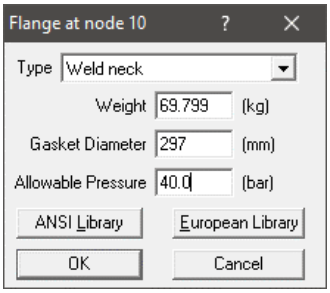


From the snap shots shown above, Lengths L1 and L2 on either side of the nozzle are the distances from the nozzle center line to the nearest location on vessel where the "ovalization deformation" of the vessel is stopped such as at a stiffener on the inner or outer surface of the vessel, or at the center of a saddle support to the vessel or at the junction to the torispherical enclosure (also called the head) or at a tube sheet inside the vessel etc.

Nozzle stiffness computed by CAEPIPE can be seen through Layout window > View > List > Nozzle Stiffnesses.

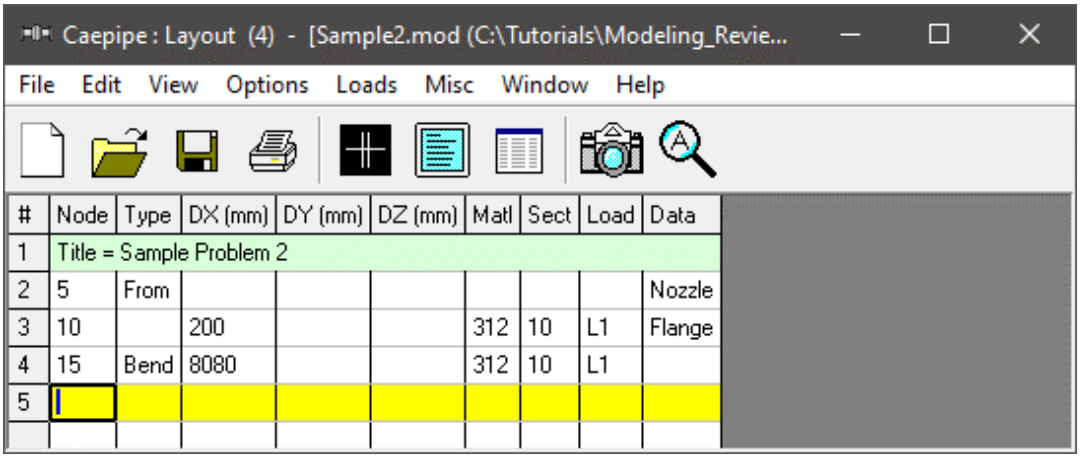


Now, press Enter to move the highlight to the next row (#3). Tab to the Type column. The next Node 10 is automatically assigned. Tab over to DX, type 200 (mm), Tab over to Material, press Enter to open the list of materials and select 312. Next Tab over to Section and press Enter. Select section 10 and press OK. Tab over to Load and press Enter, select L1 and click OK. Tab again to Data to input the flanges mating with the pipe and the equipment nozzle. Type "fl" to model flange and enter the data as shown below and press OK. CAEPIPE moves the highlight automatically to the next (new) row (#4).

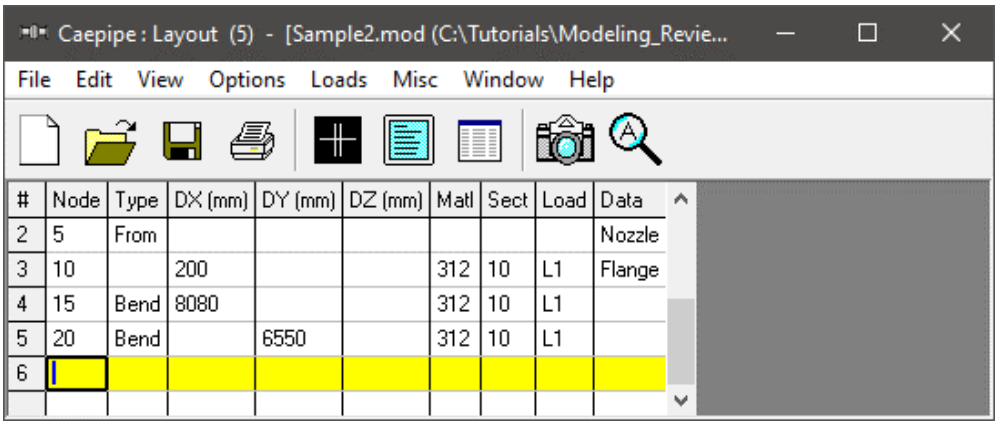


Tab to the type column. The next node 15 is automatically assigned.

Node 15 has a LR (long radius) bend (in CAEPIPE, a bend node is defined always at the tangent intersection point, being such, this node does not exist on the physical bend). Tab to the Type column; type "ben" to insert a default LR bend. Tab to DX, type in 8080 (mm), press Enter. CAEPIPE automatically enters the material, section and load from the previous row and moves the highlight to the next new row.



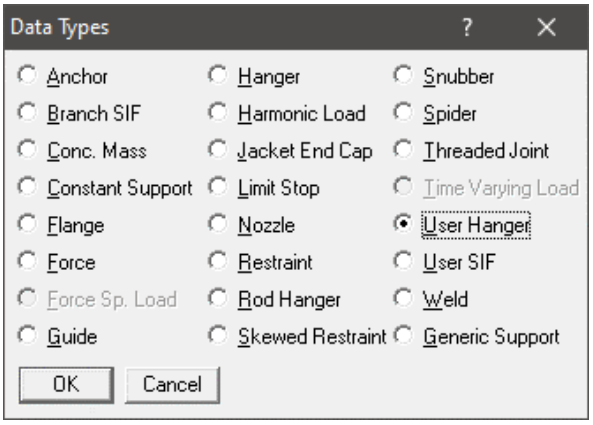
The following vertical bend (at node 20) can be modeled as before. Tab to Type (node 20 is automatically inserted), and type "ben" to insert a default LR bend, Tab again to DY, type 6550 (mm) and press Enter.



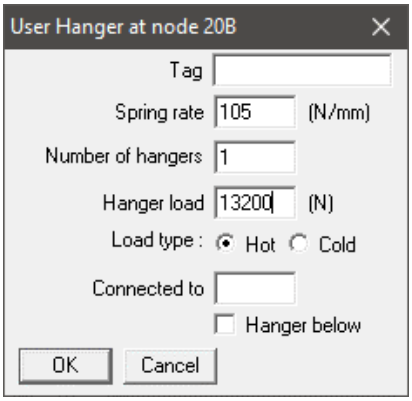
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6									

This bend has an already existing hanger (called "User Hanger" in CAEPIPE) at the far end, referred to as node 20B, an internally generated bend node.

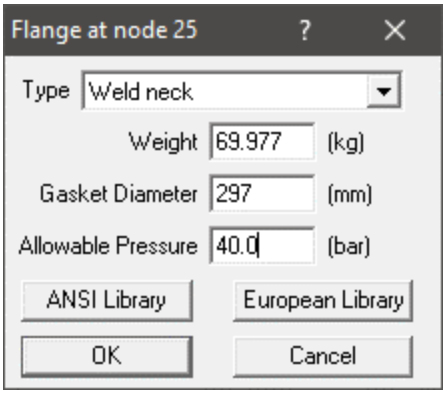
So, on the next row, type 20B for Node, Tab to Type, press "L" for Location, which spawns the available data types you can insert at this node. Pick "User Hanger" from the dialog.



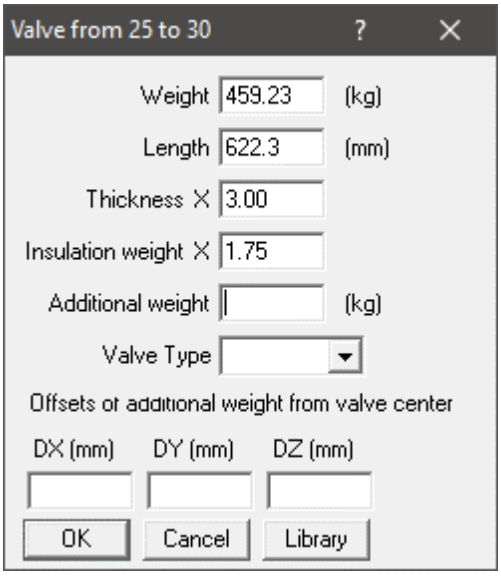
Enter its properties as shown. Click on OK.

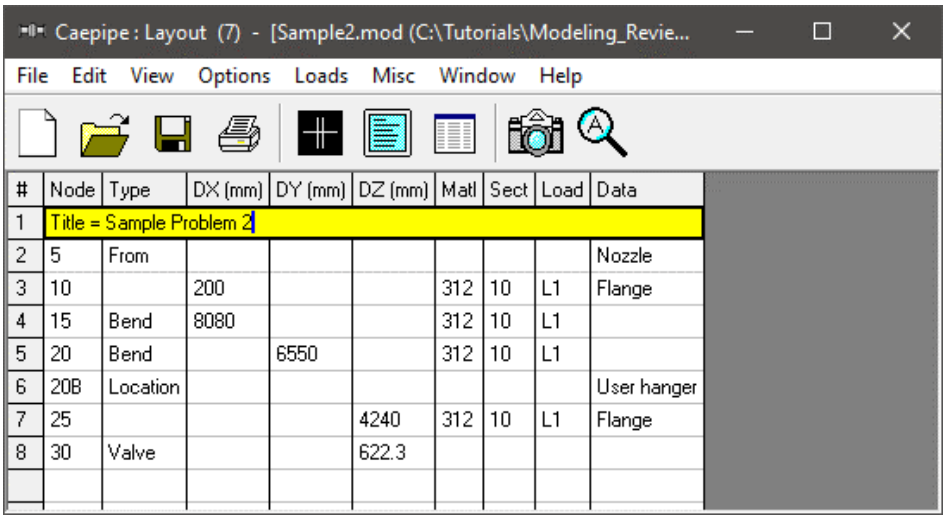


Next, the line moves in the Z direction to the flange node 25. Pressing Tab on the new row generates node 25 for you. Tab to DZ, type 4240, (click in Data column) or press Ctrl+Shift+D to move cursor to Data column. Type "fl" to open the Flange Data type dialog. Enter the details shown below and press OK.



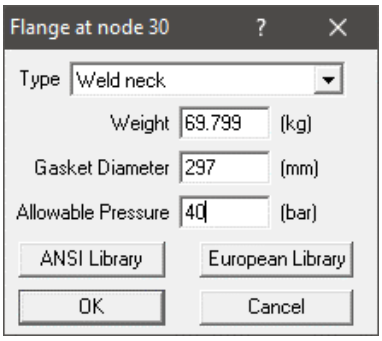
A valve is placed next from Node 25 to Node 30, where another mating flange is located. Pressing Tab on the new row generates node 30. Tab to the Type column; type "v" to insert a "Valve" and enter the data as shown below and press OK.



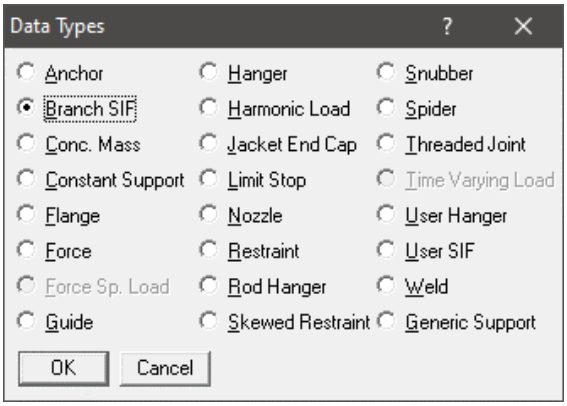


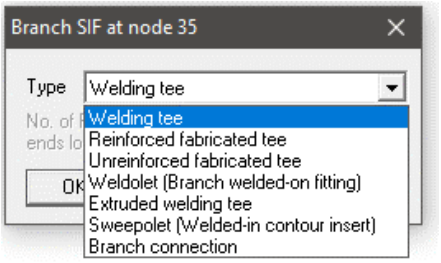
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
1	Title = Sample Problem 2								
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3				

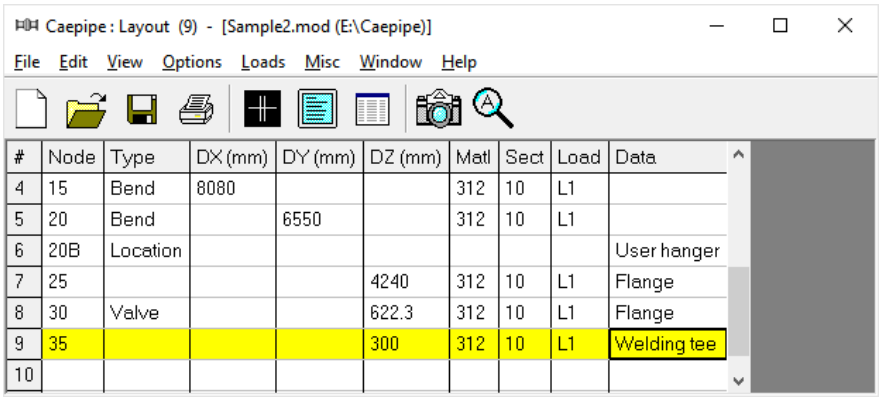
Tab to Data and type "fl" to enter a "flange". Type "fl" to open the Flange Data type dialog. Enter the details shown below and press OK.



Next model a pipe element till node 35 (welding tee). Press Tab for node 35, Tab to DZ, type 300, (click in Data column) or press Ctrl+Shift+D to move cursor to Data column. Type "br" (or right-click in Data, select Branch SIF) to open the Tee types Data type dialog. Select Welding Tee from the dropdown box. Click on OK (or press Enter).



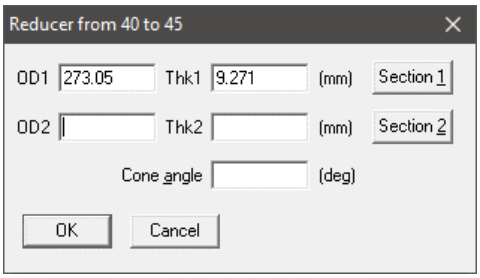




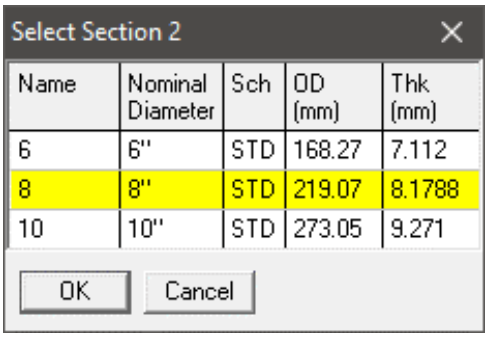
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10									

Next model a pipe element till node 40. Press Tab for node 40, Tab to DZ, type 300 and press Enter.

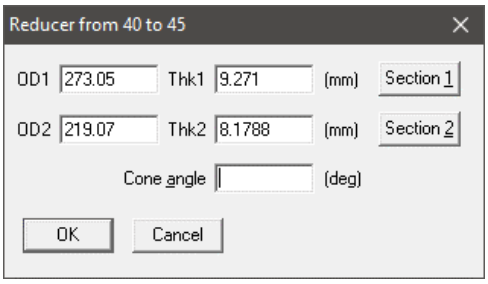
The next element is a 10x8 concentric reducer. Here is how to model it. Tab for the next node # (45), type "red" for Reducer in the Type column. CAEPIPE displays the Reducer dialog with the current section properties.



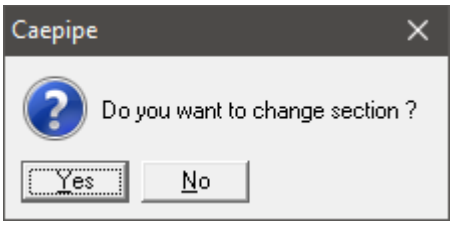
Click on "Section 2" button to select the following section, in this case, the 8" section. After placing the highlight on the 8" section, press Enter (or click on OK).

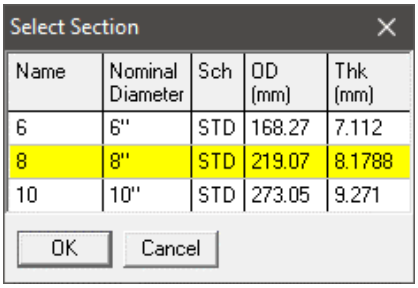


You are back at the Reducer dialog.

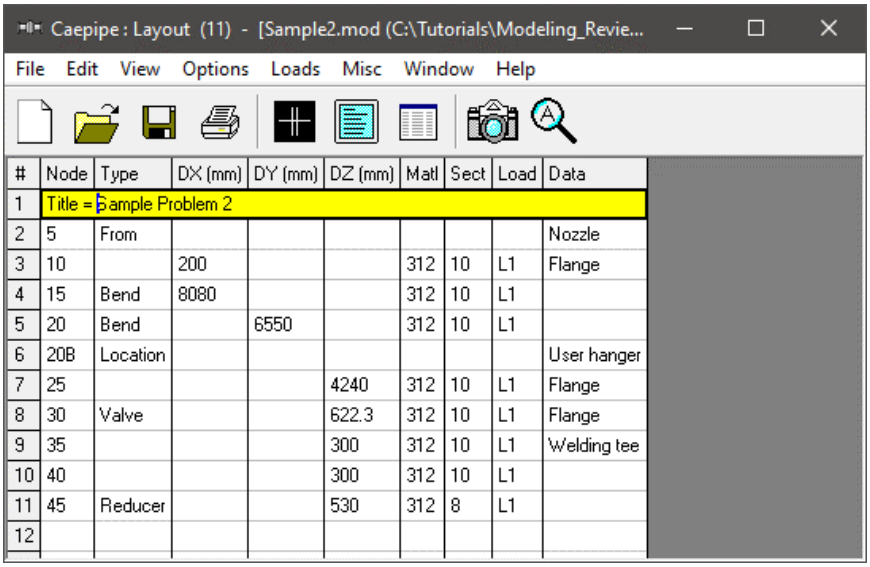


Click on OK to finish inserting the reducer. On the layout screen, type 530 for DZ and press Enter, at which point CAEPIPE wants you to confirm the section change. Click on Yes.



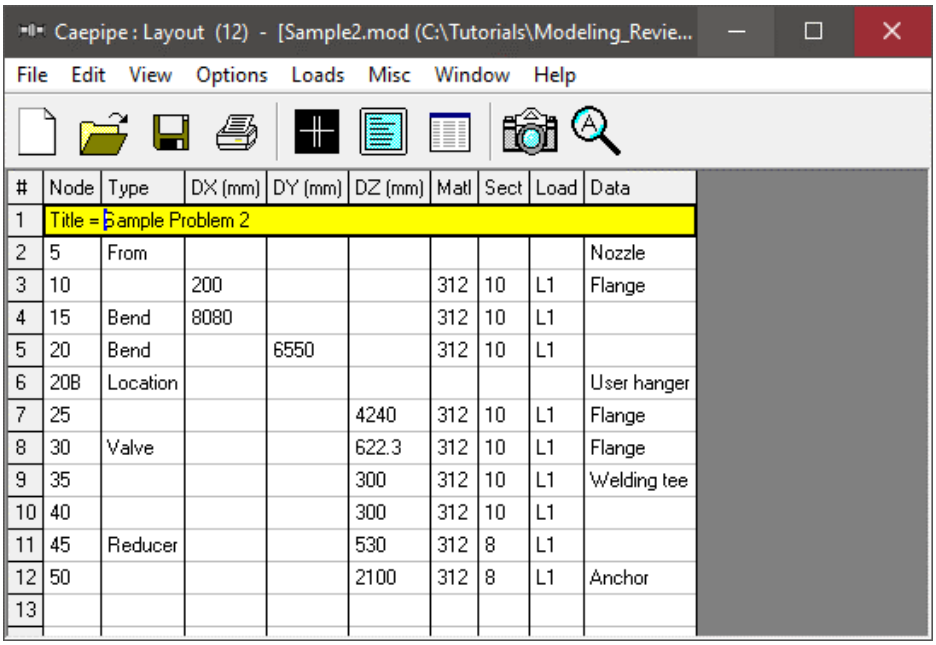


Then select 8 as the new section from here on. Press Enter to move to next row.



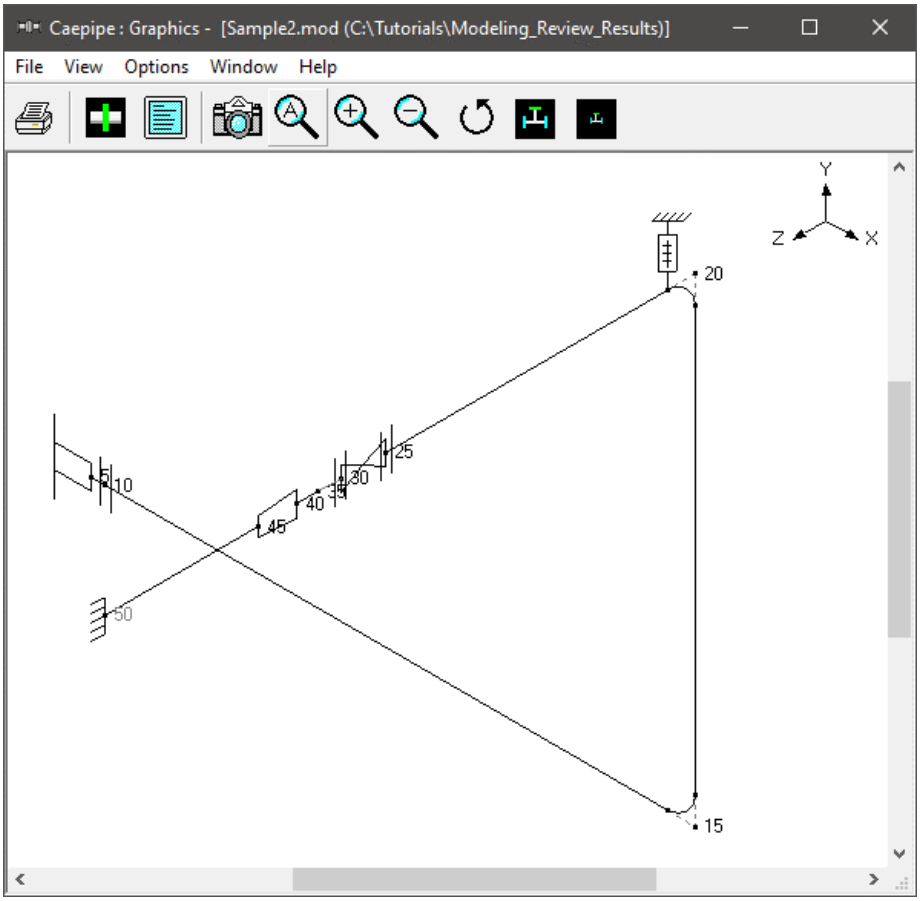
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
1	Title = Sample Problem 2								
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12									

The last element here is an 8" pipe that ends at node 50. As before, press Tab for Node 50, type 2100 for length in the same direction. Press Ctrl+Shift+D to go to Data and press A to insert a rigid anchor (note that CAEPIPE inserts the correct old material, new section and old load for this row).

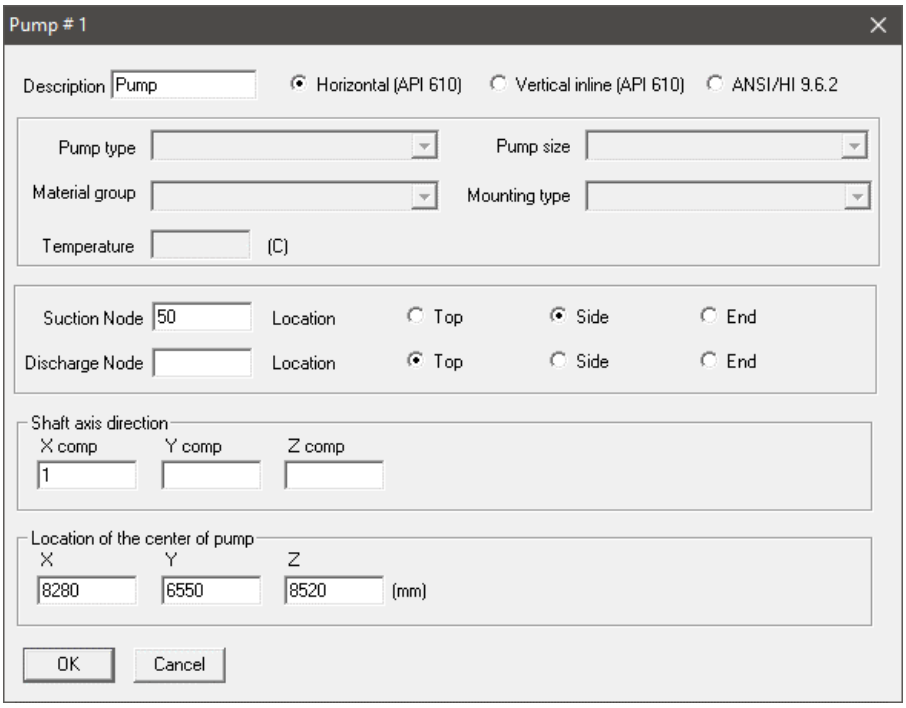


#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
1	Title = Sample Problem 2								
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13									

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

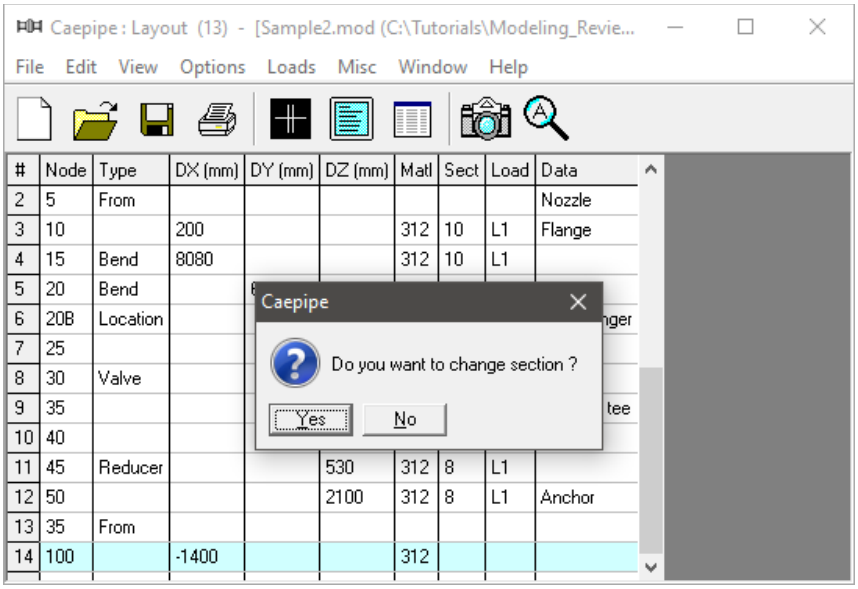


Node 50 is connecting to a Side Suction Nozzle of an API 610 Horizontal Pump. To model this, select the option "Pumps" through Layout Window > Misc. Double click on an empty row and enter the values as shown below. Once modeled, CAEPIPE will automatically perform the Pump Qualification and shows the report in Results.

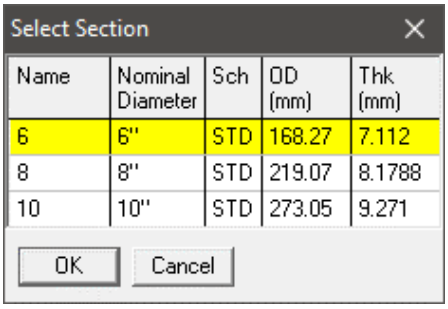


Now the 6" branch

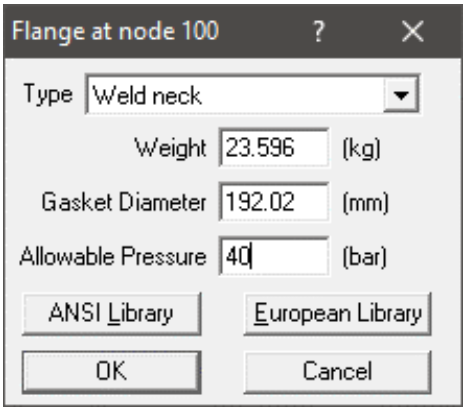
On the next row (#13), type 35 for Node, Tab to the Type column, type 'f' (for "From", since we are beginning a new branch from an existing Node 35), press Enter. In the next row (#14), type "100" in the Node column to clearly identify the new branch. Tab to DX and enter –1400. CAEPIPE inserts the previous 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 Section selection dialog.

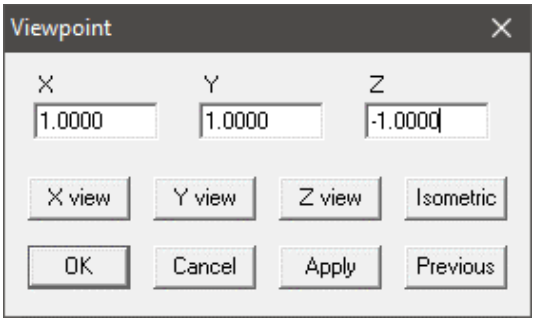


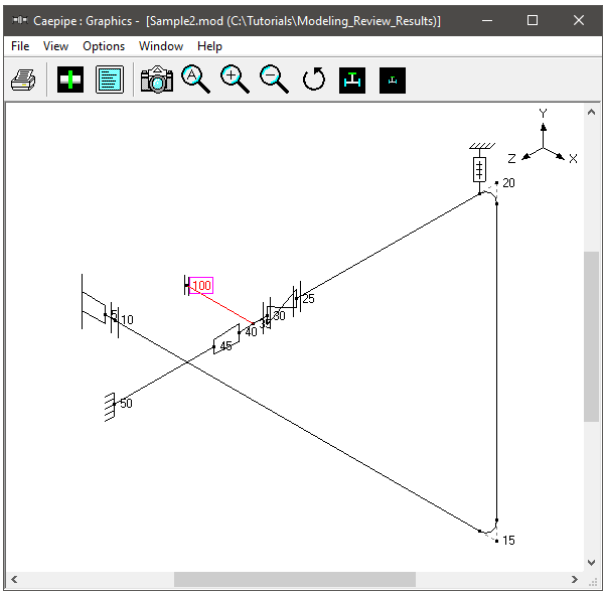
Select the 6" section by double clicking on it. The section (6) is entered in the Section column in the Layout window. The load is again automatically inserted from the previous load. Lastly, type "fl" in the Data column and hit enter to create a mating Flange. This will bring up the Flange type dialog box.

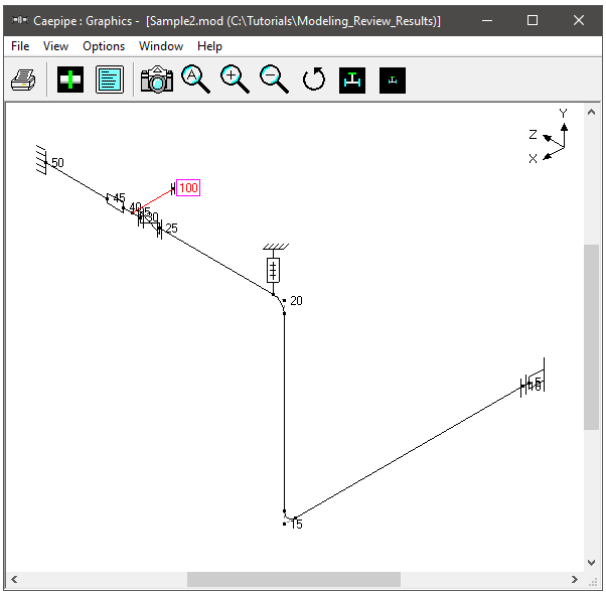


Type in 23.596 for Weight, 192.02 for Gasket Diameter, 40 for Allowable Pressure and click Ok.

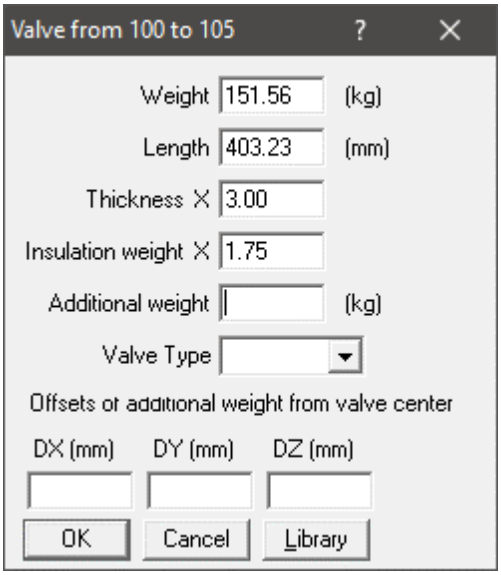
The graphics window will look like this. For better view, rotate the model by clicking the icon  and scrolling the horizontal scroll bar towards left using the mouse left button or through keyboard left arrow key. Alternatively, you can specify the viewpoint as shown below by selecting the icon  from the graphics frame.





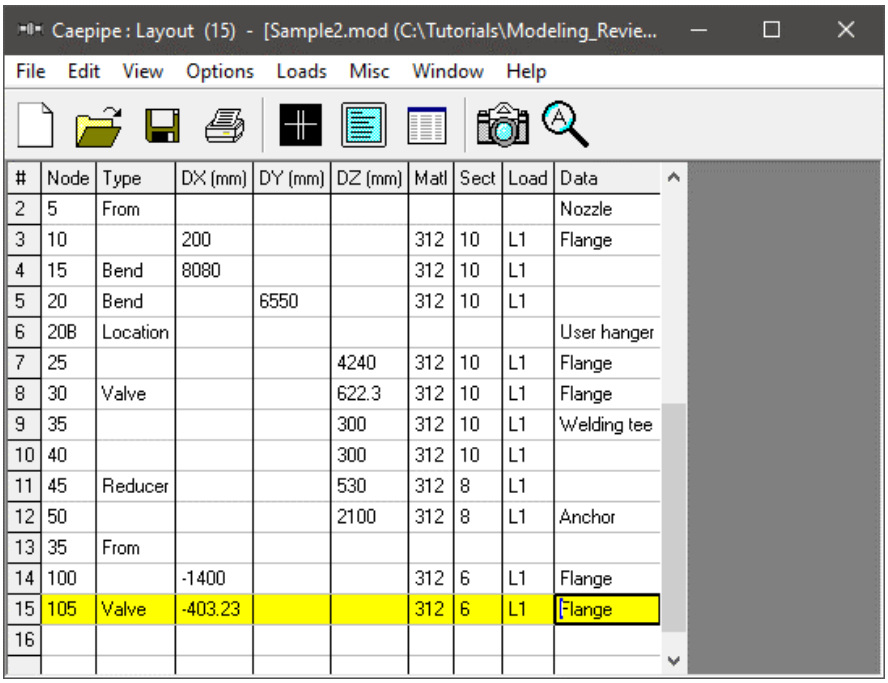


In the next row (#15), Tab to the Type column. The next Node 105 is automatically assigned. In the Type column, type 'v' (for Valve). This brings up the Valve dialog box.



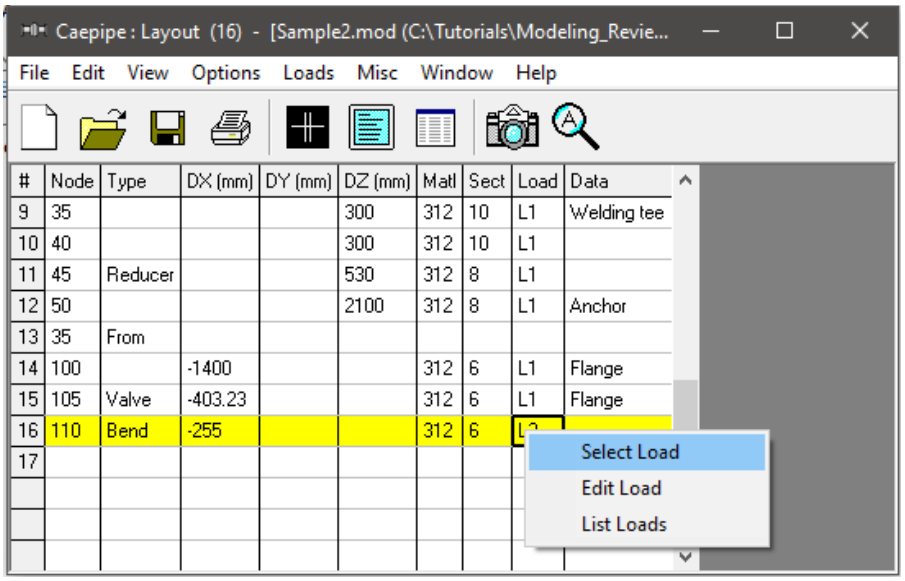
In the Valve dialog box, type 151.56 for Weight, 403.23 for Length, 3.00 for Thickness, and 1.75 for Insulation weight. Then press Enter or click on OK to input the valve. Press Enter again. You will see that the DX, Material, Section and Load information is automatically input in the Layout window.

You can now copy the flange along with data from Node 100 and paste it at Node 105. To perform this, highlight row # 14 and press Ctrl+C. Then move the cursor to Data column of row #15 and press Ctrl+V to paste the flange. Press Enter to move to the next row.



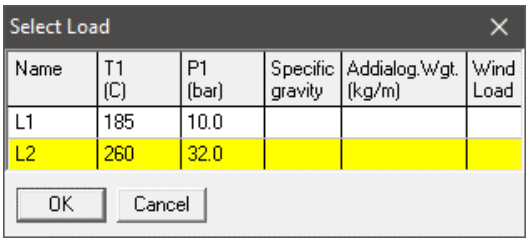
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13	35	From							
14	100		-1400			312	6	L1	Flange
15	105	Valve	-403.23			312	6	L1	Flange
16									

In the next row (#16), Tab to the Type column, type "ben" to create a Long Radius Bend and then Tab to the DX column. The default LR Bend is automatically input when you Tab over. In the DX column type –255 and hit Enter. The Material, Section and Load information and is automatically input. As the Temperature and Pressure is changing from this element, change the Load from L1 to L2 by right clicking on the "L1" in the Load field.



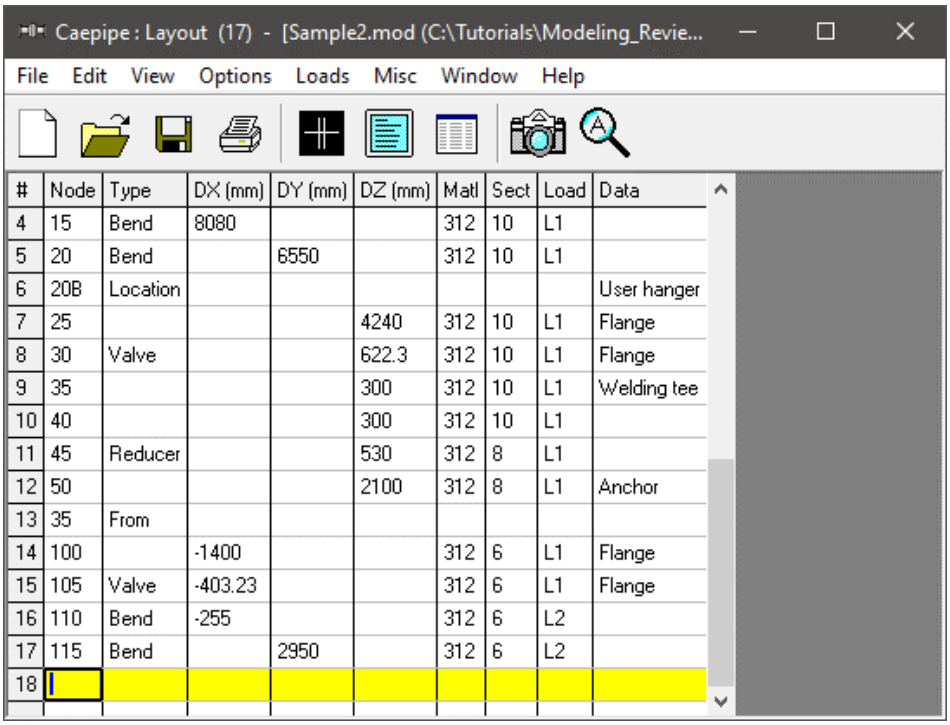
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13	35	From							
14	100		-1400			312	6	L1	Flange
15	105	Valve	-403.23			312	6	L1	Flange
16	110	Bend	-255			312	6	L2	
17									

This will bring up a small Context menu from which you will choose Select Load. This will bring up the Select Load window. Highlight L2 and click Ok. Press Enter to complete inputting Node 110 at row (#16).

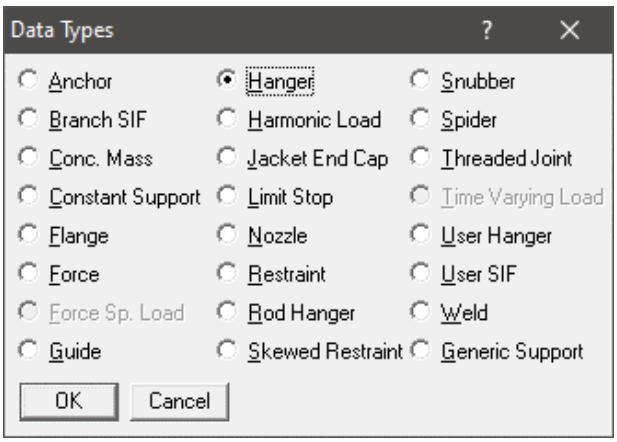


In the next row (#17), create another Long Radius Bend just like the one in row (#17), except change the DX -255 to DY 2950 and press Enter.

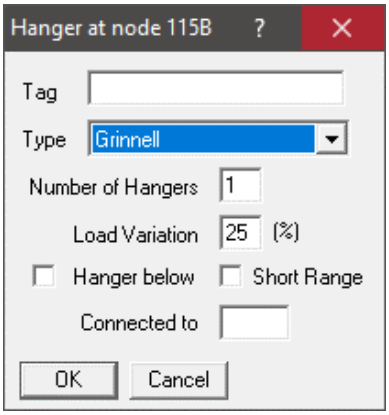
Your Layout window should look like this.



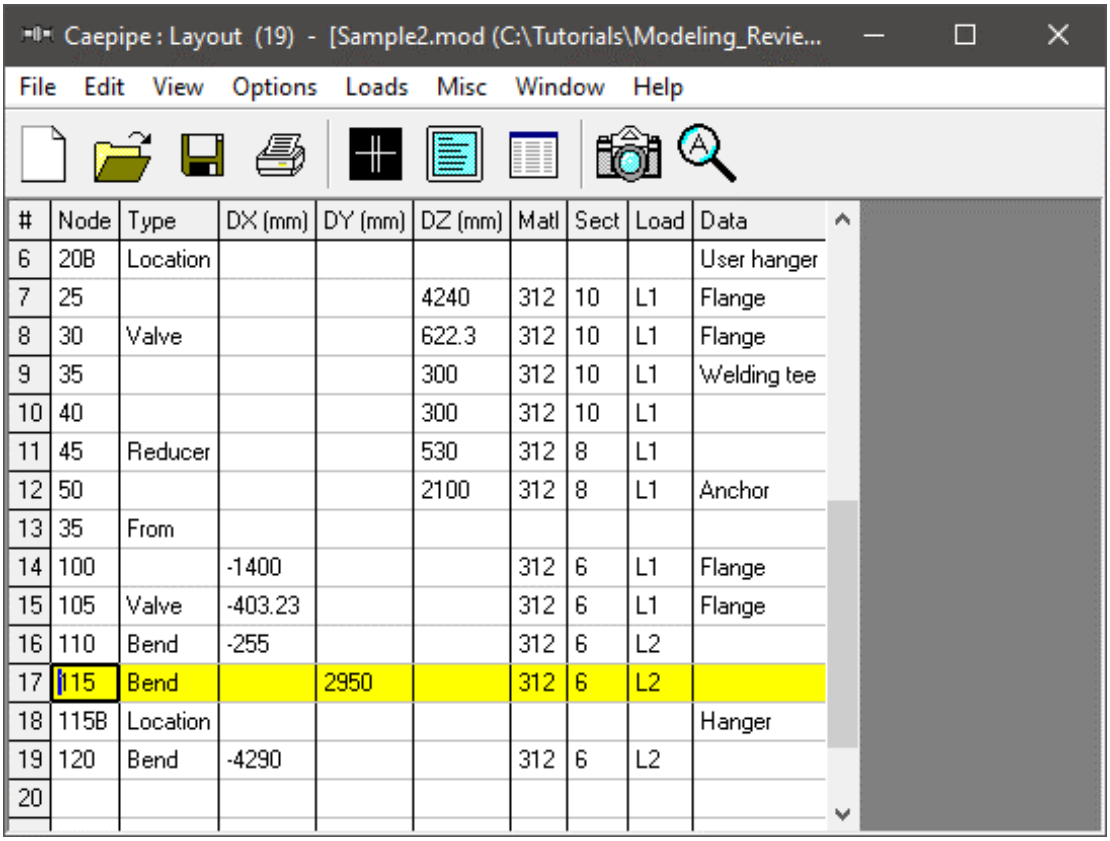
Start the next row (#18) by typing 115B in the Node column. Tab to the Type column and type "L" to specify a Location type. This will automatically open the Data Types dialog box. Select Hanger.



Another dialog box will appear with specific Hanger type input options. Keep the default settings and click OK.

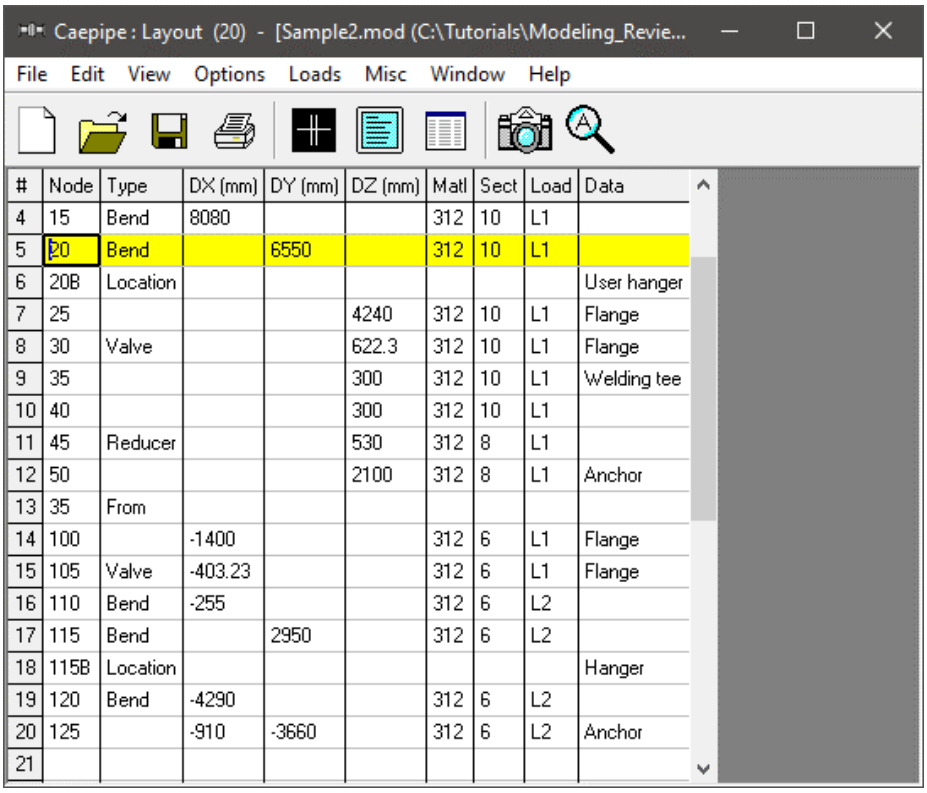


At Node 120 on the next row (#19), Tab to the Type column and input a default LR Bend by typing "ben". Tab to the DX column and input –4290 and press Enter.



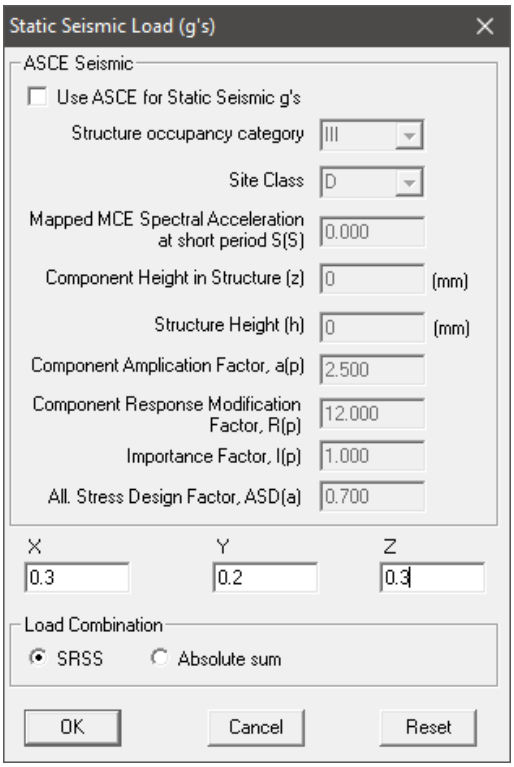
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13	35	From							
14	100		-1400			312	6	L1	Flange
15	105	Valve	-403.23			312	6	L1	Flange
16	110	Bend	-255			312	6	L2	
17	115	Bend		2950		312	6	L2	
18	115B	Location							Hanger
19	120	Bend	-4290			312	6	L2	
20									

On the next row (#20), Tab over to the DX column and input -910, then in DY input –3660. Create an Anchor in the Data column by either pressing Ctrl+Shift+D or Tabbing to the Data column and typing "a". Press Enter and you are done with Layout window input.

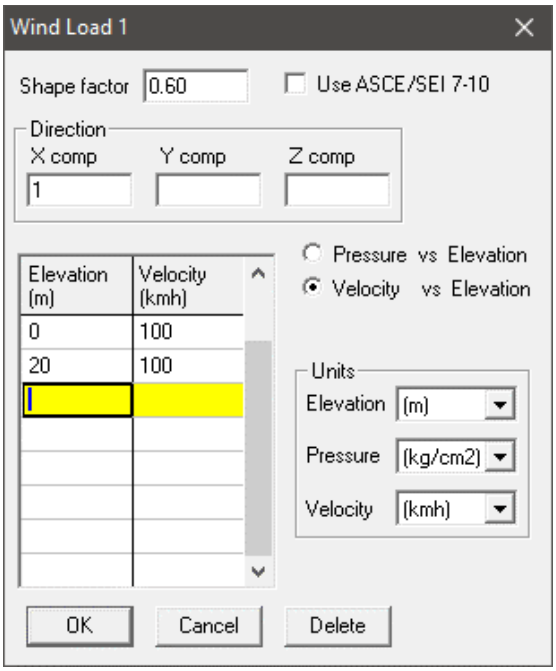


#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13	35	From							
14	100		-1400			312	6	L1	Flange
15	105	Valve	-403.23			312	6	L1	Flange
16	110	Bend	-255			312	6	L2	
17	115	Bend		2950		312	6	L2	
18	115B	Location							Hanger
19	120	Bend	-4290			312	6	L2	
20	125		-910	-3660		312	6	L2	Anchor
21									

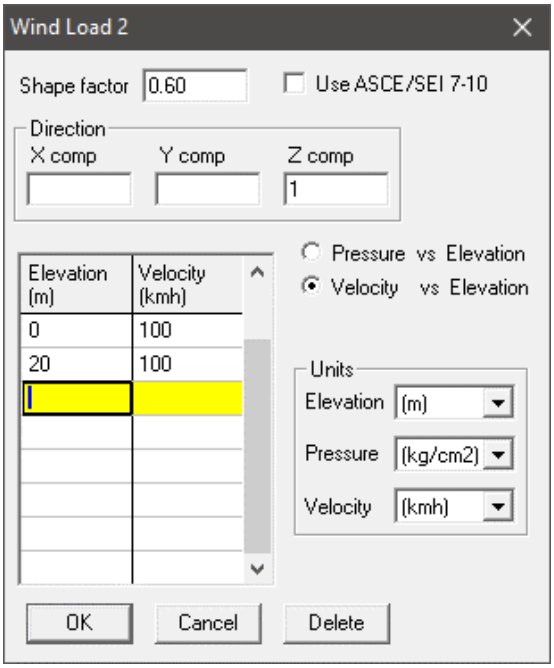
Define "Static seismic" through Layout Window > Loads > Static Seismic. Enter the value as shown below.



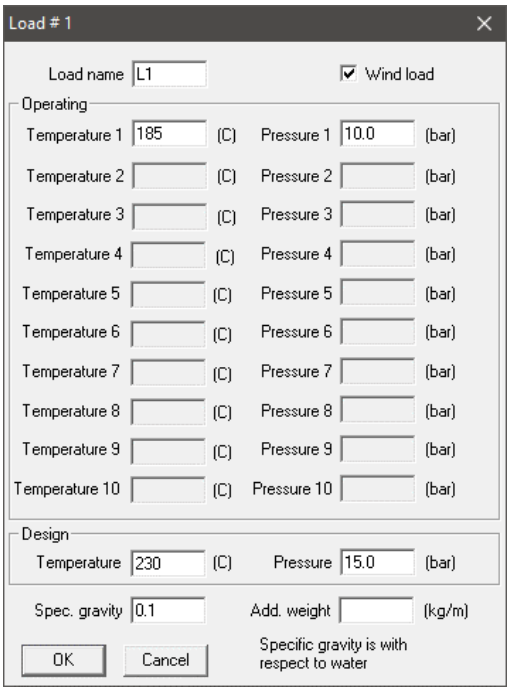
Let us define "Wind Load" profile in +X direction through Layout Window > Loads > Wind 1 and enter the data as shown below and press OK. The maximum elevation of 20m is chosen so that the entire piping system experiences wind load.



Similarly, define "Wind Load" profile in +Z direction through Layout Window > Loads > Wind 2 and enter the data as shown below and press OK.



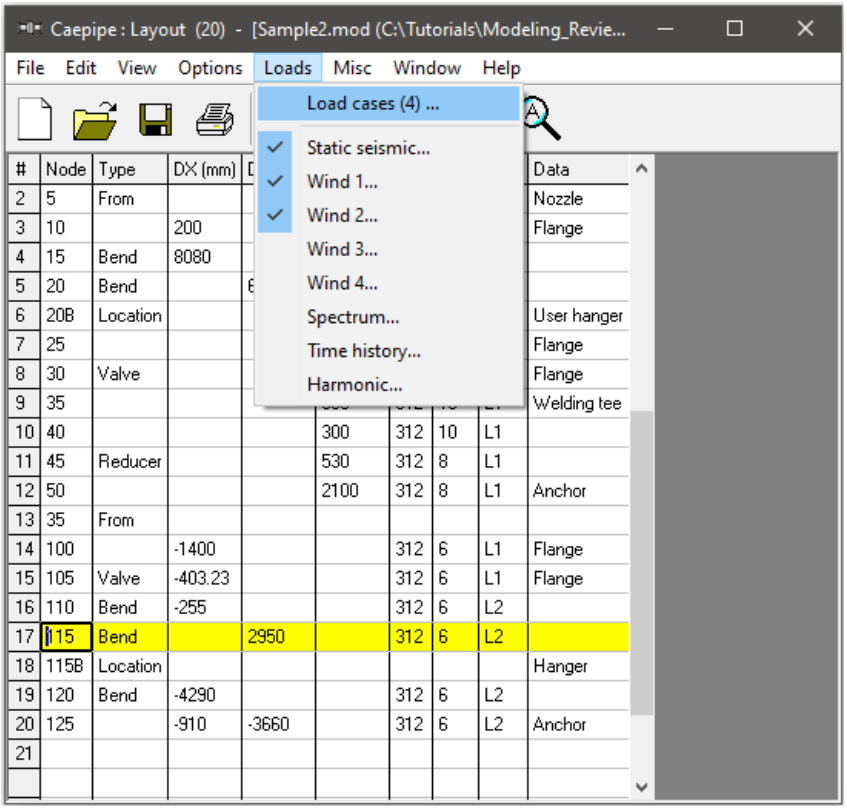
Assign the Wind Load defined above to the stress layout through Layout window > Misc > Loads and then double click on the Loads "L1" and select the check box "Wind load" as shown below.



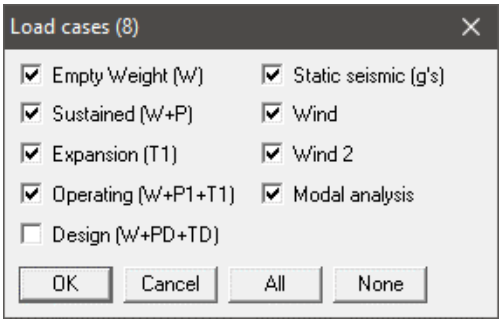
Similarly, select the check box "Wind load" for "L2".

5. Select Load Cases for Analysis

Select Loads cases from the Loads menu.



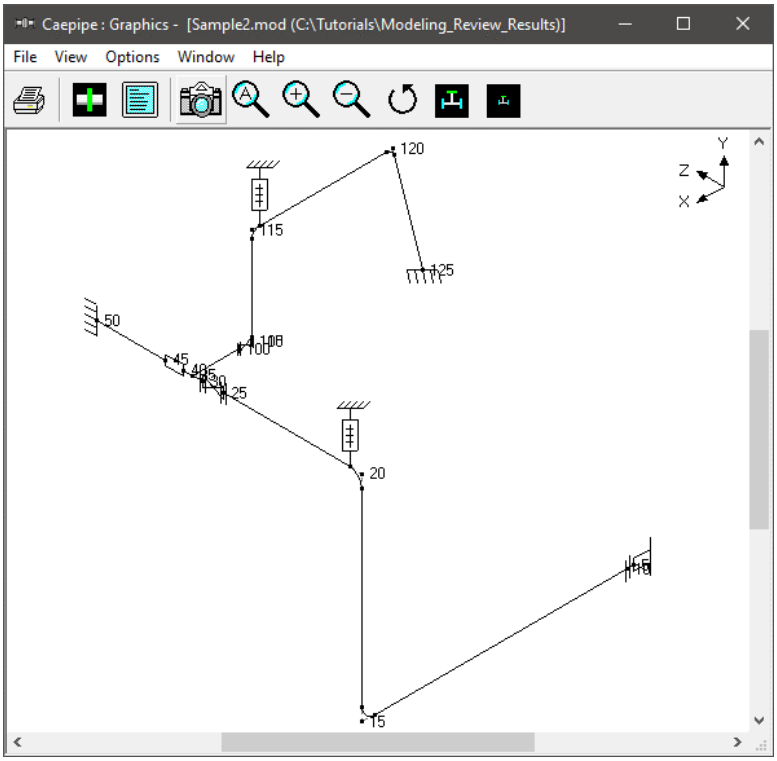
The Load cases dialog is shown.

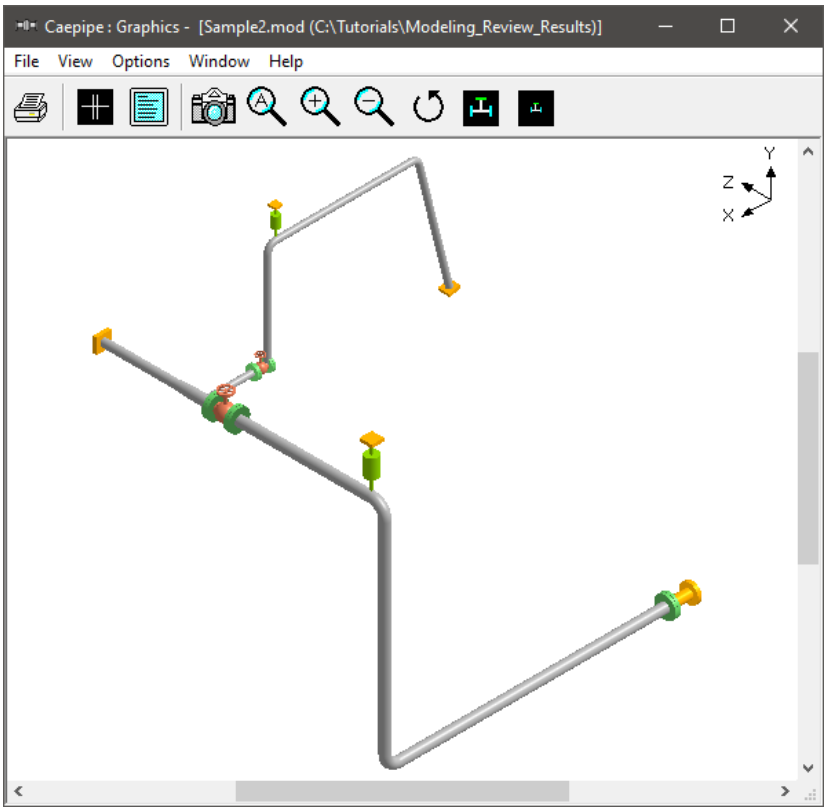


By default, Empty Weight (W), Sustained (W+P), Expansion (T1) and Operating (W+P1+T1) load cases are already selected. Add Static Seismic (g's), Wind, Wind 2, and the Modal analysis Load cases by clicking on the checkbox next to it. Design (W+PD+TD) load cases when selected for the Analysis, CAEPIPE will compute and show results for Displacements, Element Forces & Moments, Support Loads and Support Load Summary. Design load cases 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.

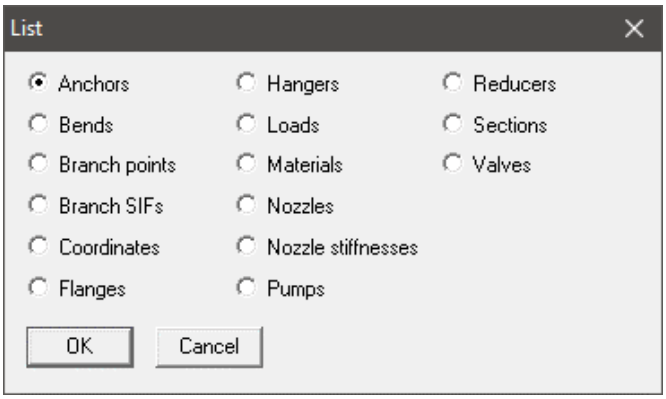




To return to the non-rendered view, click on the Do not render button (or press Ctrl+R).

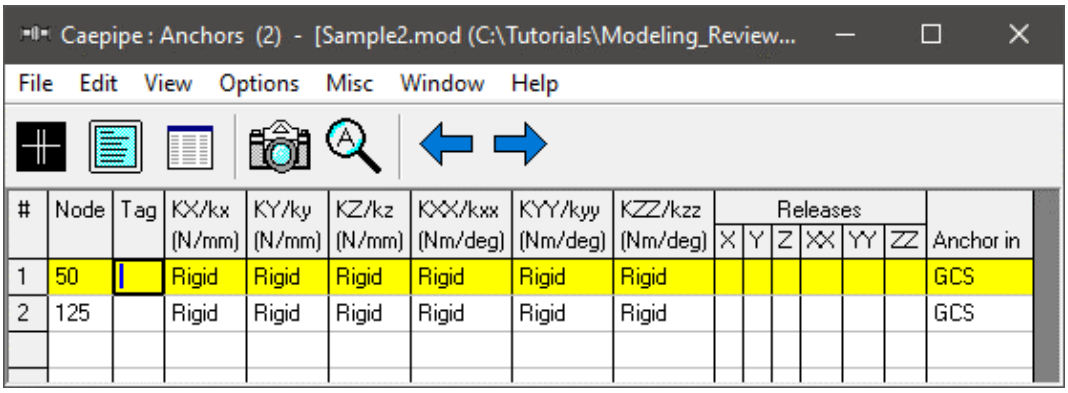
List

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.

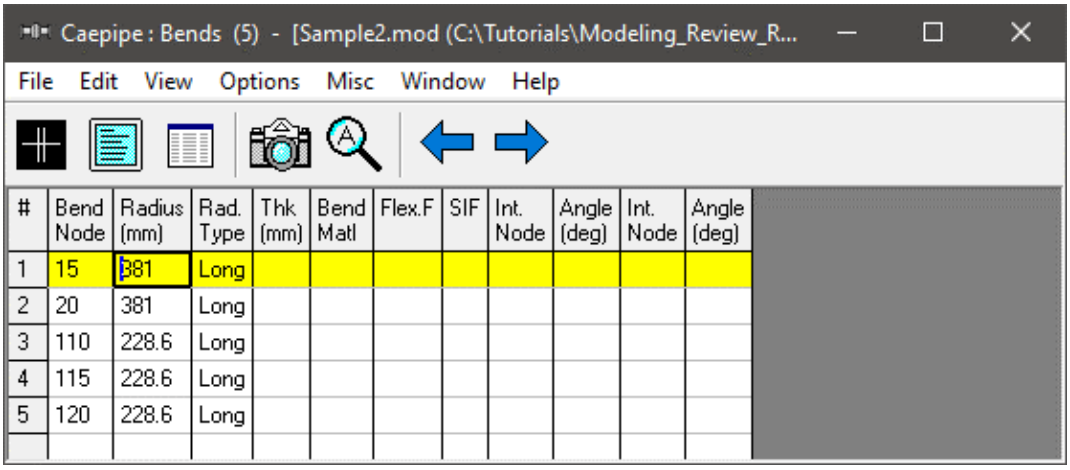
A list of all the anchors present in this sample model is shown below:



#	Node	Tag	KX/kx (N/mm)	KY/ky (N/mm)	KZ/kz (N/mm)	KXX/kxx (Nm/deg)	KYY/kyy (Nm/deg)	KZZ/kzz (Nm/deg)	Releases X	Y	Z	XX	YY	ZZ	Anchor in
1	50		Rigid	Rigid	Rigid	Rigid	Rigid	Rigid							GCS
2	125		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.

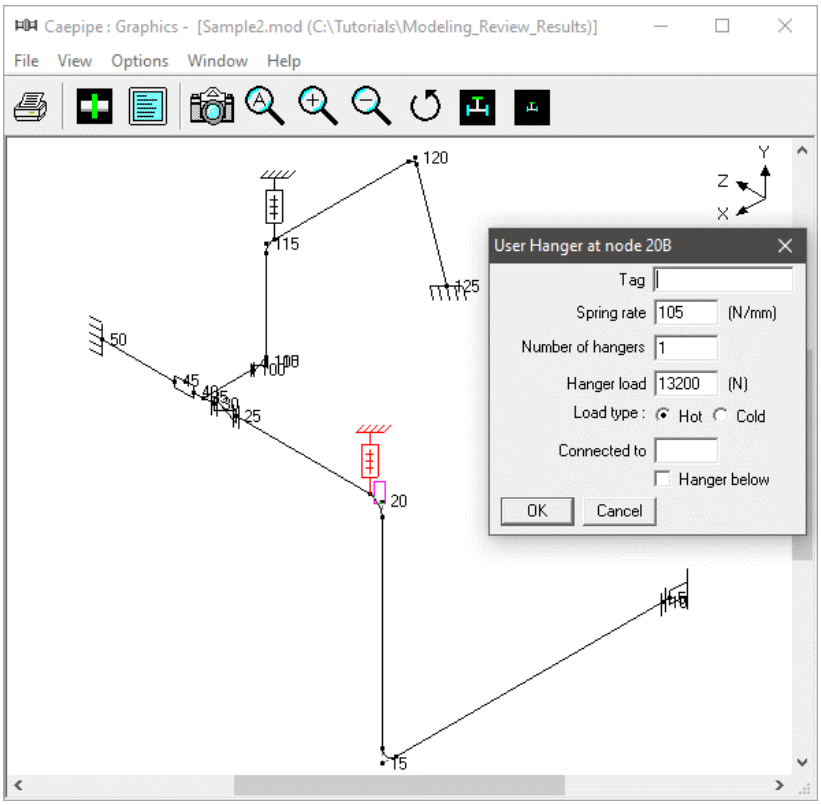
A list of all the bends in the sample model is shown below:



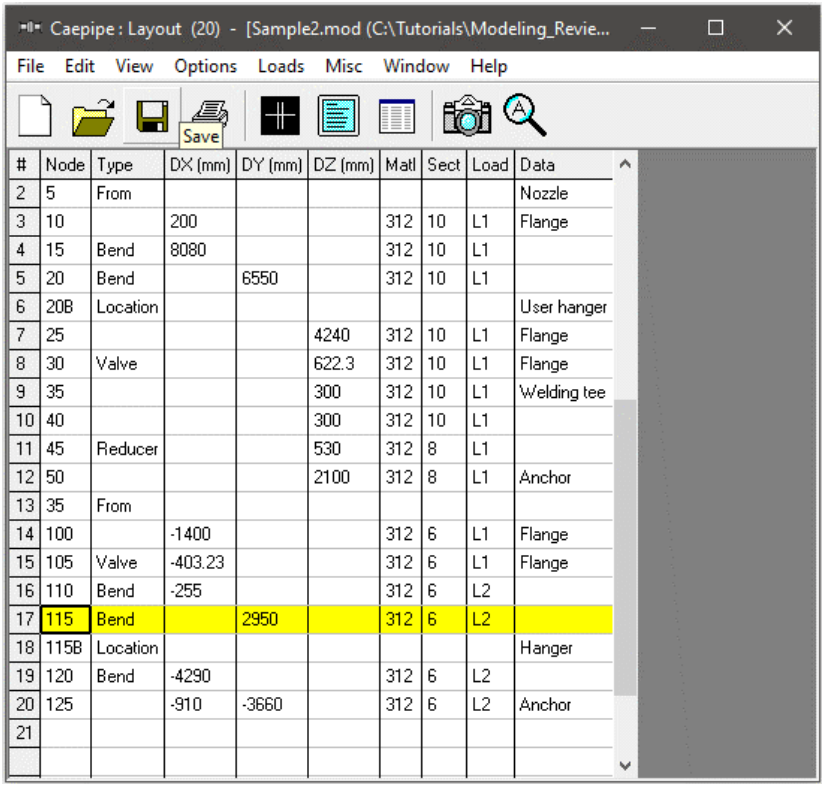
#	Bend Node	Radius (mm)	Rad. Type	Thk (mm)	Bend Matl	Flex.F	SIF	Int. Node	Angle (deg)	Int. Node	Angle (deg)
1	15	381	Long								
2	20	381	Long								
3	110	228.6	Long								
4	115	228.6	Long								
5	120	228.6	Long								

Editing in the Graphics Window

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



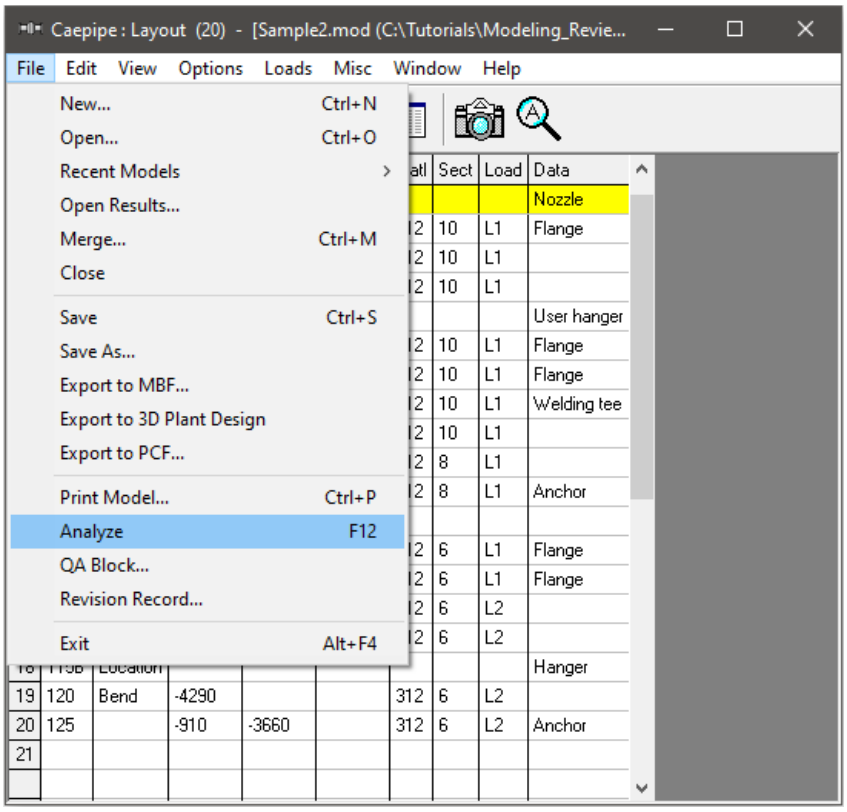
 Save the model by clicking on the Save button.



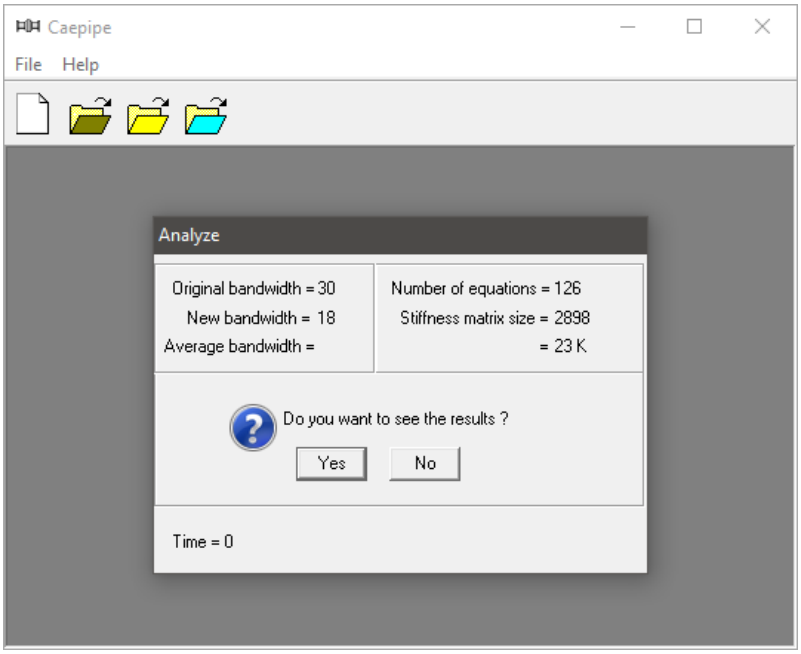
#	Node	Type	DX (mm)	DY (mm)	DZ (mm)	Matl	Sect	Load	Data
2	5	From							Nozzle
3	10		200			312	10	L1	Flange
4	15	Bend	8080			312	10	L1	
5	20	Bend		6550		312	10	L1	
6	20B	Location							User hanger
7	25				4240	312	10	L1	Flange
8	30	Valve			622.3	312	10	L1	Flange
9	35				300	312	10	L1	Welding tee
10	40				300	312	10	L1	
11	45	Reducer			530	312	8	L1	
12	50				2100	312	8	L1	Anchor
13	35	From							
14	100		-1400			312	6	L1	Flange
15	105	Valve	-403.23			312	6	L1	Flange
16	110	Bend	-255			312	6	L2	
17	115	Bend		2950		312	6	L2	
18	115B	Location							Hanger
19	120	Bend	-4290			312	6	L2	
20	125		-910	-3660		312	6	L2	Anchor
21									

6. Analyze

Click on Analyze under the File menu.

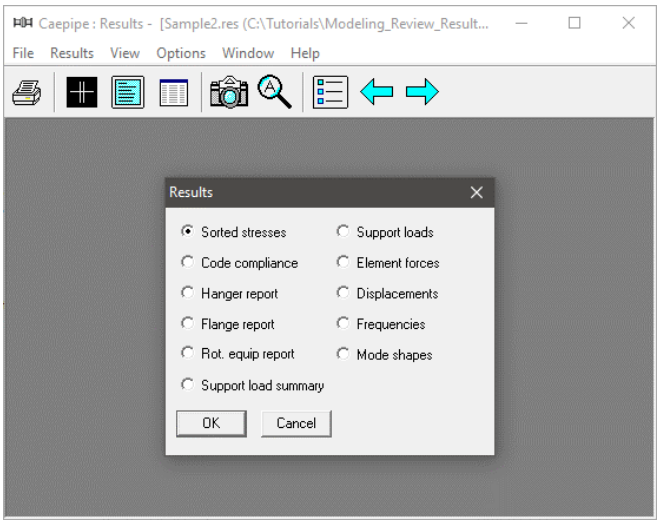


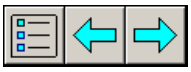
After the analysis, you are asked if you want to see the results. Select Yes.



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.



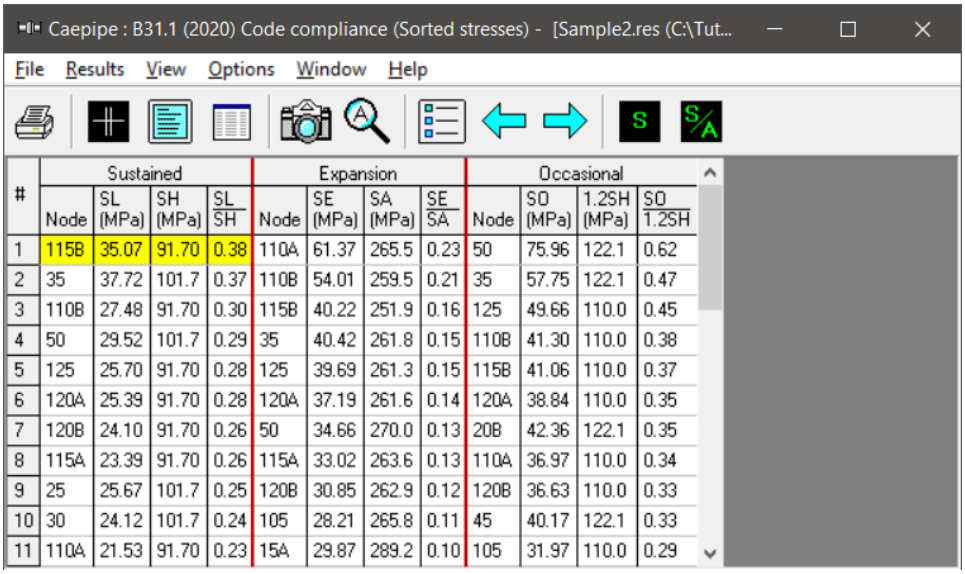


Select an item of interest by clicking on it. When you are viewing the results, use Tab (or Next Result button) to view the next result and Shift+Tab (or Previous Result button) to view the previous result. The Results dialog can be brought up by clicking on the Results icon (or press Ctrl+R).

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:

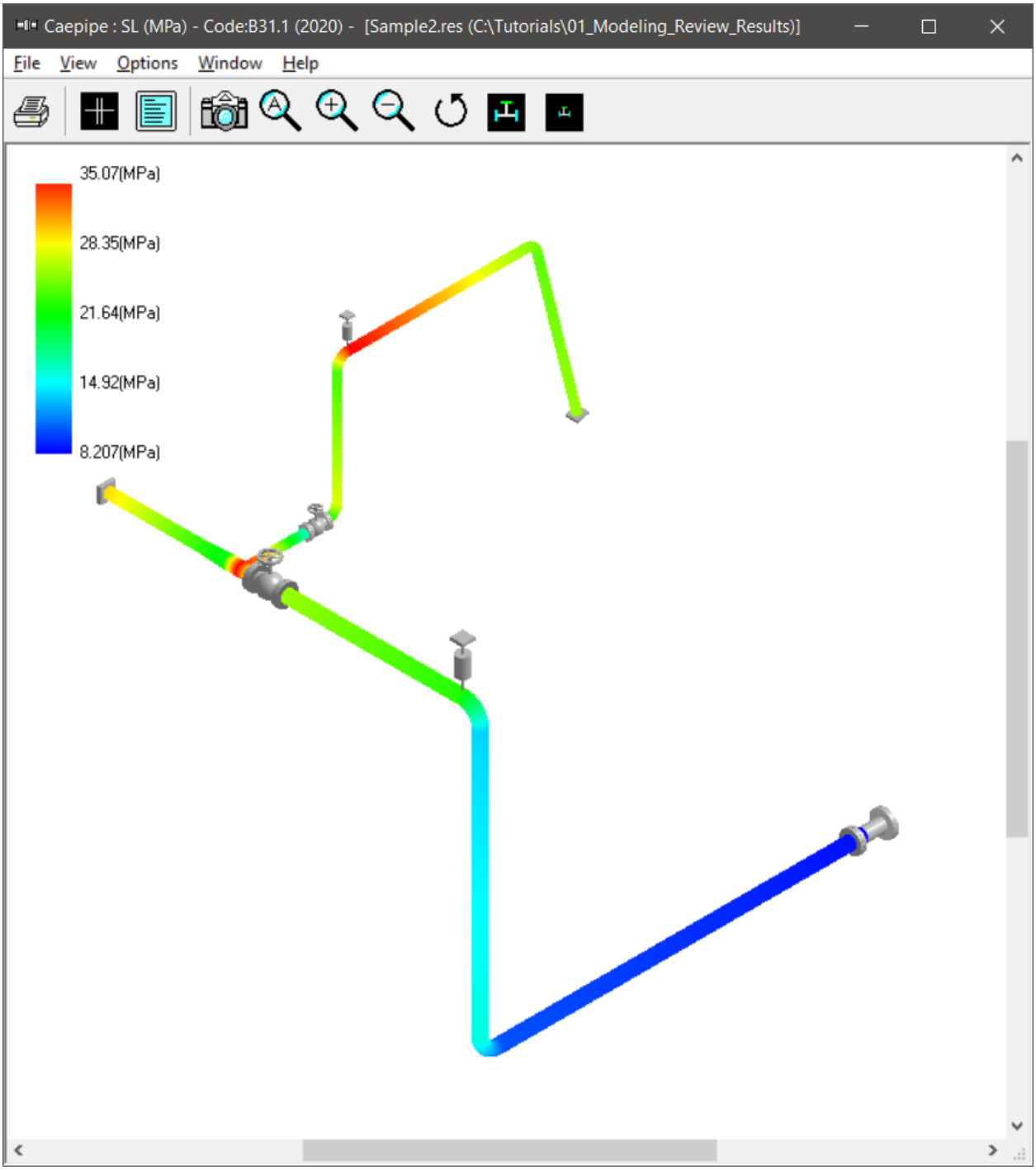
Sorted stresses

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



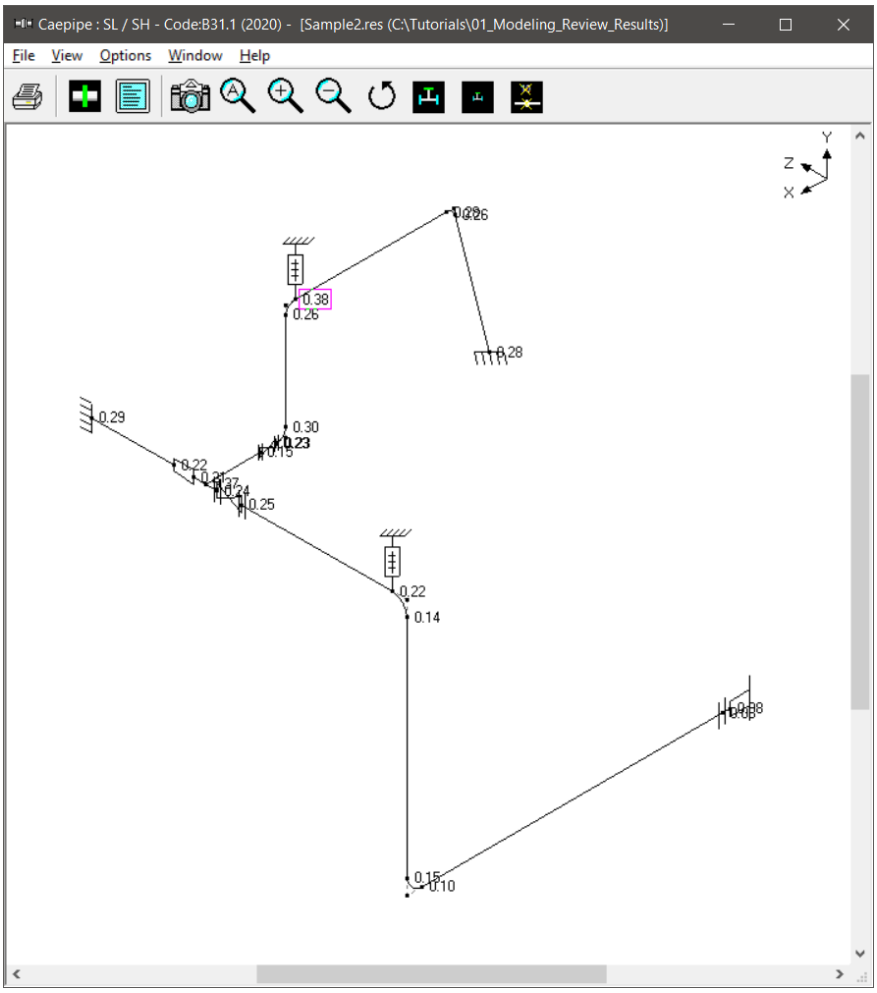
#	Sustained				Expansion				Occasional			
	Node	SL (MPa)	SH (MPa)	SL / SH	Node	SE (MPa)	SA (MPa)	SE / SA	Node	SO (MPa)	1.2SH (MPa)	SO / 1.2SH
1	115B	35.07	91.70	0.38	110A	61.37	265.5	0.23	50	75.96	122.1	0.62
2	35	37.72	101.7	0.37	110B	54.01	259.5	0.21	35	57.75	122.1	0.47
3	110B	27.48	91.70	0.30	115B	40.22	251.9	0.16	125	49.66	110.0	0.45
4	50	29.52	101.7	0.29	35	40.42	261.8	0.15	110B	41.30	110.0	0.38
5	125	25.70	91.70	0.28	125	39.69	261.3	0.15	115B	41.06	110.0	0.37
6	120A	25.39	91.70	0.28	120A	37.19	261.6	0.14	120A	38.84	110.0	0.35
7	120B	24.10	91.70	0.26	50	34.66	270.0	0.13	20B	42.36	122.1	0.35
8	115A	23.39	91.70	0.26	115A	33.02	263.6	0.13	110A	36.97	110.0	0.34
9	25	25.67	101.7	0.25	120B	30.85	262.9	0.12	120B	36.63	110.0	0.33
10	30	24.12	101.7	0.24	105	28.21	265.8	0.11	45	40.17	122.1	0.33
11	110A	21.53	91.70	0.23	15A	29.87	289.2	0.10	105	31.97	110.0	0.29

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 columns or click in a particular column.

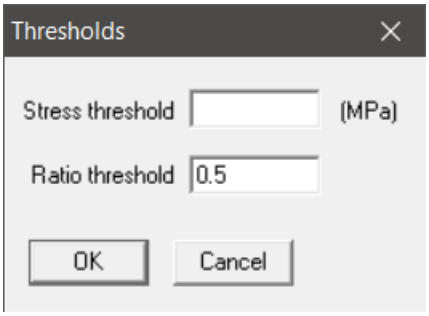


The stress ratios may similarly be rendered by using the Show stress ratios button (or choose View > Show Stress Ratios).

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

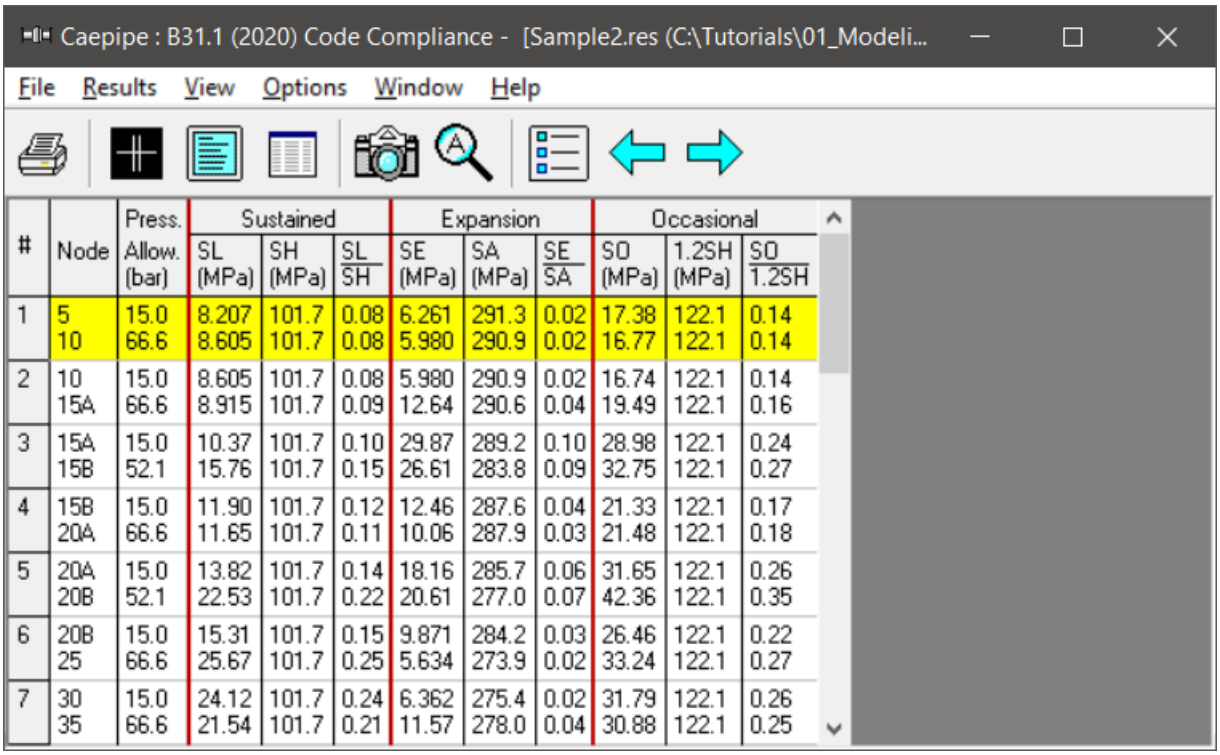


While plotting stresses or stress ratios, thresholds may be specified from the graphics window (choose View > Thresholds). Only those stresses or stress ratios exceeding the threshold are plotted.



Code compliance

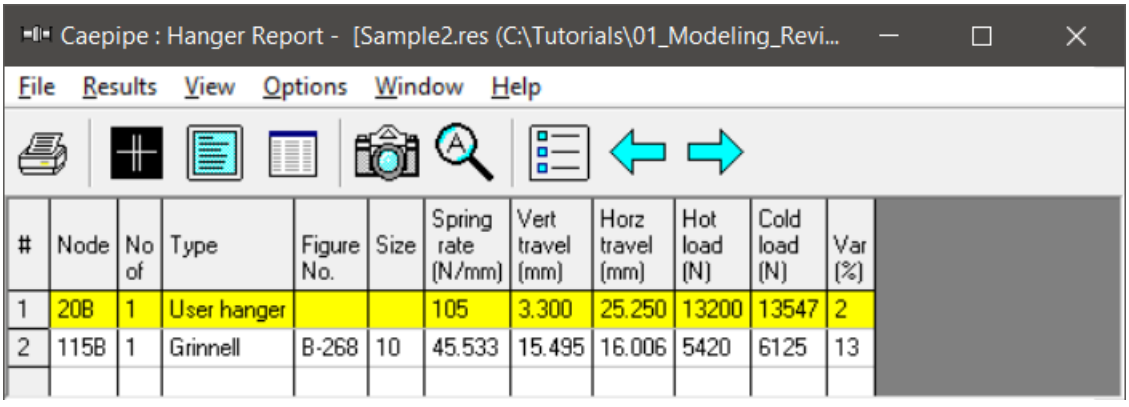
Element stresses and stress ratios calculated according to the selected piping code are shown under Code compliance. Design pressure and CAEPIPE computed Allowable pressure are shown in 2nd column.



#	Node	Press. Allow. (bar)	Sustained SL (MPa)	Sustained SH (MPa)	Sustained SL/SH	Expansion SE (MPa)	Expansion SA (MPa)	Expansion SE/SA	Occasional SO (MPa)	Occasional 1.2SH (MPa)	Occasional SO/1.2SH
1	5	15.0	8.207	101.7	0.08	6.261	291.3	0.02	17.38	122.1	0.14
	10	66.6	8.605	101.7	0.08	5.980	290.9	0.02	16.77	122.1	0.14
2	10	15.0	8.605	101.7	0.08	5.980	290.9	0.02	16.74	122.1	0.14
	15A	66.6	8.915	101.7	0.09	12.64	290.6	0.04	19.49	122.1	0.16
3	15A	15.0	10.37	101.7	0.10	29.87	289.2	0.10	28.98	122.1	0.24
	15B	52.1	15.76	101.7	0.15	26.61	283.8	0.09	32.75	122.1	0.27
4	15B	15.0	11.90	101.7	0.12	12.46	287.6	0.04	21.33	122.1	0.17
	20A	66.6	11.65	101.7	0.11	10.06	287.9	0.03	21.48	122.1	0.18
5	20A	15.0	13.82	101.7	0.14	18.16	285.7	0.06	31.65	122.1	0.26
	20B	52.1	22.53	101.7	0.22	20.61	277.0	0.07	42.36	122.1	0.35
6	20B	15.0	15.31	101.7	0.15	9.871	284.2	0.03	26.46	122.1	0.22
	25	66.6	25.67	101.7	0.25	5.634	273.9	0.02	33.24	122.1	0.27
7	30	15.0	24.12	101.7	0.24	6.362	275.4	0.02	31.79	122.1	0.26
	35	66.6	21.54	101.7	0.21	11.57	278.0	0.04	30.88	122.1	0.25

Hanger report

The hanger report is shown below.



#	Node	No of	Type	Figure No.	Size	Spring rate (N/mm)	Vert travel (mm)	Horz travel (mm)	Hot load (N)	Cold load (N)	Var (%)
1	20B	1	User hanger			105	3.300	25.250	13200	13547	2
2	115B	1	Grinnell	B-268	10	45.533	15.495	16.006	5420	6125	13

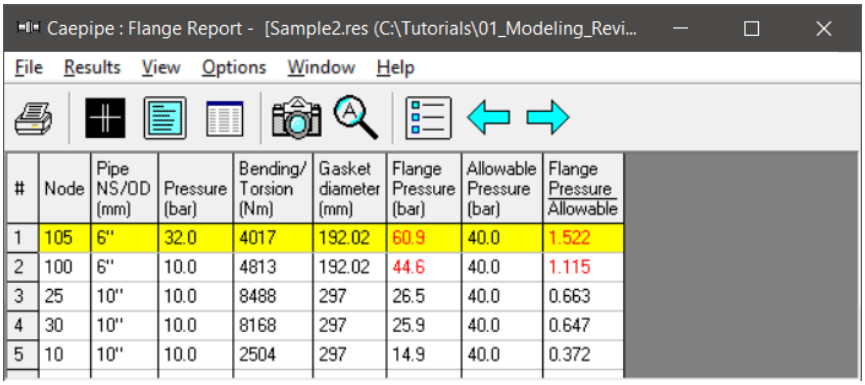
The "No of" field shows the number of hangers required at the indicated location. The Figure No. and Size refer to the manufacturer's catalog. The vertical travel (also referred to as "Hanger travel") is the vertical deflection at the hanger location for the first operating load case. Similarly, the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

Flange report

The Flange report in the CAEPIPE results window shows the loads at each flange location for the operating case (W+P1+T1).

The Flange Pressure is an "equivalent pressure" calculated from the actual pressure in the piping element, the bending moment and the axial force on the flange for the first operating case (W+P1+T1).



#	Node	Pipe NS/OD (mm)	Pressure (bar)	Bending/ Torsion (Nm)	Gasket diameter (mm)	Flange Pressure (bar)	Allowable Pressure (bar)	Flange Pressure Allowable
1	105	6"	32.0	4017	192.02	60.9	40.0	1.522
2	100	6"	10.0	4813	192.02	44.6	40.0	1.115
3	25	10"	10.0	8488	297	26.5	40.0	0.663
4	30	10"	10.0	8168	297	25.9	40.0	0.647
5	10	10"	10.0	2504	297	14.9	40.0	0.372

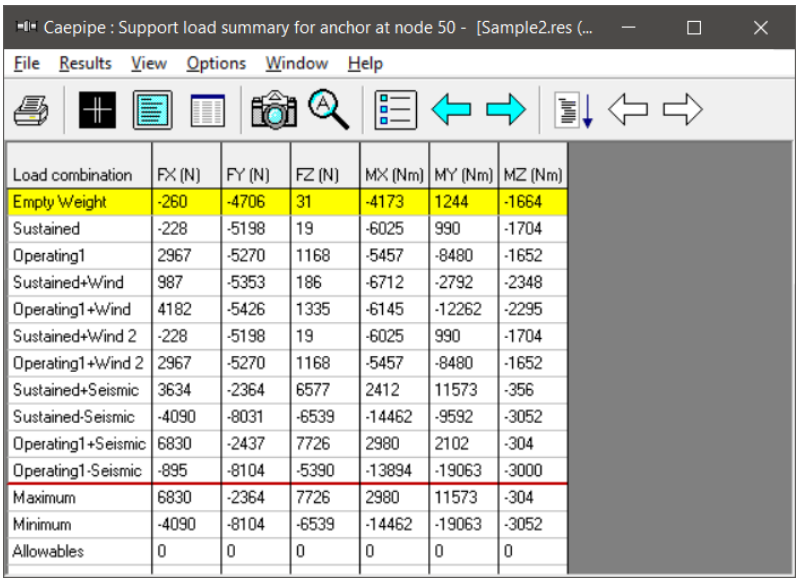
The last column shows a ratio of this "equivalent" Flange Pressure to a user-input Allowable Pressure. This ratio is flagged in red when it exceeds 1.0.

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.

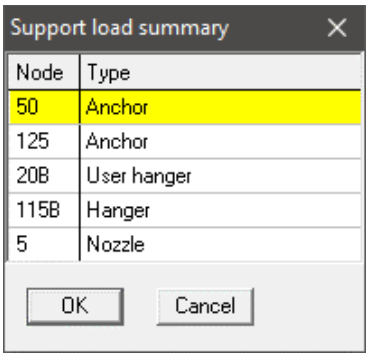
Note: Allowable loads at an equipment nozzle can be calculated using the module "Nozzle Evaluation" available in CAEPIPE through Main Frame > New > Nozzle Evaluation.

The allowable loads thus calculated can then be entered as "User Allowables" in CAEPIPE Stress Model through Layout window > Misc. See the CAEPIPE tutorial titled "*Tutorial on Qualification of Nozzles to Equipment using CAEPIPE*" for more details.



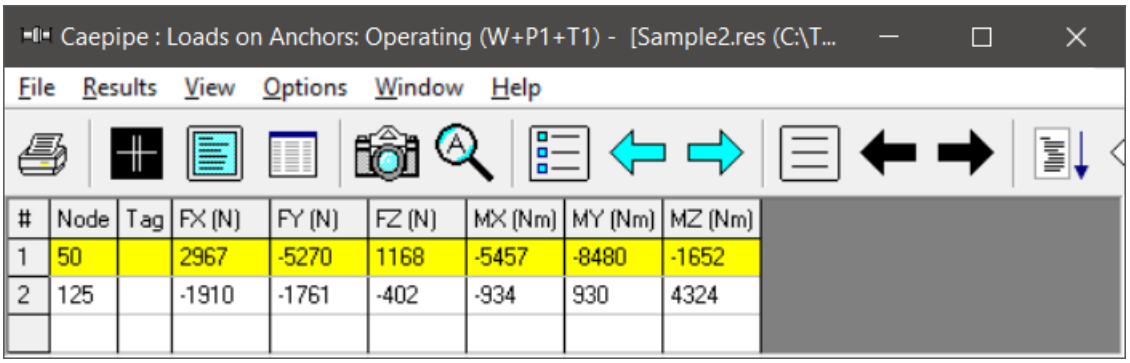
Load combination	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
Empty Weight	-260	-4706	31	-4173	1244	-1664
Sustained	-228	-5198	19	-6025	990	-1704
Operating1	2967	-5270	1168	-5457	-8480	-1652
Sustained+Wind	987	-5353	186	-6712	-2792	-2348
Operating1+Wind	4182	-5426	1335	-6145	-12262	-2295
Sustained+Wind 2	-228	-5198	19	-6025	990	-1704
Operating1+Wind 2	2967	-5270	1168	-5457	-8480	-1652
Sustained+Seismic	3634	-2364	6577	2412	11573	-356
Sustained-Seismic	-4090	-8031	-6539	-14462	-9592	-3052
Operating1+Seismic	6830	-2437	7726	2980	2102	-304
Operating1-Seismic	-895	-8104	-5390	-13894	-19063	-3000
Maximum	6830	-2364	7726	2980	11573	-304
Minimum	-4090	-8104	-6539	-14462	-19063	-3052
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.).



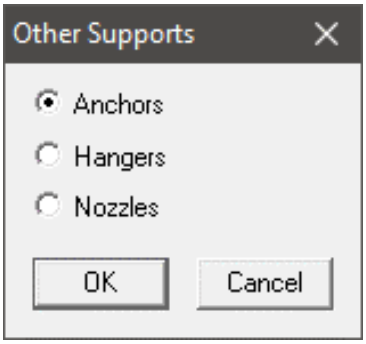
Support loads

Support loads are the loads acting on all the supports of each support type for a specific loading case. The loads on anchors for the Operating load case are shown below.

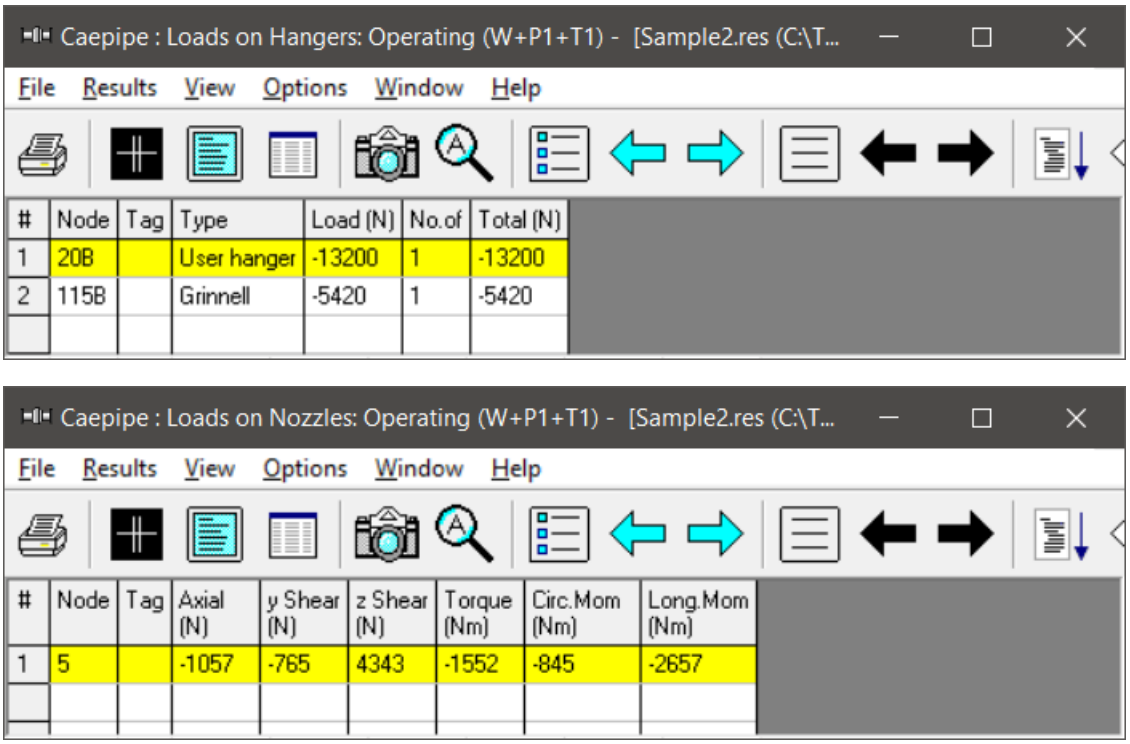


Use the Load cases button, Next load case button(Right arrow) or Previous load case button (Left arrow) to see loads for different load cases(e.g. Sustained, Expansion etc.).

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



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



Caepipe : Loads on Hangers: Operating (W+P1+T1) - [Sample2.res (C:\T...

File Results View Options Window Help

#	Node	Tag	Type	Load (N)	No.of	Total (N)
1	20B		User hanger	-13200	1	-13200
2	115B		Grinnell	-5420	1	-5420

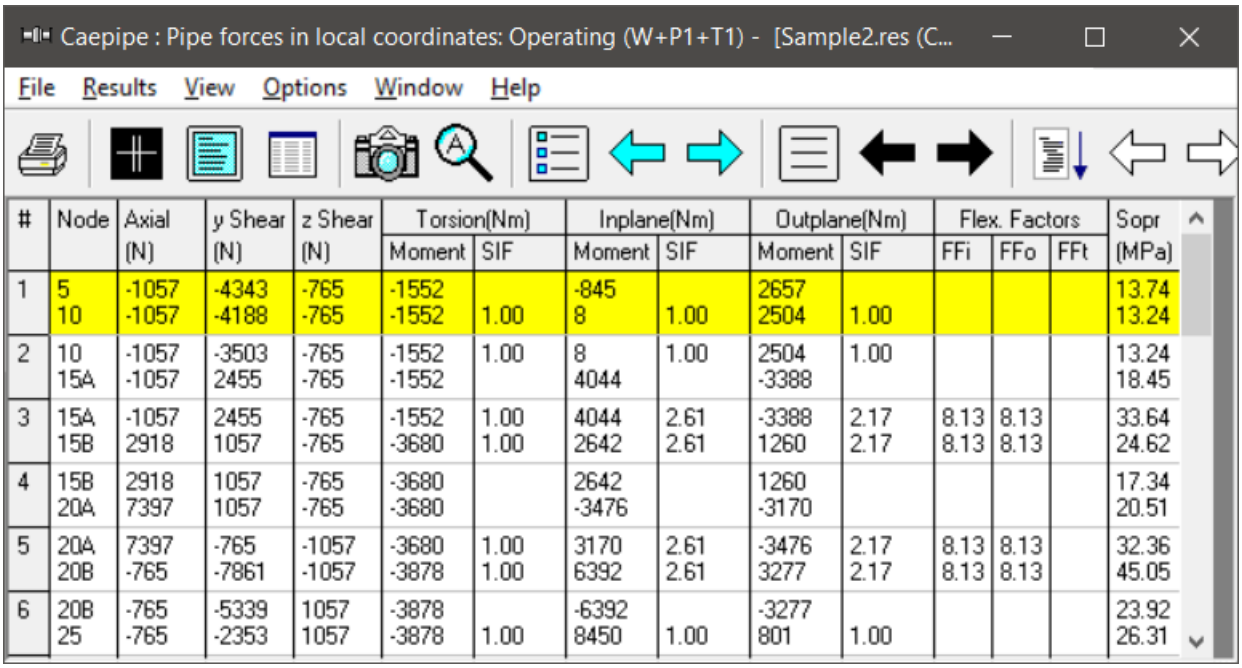
Caepipe : Loads on Nozzles: Operating (W+P1+T1) - [Sample2.res (C:\T...

File Results View Options Window Help

#	Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
1	5		-1057	-765	4343	-1552	-845	-2657

Element forces

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

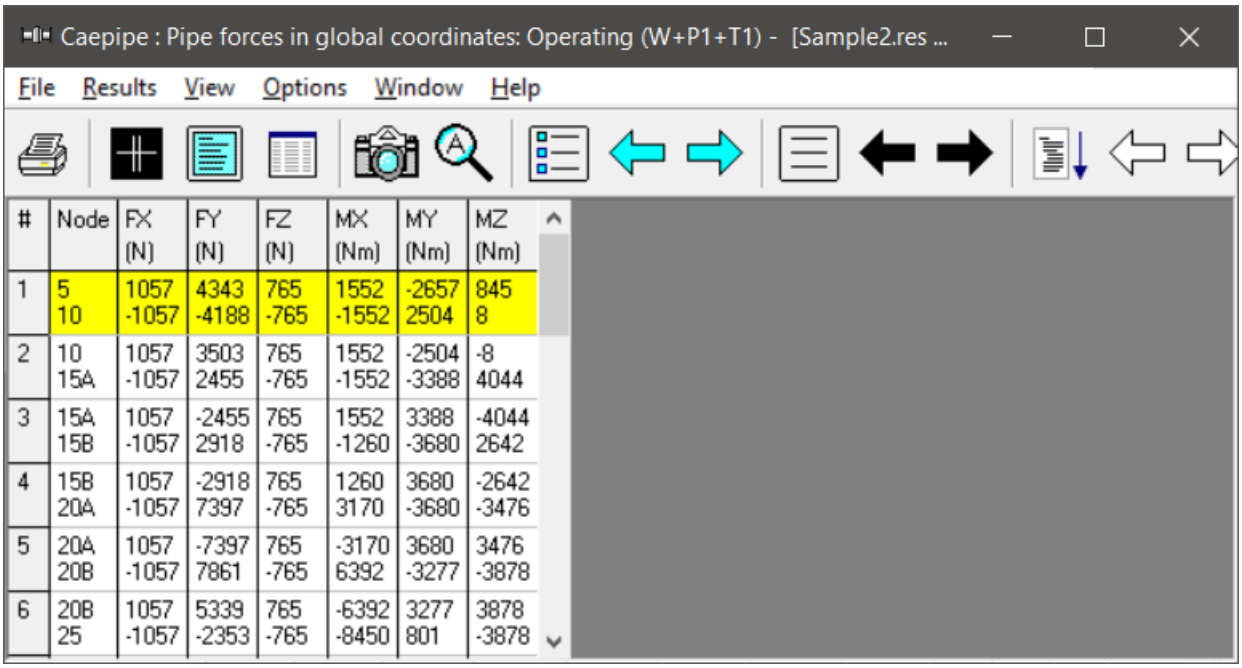


Caepipe : Pipe forces in local coordinates: Operating (W+P1+T1) - [Sample2.res (C...

File Results View Options Window Help

#	Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	Sopr (MPa)
1	5 10	-1057 -1057	-4343 -4188	-765 -765	-1552 -1552	1.00	-845 8	1.00	2657 2504	1.00				13.74 13.24
2	10 15A	-1057 -1057	-3503 2455	-765 -765	-1552 -1552	1.00	8 4044	1.00	2504 -3388	1.00				13.24 18.45
3	15A 15B	-1057 2918	2455 1057	-765 -765	-1552 -3680	1.00 1.00	4044 2642	2.61 2.61	-3388 1260	2.17 2.17	8.13 8.13	8.13 8.13		33.64 24.62
4	15B 20A	2918 7397	1057 1057	-765 -765	-3680 -3680		2642 -3476		1260 -3170					17.34 20.51
5	20A 20B	7397 -765	-765 -7861	-1057 -1057	-3680 -3878	1.00 1.00	3170 6392	2.61 2.61	-3476 3277	2.17 2.17	8.13 8.13	8.13 8.13		32.36 45.05
6	20B 25	-765 -765	-5339 -2353	1057 1057	-3878 -3878	1.00	-6392 8450	1.00	-3277 801	1.00				23.92 26.31

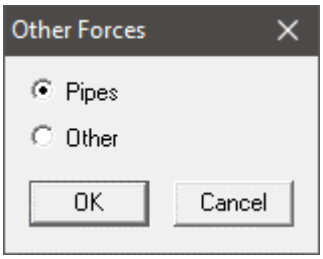
Use the Global forces button (F7) to see the element forces in global coordinates.

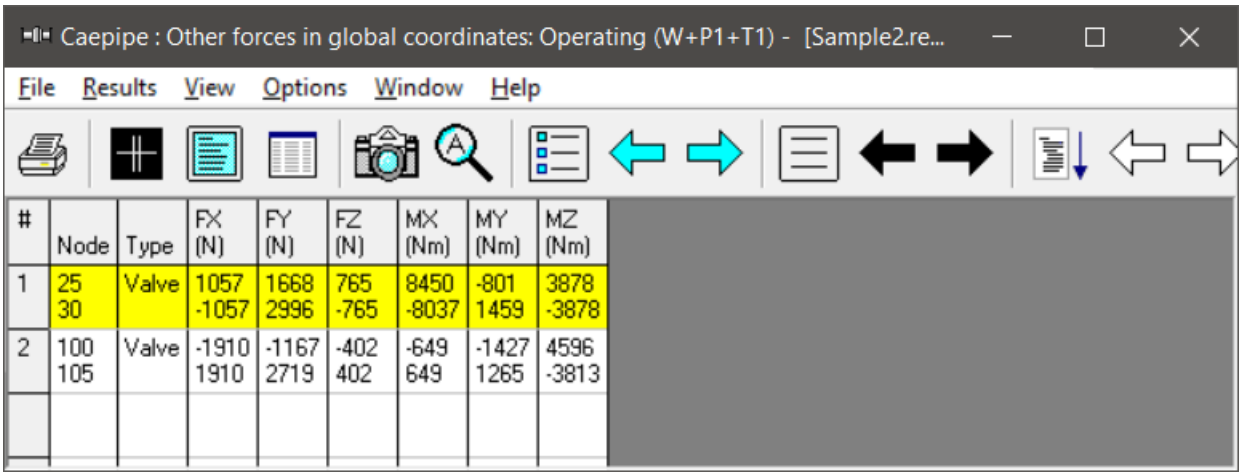


#	Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
1	5 10	1057 -1057	4343 -4188	765 -765	1552 -1552	-2657 2504	845 8
2	10 15A	1057 -1057	3503 2455	765 -765	1552 -1552	-2504 -3388	-8 4044
3	15A 15B	1057 -1057	-2455 2918	765 -765	1552 -1260	3388 -3680	-4044 2642
4	15B 20A	1057 -1057	-2918 7397	765 -765	1260 3170	3680 -3680	-2642 -3476
5	20A 20B	1057 -1057	-7397 7861	765 -765	-3170 6392	3680 -3277	3476 -3878
6	20B 25	1057 -1057	5339 -2353	765 -765	-6392 -8450	3277 801	3878 -3878

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

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.).

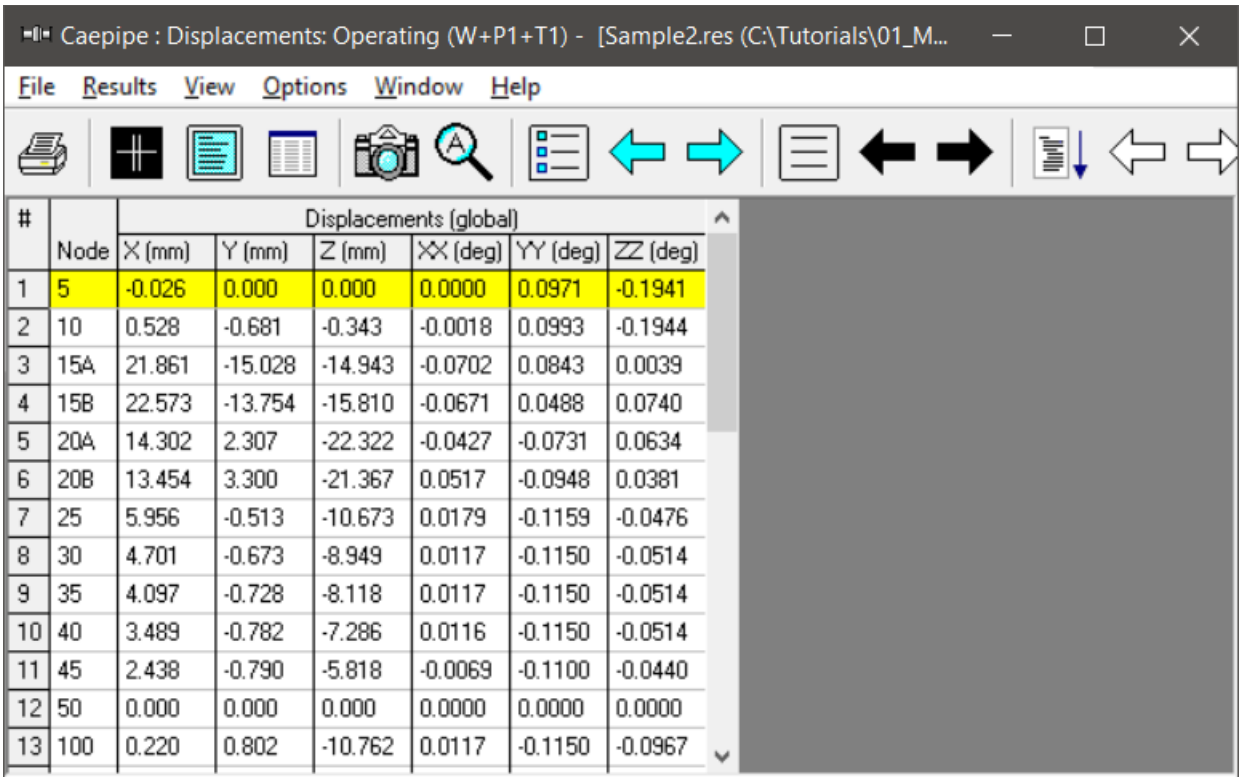




#	Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
1	25 30	Valve	1057 -1057	1668 2996	765 -765	8450 -8037	-801 1459	3878 -3878
2	100 105	Valve	-1910 1910	-1167 2719	-402 402	-649 649	-1427 1265	4596 -3813

Displacements

The nodal displacements are shown.

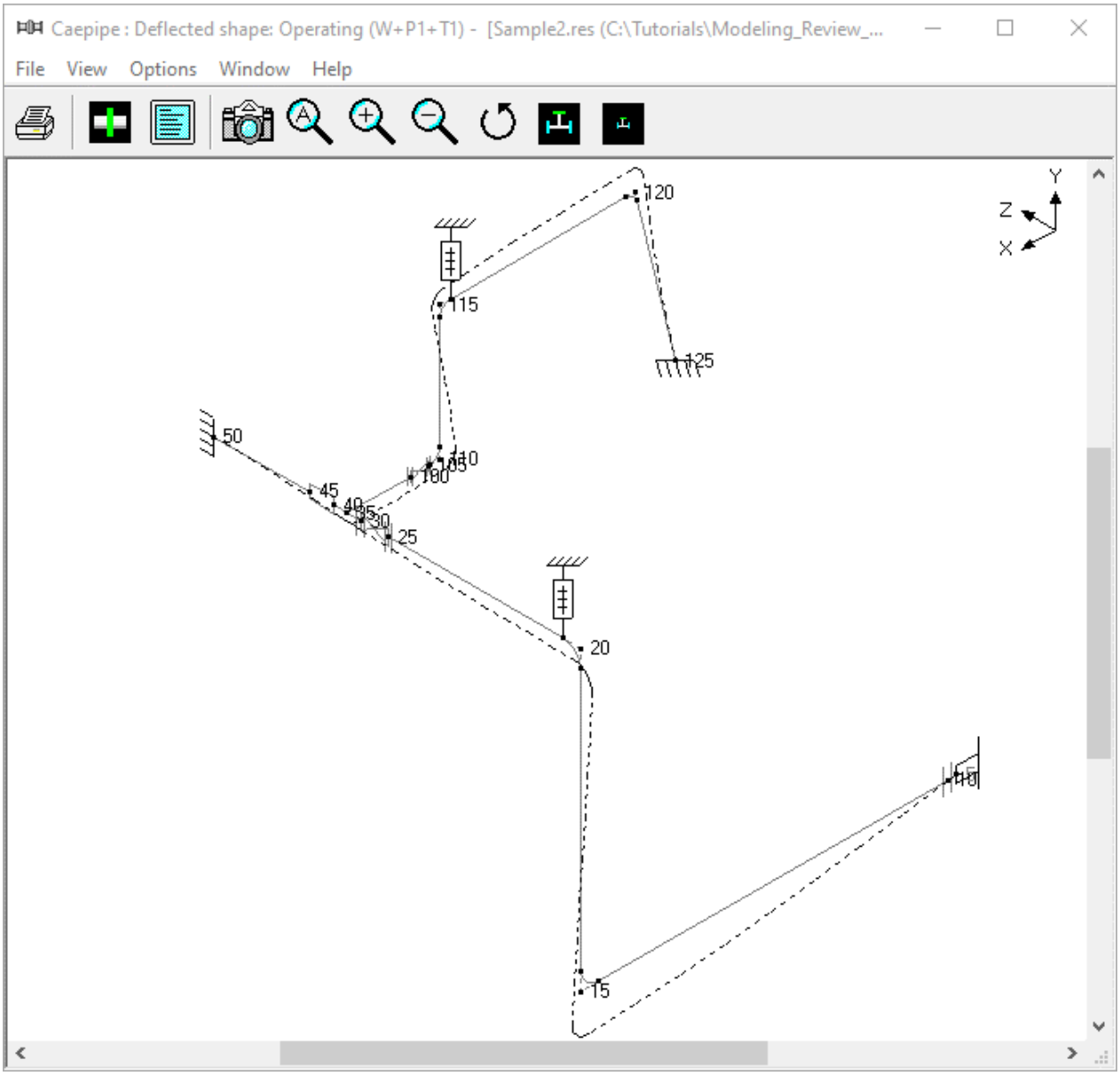


#	Node	Displacements (global) X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
1	5	-0.026	0.000	0.000	0.0000	0.0971	-0.1941
2	10	0.528	-0.681	-0.343	-0.0018	0.0993	-0.1944
3	15A	21.861	-15.028	-14.943	-0.0702	0.0843	0.0039
4	15B	22.573	-13.754	-15.810	-0.0671	0.0488	0.0740
5	20A	14.302	2.307	-22.322	-0.0427	-0.0731	0.0634
6	20B	13.454	3.300	-21.367	0.0517	-0.0948	0.0381
7	25	5.956	-0.513	-10.673	0.0179	-0.1159	-0.0476
8	30	4.701	-0.673	-8.949	0.0117	-0.1150	-0.0514
9	35	4.097	-0.728	-8.118	0.0117	-0.1150	-0.0514
10	40	3.489	-0.782	-7.286	0.0116	-0.1150	-0.0514
11	45	2.438	-0.790	-5.818	-0.0069	-0.1100	-0.0440
12	50	0.000	0.000	0.000	0.0000	0.0000	0.0000
13	100	0.220	0.802	-10.762	0.0117	-0.1150	-0.0967

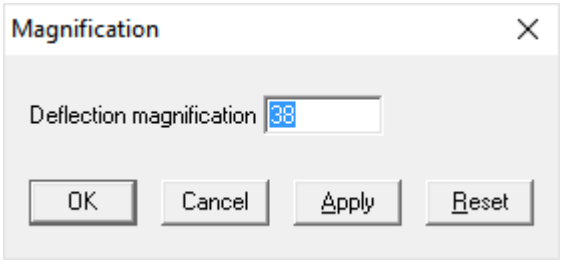
Use the Load cases button, Next load case button (Right arrow) or Previous load case button (Left arrow) to see loads for different load cases(e.g. Sustained, Expansion etc.).

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.

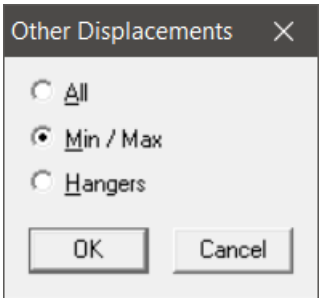


Choose View > Magnification to change the magnification of the deflected shape.

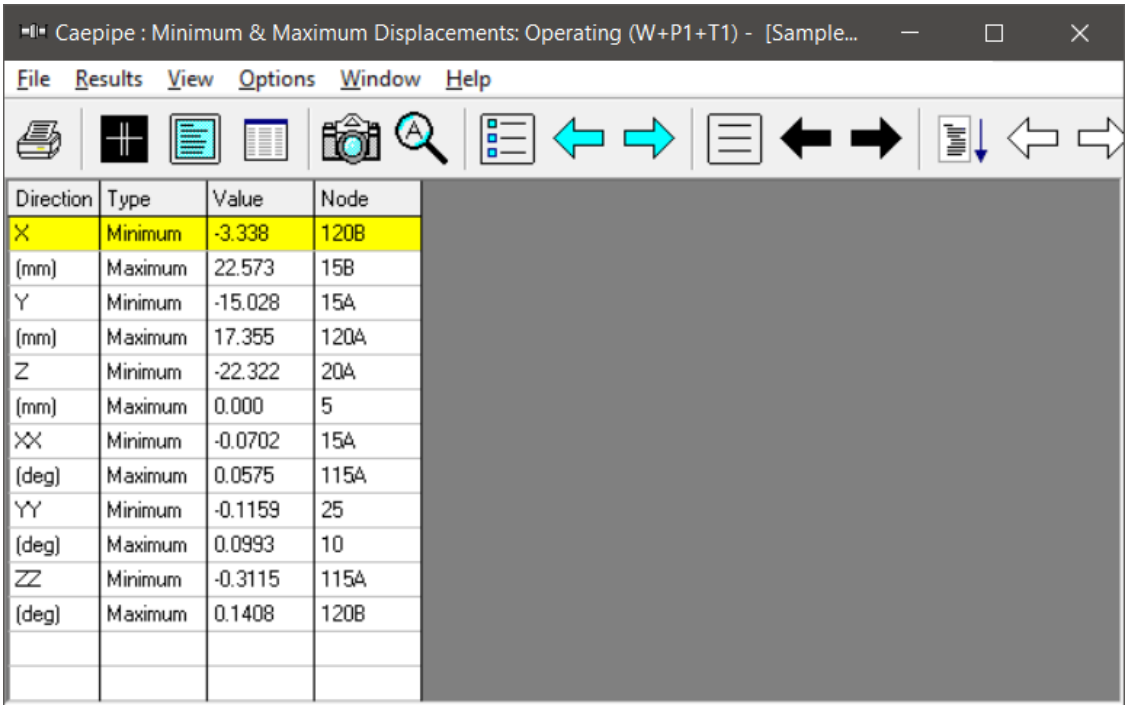


The reset button is used to calculate a default magnification factor which scales the maximum deflection to about 5% of the width of the graphics window.

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.).

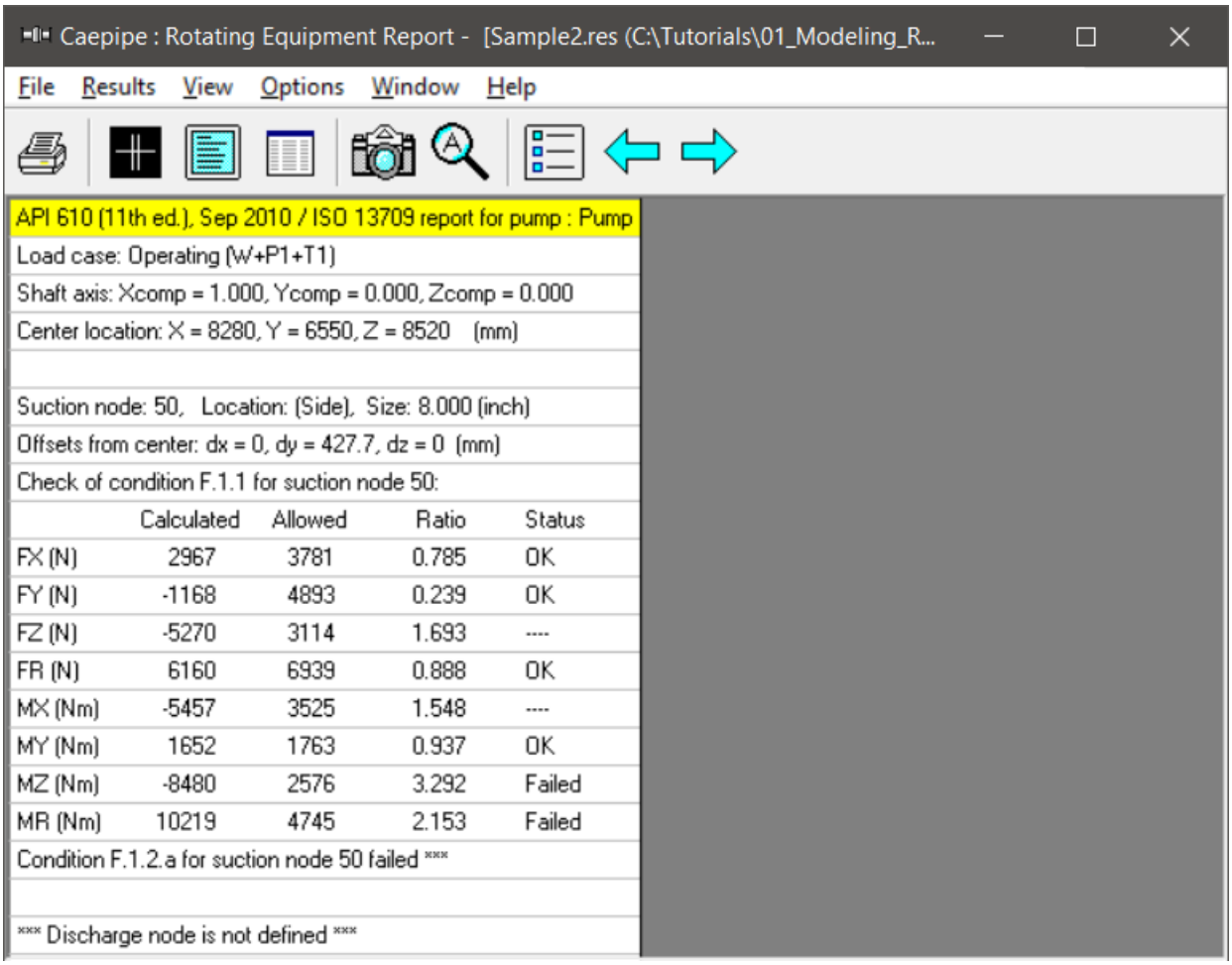


The minimum and maximum displacements for each of the directions and the corresponding nodes are shown below.



Direction	Type	Value	Node
X	Minimum	-3.338	120B
(mm)	Maximum	22.573	15B
Y	Minimum	-15.028	15A
(mm)	Maximum	17.355	120A
Z	Minimum	-22.322	20A
(mm)	Maximum	0.000	5
XX	Minimum	-0.0702	15A
(deg)	Maximum	0.0575	115A
YY	Minimum	-0.1159	25
(deg)	Maximum	0.0993	10
ZZ	Minimum	-0.3115	115A
(deg)	Maximum	0.1408	120B

The Pump qualification report (Rotating Equipment report) is shown below.



Frequencies and Mode shapes

A list of natural frequencies, periods, modal participation factors and modal mass fractions is shown next. You can show each frequency's mode shape graphically or animate it by clicking on Show mode shape or Show animated mode shape button in the toolbar.

Caepipe : Frequencies - [Sample2.res (C:\Tutorials\01_Modeling_Review_Results)]

File Results View Options Window Help

#	Frequency (Hz)	Period (second)	Participation factors			Modal mass / Total mass		
			X	Y	Z	X	Y	Z
1	1.706	0.5861	-0.7142	1.9228	-1.2093	0.0292	0.2119	0.0838
2	2.455	0.4073	-0.8013	2.2492	1.5136	0.0368	0.2899	0.1313
3	2.690	0.3717	-2.5039	-1.3428	0.3230	0.3593	0.1033	0.0060
4	4.673	0.2140	0.3889	-0.3474	1.2781	0.0087	0.0069	0.0936
5	6.395	0.1564	-1.0978	0.8783	-0.0957	0.0691	0.0442	0.0005
6	7.033	0.1422	0.5407	1.0975	-0.0498	0.0168	0.0690	0.0001
7	7.672	0.1303	0.1321	-0.1976	0.1461	0.0010	0.0022	0.0012
8	10.024	0.0998	1.2558	0.0829	-0.1343	0.0904	0.0004	0.0010
9	11.761	0.0850	-0.0675	0.9579	-0.1086	0.0003	0.0526	0.0007
10	14.063	0.0711	-0.6784	-0.1013	-1.1818	0.0264	0.0006	0.0800
11	30.957	0.0323	-2.2978	-0.0528	0.0075	0.3026	0.0002	0.0000
12	54.033	0.0185	-0.1696	0.2347	-0.6241	0.0016	0.0032	0.0223
13					Total	0.9420	0.7843	0.4206

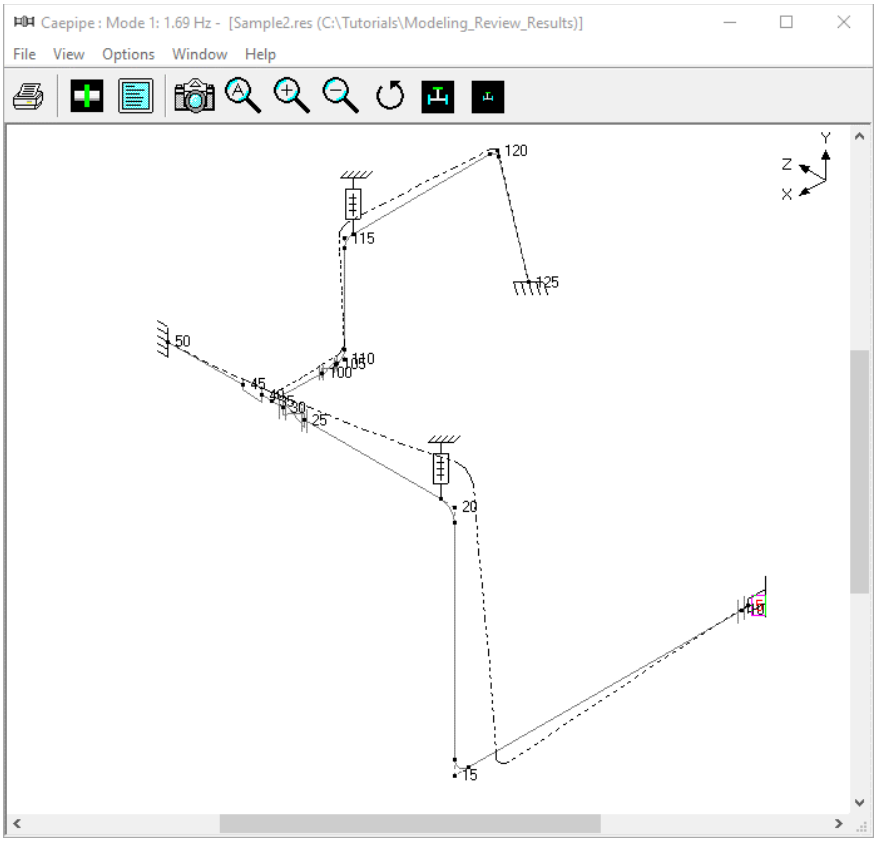
Each frequency's mode shape detail is shown in the next window. As in the earlier window, you can show graphically the mode shape or animate it by clicking on the appropriate button.

Caepipe : Mode 1: 1.71 Hz - [Sample2.res (C:\Tutorials\01_Modeling_Review_Res...

File Results View Options Window Help

#	Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
1	5	0.000	0.000	0.000	0.0000	0.0586	0.0445
2	10	0.000	0.156	-0.207	0.0017	0.0600	0.0447
3	15A	0.000	6.247	-10.202	0.0659	0.0768	0.0436
4	15B	-0.272	6.526	-10.161	0.0868	0.0618	0.0391
5	20A	-3.805	6.524	-0.570	0.0930	0.0447	0.0292
6	20B	-3.691	6.000	0.000	0.0694	0.0413	0.0252
7	25	-1.299	2.100	0.000	0.0458	0.0283	0.0130
8	30	-0.996	1.609	0.000	0.0447	0.0275	0.0125
9	35	-0.851	1.374	0.000	0.0447	0.0275	0.0125
10	40	-0.707	1.140	0.000	0.0447	0.0275	0.0125
11	45	-0.467	0.751	0.000	0.0392	0.0242	0.0107
12	50	0.000	0.000	0.000	0.0000	0.0000	0.0000
13	100	-0.851	1.067	0.663	0.0447	0.0275	0.0109
14	105	-0.851	0.992	0.854	0.0441	0.0268	0.0105

The graphic window will show the mode shape as below.

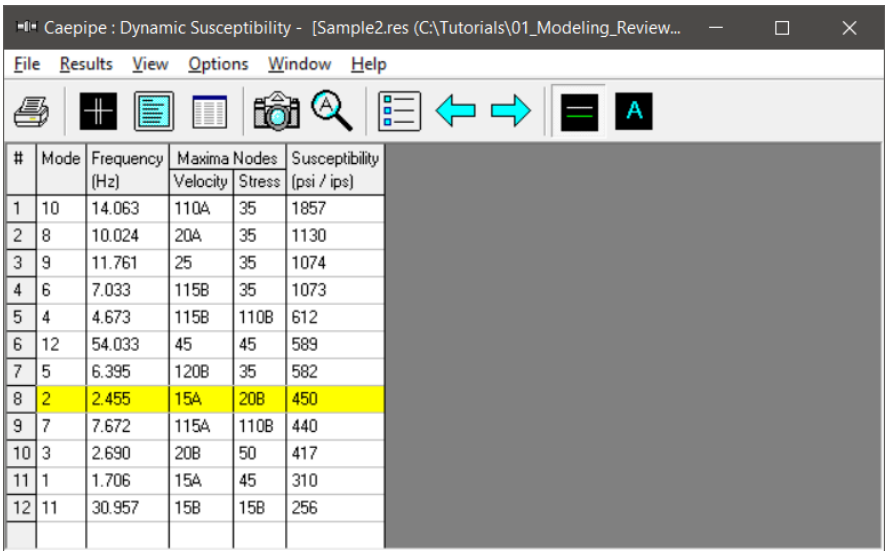


Use the black arrow buttons to cycle through the different Modes.

Dynamic Susceptibility

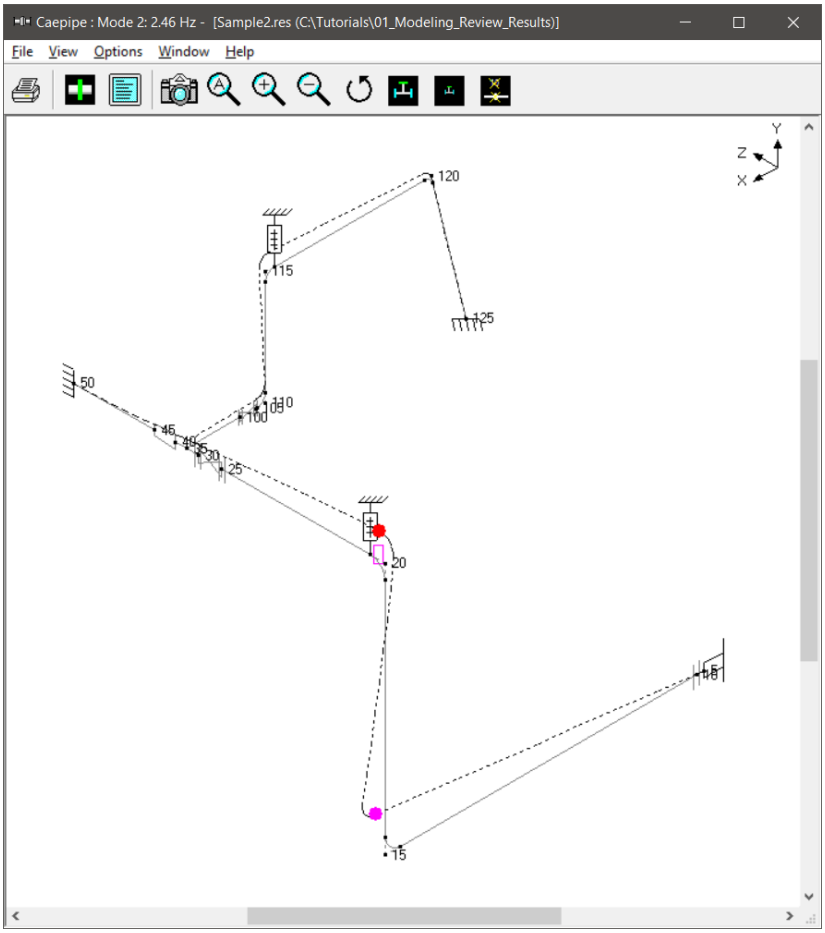
Note: *Dynamic Susceptibility is NOT available for Evaluation Version of CAEPIPE. For Full Version of CAEPIPE, this feature can be turned ON by setting an environment variable "HARTLEN" that needs to be declared under My Computer or This PC Icon > Mouse Right Click > Properties > Advanced System Settings > Environmental Variable with its Value set to (YES). Refer to CAEPIPE User's Manual for more details.*

The stress / velocity method, implemented in CAEPIPE as the "Dynamic Susceptibility" feature, provides quantified insights into the stress versus vibration characteristics of the system layout per se.

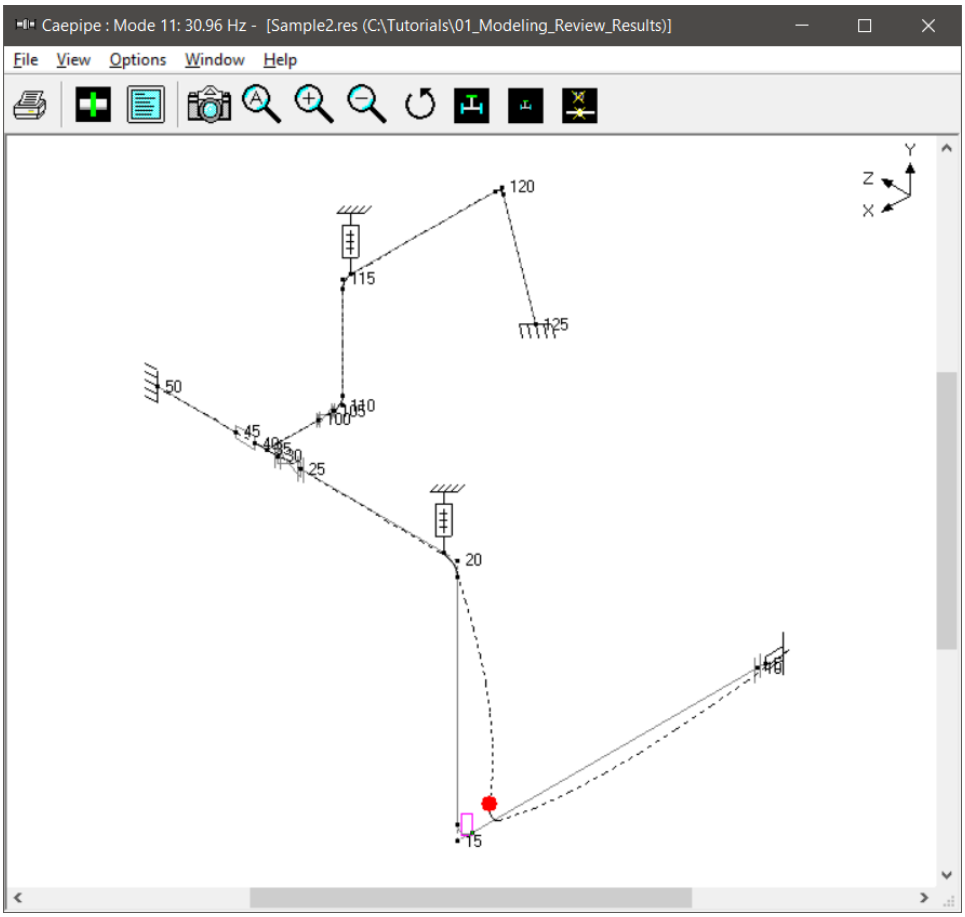


#	Mode	Frequency (Hz)	Maxima Nodes Velocity	Stress	Susceptibility (psi / ips)
1	10	14.063	110A	35	1857
2	8	10.024	20A	35	1130
3	9	11.761	25	35	1074
4	6	7.033	115B	35	1073
5	4	4.673	115B	110B	612
6	12	54.033	45	45	589
7	5	6.395	120B	35	582
8	2	2.455	15A	20B	450
9	7	7.672	115A	110B	440
10	3	2.690	20B	50	417
11	1	1.706	15A	45	310
12	11	30.957	15B	15B	256

Pressing the Animated mode shape button (or View > Show animated mode shape) for Mode 2, for example, shows the maximum dynamic bending stress at the Bend Far End Node 20B (RED dot) and the maximum velocity at the Bend Node 15A (PINK dot).



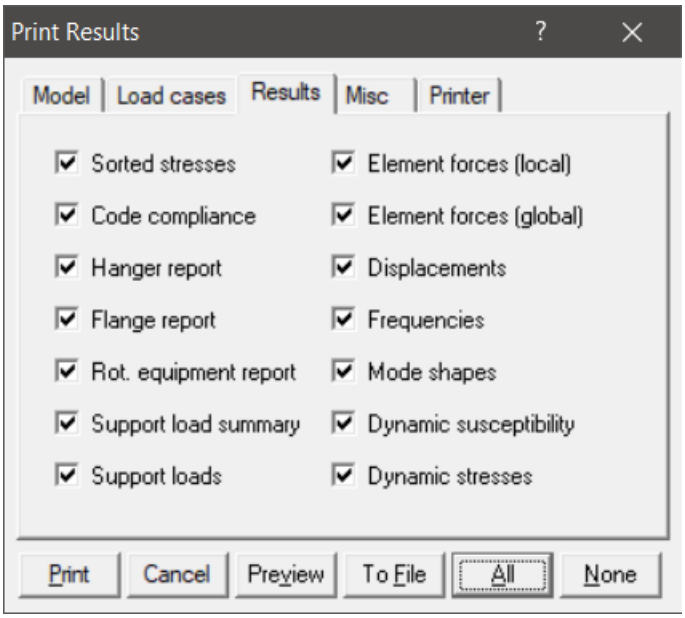
In case the maximum dynamic bending stress and the maximum velocity occur at the same node for a specific mode, then the RED and PINK dots overlap with each other and only the RED dot is seen for that mode. See the Animated mode shape shown below for mode 11 as an example.



The dynamic susceptibility module *does not apply directly to meeting code or other formal stress analysis requirements.* However, it is an incisive analytical tool to help the designer understand the stress / vibration relationship, assess the situation and to decide how to modify the design if necessary to possibly reduce the susceptibility to vibration. It can be used for design, planning acceptance tests, troubleshooting and correction.

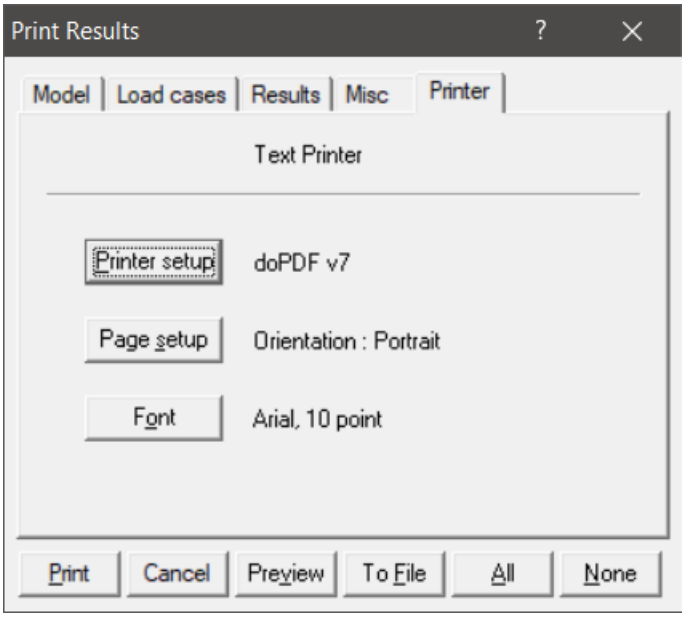
Print

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. Note that for sorted stresses and code compliance, wherever the stress ratio exceeds 1.00, the corresponding stress and stress ratio are shown in white letters on black background. Similarly, wherever the Flange Pressure exceeds the Allowable Pressure, the corresponding Flange Pressure and the 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

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Analysis Options

Code : Piping code = B31.1 (2020)
Include axial force in stress calculations
Use liberal allowable stresses
Use B31J for SIFs and Flexibility Factors

Temperature : Reference temperature = 21.11 (C)
Number of thermal cycles = 7000
Number of thermal loads = 1
Thermal = Operating - Sustained
Use modulus at reference temperature

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

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

Misc. : Include hanger stiffness
Vertical direction = Y

B31.1 (2020) Code compliance (Sorted stresses)

Sustained				Expansion				Occasional			
Node	SL (MPa)	SH (MPa)	SL / SH	Node	SE (MPa)	SA (MPa)	SE / SA	Node	SO (MPa)	1.2SH (MPa)	SO / 1.2SH
115B	35.07	91.70	0.38	110A	61.37	265.5	0.23	50	75.96	122.1	0.62
35	37.72	101.7	0.37	110B	54.01	259.5	0.21	35	57.75	122.1	0.47
110B	27.48	91.70	0.30	115B	40.22	251.9	0.16	125	49.66	110.0	0.45
50	29.52	101.7	0.29	35	40.42	261.8	0.15	110B	41.30	110.0	0.38
125	25.70	91.70	0.28	125	39.69	261.3	0.15	115B	41.06	110.0	0.37
120A	25.39	91.70	0.28	120A	37.19	261.6	0.14	120A	38.84	110.0	0.35
120B	24.10	91.70	0.26	50	34.66	270.0	0.13	20B	42.36	122.1	0.35
115A	23.39	91.70	0.26	115A	33.02	263.6	0.13	110A	36.97	110.0	0.34
25	25.67	101.7	0.25	120B	30.85	262.9	0.12	120B	36.63	110.0	0.33
30	24.12	101.7	0.24	105	28.21	265.8	0.11	45	40.17	122.1	0.33
110A	21.53	91.70	0.23	15A	29.87	289.2	0.10	105	31.97	110.0	0.29
105	21.15	91.70	0.23	100	27.01	284.0	0.10	25	33.24	122.1	0.27
45	22.87	101.7	0.22	15B	26.61	283.8	0.09	15B	32.75	122.1	0.27
20B	22.53	101.7	0.22	20B	20.61	277.0	0.07	115A	29.09	110.0	0.26
40	20.97	101.7	0.21	20A	18.16	285.7	0.06	30	31.79	122.1	0.26
15B	15.76	101.7	0.15	45	16.10	276.7	0.06	20A	31.65	122.1	0.26
100	15.53	101.7	0.15	30	6.362	275.4	0.02	15A	28.98	122.1	0.24
20A	13.82	101.7	0.14	5	6.261	291.3	0.02	40	26.81	122.1	0.22
15A	10.37	101.7	0.10	25	5.634	273.9	0.02	100	26.57	122.1	0.22
10	8.605	101.7	0.08	10	5.980	290.9	0.02	5	17.38	122.1	0.14
5	8.207	101.7	0.08	40	4.298	278.6	0.02	10	16.77	122.1	0.14

B31.1 (2020) Code Compliance

Node	Press. Allow. (bar)	Sustained SL (MPa)	Sustained SH (MPa)	Sustained SL/SH	Expansion SE (MPa)	Expansion SA (MPa)	Expansion SE/SA	Occasional SO (MPa)	Occasional 1.2SH (MPa)	Occasional SO/1.2SH
5	15.0	8.207	101.7	0.08	6.261	291.3	0.02	17.38	122.1	0.14
10	66.6	8.605	101.7	0.08	5.980	290.9	0.02	16.77	122.1	0.14
10	15.0	8.605	101.7	0.08	5.980	290.9	0.02	16.74	122.1	0.14
15A	66.6	8.915	101.7	0.09	12.64	290.6	0.04	19.49	122.1	0.16
15A	15.0	10.37	101.7	0.10	29.87	289.2	0.10	28.98	122.1	0.24
15B	52.1	15.76	101.7	0.15	26.61	283.8	0.09	32.75	122.1	0.27
15B	15.0	11.90	101.7	0.12	12.46	287.6	0.04	21.33	122.1	0.17
20A	66.6	11.65	101.7	0.11	10.06	287.9	0.03	21.48	122.1	0.18
20A	15.0	13.82	101.7	0.14	18.16	285.7	0.06	31.65	122.1	0.26
20B	52.1	22.53	101.7	0.22	20.61	277.0	0.07	42.36	122.1	0.35
20B	15.0	15.31	101.7	0.15	9.871	284.2	0.03	26.46	122.1	0.22
25	66.6	25.67	101.7	0.25	5.634	273.9	0.02	33.24	122.1	0.27
30	15.0	24.12	101.7	0.24	6.362	275.4	0.02	31.79	122.1	0.26
35	66.6	21.54	101.7	0.21	11.57	278.0	0.04	30.88	122.1	0.25
35	15.0	21.51	101.7	0.21	1.809	278.0	0.01	25.95	122.1	0.21
40	66.6	19.33	101.7	0.19	2.824	280.2	0.01	24.65	122.1	0.20
40	15.0	20.97	101.7	0.21	4.298	278.6	0.02	26.81	122.1	0.22
45		22.87	101.7	0.22	16.10	276.7	0.06	40.17	122.1	0.33
45	15.0	21.04	101.7	0.21	10.57	278.5	0.04	36.51	122.1	0.30
50	73.4	29.52	101.7	0.29	34.66	270.0	0.13	75.96	122.1	0.62
35	15.0	37.72	101.7	0.37	40.42	261.8	0.15	57.75	122.1	0.47
100	83.5	15.53	101.7	0.15	27.01	284.0	0.10	26.57	122.1	0.22
105	48.0	21.15	91.70	0.23	28.21	265.8	0.11	31.97	110.0	0.29
110A	77.2	20.54	91.70	0.22	28.29	266.5	0.11	31.48	110.0	0.29
110A	48.0	21.53	91.70	0.23	61.37	265.5	0.23	36.97	110.0	0.34
110B	59.8	27.48	91.70	0.30	54.01	259.5	0.21	41.30	110.0	0.38
110B	48.0	24.40	91.70	0.27	25.40	262.6	0.10	34.05	110.0	0.31
115A	77.2	22.10	91.70	0.24	16.90	264.9	0.06	26.27	110.0	0.24
115A	48.0	23.39	91.70	0.26	33.02	263.6	0.13	29.09	110.0	0.26
115B	59.8	35.07	91.70	0.38	40.22	251.9	0.16	41.06	110.0	0.37
115B	48.0	28.45	91.70	0.31	19.05	258.5	0.07	32.72	110.0	0.30
120A	77.2	22.75	91.70	0.25	17.27	264.2	0.07	30.89	110.0	0.28
120A	48.0	25.39	91.70	0.28	37.19	261.6	0.14	38.84	110.0	0.35
120B	59.8	24.10	91.70	0.26	30.85	262.9	0.12	36.63	110.0	0.33
120B	48.0	21.94	91.70	0.24	14.49	265.1	0.05	29.52	110.0	0.27
125	77.2	25.70	91.70	0.28	39.69	261.3	0.15	49.66	110.0	0.45

Hanger Report

Node	No of	Type	Figure No.	Size	Spring rate (N/mm)	Vert travel (mm)	Horz travel (mm)	Hot load (N)	Cold load (N)	Var (%)
20B	1	User hanger			105	3.300	25.250	13200	13547	2
115B	1	Grinnell	B-268	10	45.533	15.495	16.006	5420	6125	13

Flange report

Node	Pipe NS/OD (mm)	Pressure (bar)	Bending/ Torsion (Nm)	Gasket diameter (mm)	Flange Pressure (bar)	Allowable Pressure (bar)	Flange Pressure Allowable
105	6"	32.0	4017	192.02	60.9	40.0	1.522
100	6"	10.0	4813	192.02	44.6	40.0	1.115

Flange report

Node	Pipe NS/OD (mm)	Pressure (bar)	Bending/ Torsion (Nm)	Gasket diameter (mm)	Flange Pressure (bar)	Allowable Pressure (bar)	Flange Pressure Allowable
25	10"	10.0	8488	297	26.5	40.0	0.663
30	10"	10.0	8168	297	25.9	40.0	0.647
10	10"	10.0	2504	297	14.9	40.0	0.372

API 610 (11th ed.), Sep 2010 / ISO 13709 report for pump : Pump

Load case: Operating (W+P1+T1)
Shaft axis: Xcomp = 1.000, Ycomp = 0.000, Zcomp = 0.000
Center location: X = 8280, Y = 6550, Z = 8520 (mm)

Suction node: 50, Location: (Side), Size: 8.000 (inch)
Offsets from center: dx = 0, dy = 427.7, dz = 0 (mm)

Check of condition F.1.1 for suction node 50:

	Calculated	Allowed	Ratio	Status
FX (N)	2967	3781	0.785	OK
FY (N)	-1168	4893	0.239	OK
FZ (N)	-5270	3114	1.693	----
FR (N)	6160	6939	0.888	OK
MX (Nm)	-5457	3525	1.548	----
MY (Nm)	1652	1763	0.937	OK
MZ (Nm)	-8480	2576	3.292	Failed
MR (Nm)	10219	4745	2.153	Failed

Condition F.1.2.a for suction node 50 failed ***

*** Discharge node is not defined ***

Support load summary for anchor at node 50

Load combination	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
Empty Weight	-260	-4706	31	-4173	1244	-1664
Sustained	-228	-5198	19	-6025	990	-1704
Operating1	2967	-5270	1168	-5457	-8480	-1652
Sustained+Wind	987	-5353	186	-6712	-2792	-2348
Operating1+Wind	4182	-5426	1335	-6145	-12262	-2295
Sustained+Wind 2	-228	-5198	19	-6025	990	-1704
Operating1+Wind 2	2967	-5270	1168	-5457	-8480	-1652
Sustained+Seismic	3634	-2364	6577	2412	11573	-356
Sustained-Seismic	-4090	-8031	-6539	-14462	-9592	-3052
Operating1+Seismic	6830	-2437	7726	2980	2102	-304
Operating1-Seismic	-895	-8104	-5390	-13894	-19063	-3000
Maximum	6830	-2364	7726	2980	11573	-304
Minimum	-4090	-8104	-6539	-14462	-19063	-3052
Allowables	0	0	0	0	0	0

Support load summary for anchor at node 125

Load combination	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
Empty Weight	134	-1636	60	212	-131	-828
Sustained	144	-1767	28	55	-42	-1006
Operating1	-1910	-1761	-402	-934	930	4324
Sustained+Wind	748	-1758	-88	-250	165	-2025
Operating1+Wind	-1306	-1752	-518	-1239	1136	3304
Sustained+Wind 2	144	-1767	28	55	-42	-1006
Operating1+Wind 2	-1910	-1761	-402	-934	930	4324
Sustained+Seismic	1441	-1143	786	2015	687	1730
Sustained-Seismic	-1153	-2392	-730	-1905	-771	-3741
Operating1+Seismic	-614	-1137	356	1026	1659	7059
Operating1-Seismic	-3207	-2386	-1160	-2894	201	1588
Maximum	1441	-1137	786	2015	1659	7059
Minimum	-3207	-2392	-1160	-2894	-771	-3741
Allowables	0	0	0	0	0	0

Support load summary for hanger at node 20B

Displacements (global)	
Load combination	Load (N)
Empty Weight	-12932
Sustained	-13314
Operating1	-13200
Sustained+Wind	-13479
Operating1+Wind	-13365
Sustained+Wind 2	-13314
Operating1+Wind 2	-13200
Sustained+Seismic	-11793
Sustained-Seismic	-14835
Operating1+Seismic	-11679
Operating1-Seismic	-14721

Support load summary for hanger at node 20B

Displacements (global)	
Load combination	Load (N)
Maximum	-11679
Minimum	-14835

Support load summary for hanger at node 115B

Displacements (global)	
Load combination	Load (N)
Empty Weight	-6015
Sustained	-6058
Operating1	-5420
Sustained+Wind	-6050
Operating1+Wind	-5412
Sustained+Wind 2	-6058
Operating1+Wind 2	-5420
Sustained+Seismic	-5862
Sustained-Seismic	-6254
Operating1+Seismic	-5224
Operating1-Seismic	-5616
Maximum	-5224
Minimum	-6254

Support load summary for nozzle at node 5

Load combination	Radial (P) (N)	y Shear (VL) (N)	z Shear (VC) (N)	Torque (MT) (Nm)	Circ.Mom (MC) (Nm)	Long.Mom (ML) (Nm)
Empty Weight	126	-91	3388	465	-77	-616
Sustained	84	-47	3657	258	-218	-336
Operating1	-1057	-765	4343	-1552	-845	-2657
Sustained+Wind	956	-98	3461	-49	-223	-148
Operating1+Wind	-185	-817	4147	-1859	-850	-2470
Sustained+Wind 2	84	-47	3657	258	-218	-336
Operating1+Wind 2	-1057	-765	4343	-1552	-845	-2657
Sustained+Seismic	3930	1720	4786	3120	317	3323
Sustained-Seismic	-3762	-1813	2528	-2604	-752	-3994
Operating1+Seismic	2789	1001	5472	1310	-310	1002
Operating1-Seismic	-4903	-2532	3214	-4414	-1379	-6316
Maximum	3930	1720	5472	3120	317	3323
Minimum	-4903	-2532	2528	-4414	-1379	-6316
Allowables	0	0	0	0	0	0

Loads on Anchors: Empty Weight (W)

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		-260	-4706	31	-4173	1244	-1664
125		134	-1636	60	212	-131	-828

Loads on Hangers: Empty Weight (W)

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	-12932	1	-12932
115B		Grinnell	-6015	1	-6015

Loads on Nozzles: Empty Weight (W)

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		126	-91	3388	465	-77	-616

Pipe forces in local coordinates: Empty Weight (W)

Node	Axial	y Shear	z Shear	Torsion(Nm)		Inplane(Nm)		Outplane(Nm)		Flex. Factors		
	(N)	(N)	(N)	Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt
5	126	-3388	-91	465		-77		616				
10	126	-3244	-91	465	1.00	586	1.00	598	1.00			
10	126	-2559	-91	465	1.00	586	1.00	598	1.00			
15A	126	3016	-91	465		-1171		-100				
15A	126	3016	-91	465	1.00	-1171	2.61	-100	2.17	8.13	8.13	
15B	3449	-126	-91	-135	1.00	-2332	2.61	-499	2.17	8.13	8.13	
15B	3449	-126	-91	-135		-2332		-499				
20A	7640	-126	-91	-135		-1600		-1024				
20A	7640	-91	126	-135	1.00	1024	2.61	-1600	2.17	8.13	8.13	
20B	-91	-8073	126	-1552	1.00	4075	2.61	183	2.17	8.13	8.13	
20B	-91	-4859	-126	-1552		-4075		-183				
25	-91	-2064	-126	-1552	1.00	9284	1.00	-671	1.00			
30	-91	3938	-126	-1552	1.00	8701	1.00	-749	1.00			
35	-91	4155	-126	-1552	1.39	787	2.00	7487	1.00			
35	-31	3053	-260	1664	1.39	482	2.00	7317	1.00			
40	-31	3270	-260	1664		6368		-560				
40	-31	3270	-260	1664	1.00	6368	1.52	-560	1.52			
45	-31	3600	-260	1664	1.00	4548	1.52	-698	1.52			
45	-31	3600	-260	1664		4548		-698				
50	-31	4706	-260	1664		-4173		-1244				
35	134	1102	60	170	1.07	-305	1.47	-3216	1.86		2.44	
100	134	1614	60	170	1.00	1314	1.00	-221	1.00		2.44	
105	134	3622	60	170	1.00	258	1.00	-197	1.00			
110A	134	3631	60	170		163		-195				
110A	134	3631	60	170	1.00	163	2.27	-195	1.89	6.59	6.59	
110B	3763	-134	60	-182	1.00	-648	2.27	-156	1.89	6.59	6.59	
110B	3763	134	-60	-182		648		156				
115A	4674	134	-60	-182		314		6				
115A	4674	134	-60	-182	1.00	314	2.27	6	1.89	6.59	6.59	
115B	134	-4806	-60	-7	1.00	1372	2.27	168	1.89	6.59	6.59	
115B	134	-1209	60	-7		-1372		-168				
120A	134	211	60	-7		567		65				
120A	134	-211	-60	-7	1.00	-567	2.27	-65	1.89	6.59	6.59	
120B	-280	-207	-60	-76	1.00	-486	2.27	-22	1.89	6.59	6.59	
120B	-280	207	60	-76		486		22				
125	-1555	524	60	-76		-828		238				

Other forces in local coordinates: Empty Weight (W)

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	-91	-1380	-126	-1552	-671	9284
30		-91	3253	-126	-1552	-749	8701
100	Valve	134	1846	60	170	-221	1314
105		134	3390	60	170	-197	258

Pipe forces in global coordinates: Empty Weight (W)

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	-126	3388	91	-465	-616	77
10	126	-3244	-91	465	598	586
10	-126	2559	91	-465	-598	-586
15A	126	3016	-91	465	-100	-1171
15A	-126	-3016	91	-465	100	1171
15B	126	3449	-91	499	-135	-2332
15B	-126	-3449	91	-499	135	2332
20A	126	7640	-91	1024	-135	-1600
20A	-126	-7640	91	-1024	135	1600
20B	126	8073	-91	4075	-183	-1552
20B	-126	4859	91	-4075	183	1552
25	126	-2064	-91	-9284	-671	-1552
30	-126	-3938	91	8701	749	1552
35	126	4155	-91	-7487	-787	-1552
35	-260	-3053	31	7317	482	-1664
40	260	3270	-31	-6368	-560	1664
40	-260	-3270	31	6368	560	-1664
45	260	3600	-31	-4548	-698	1664
45	-260	-3600	31	4548	698	-1664
50	260	4706	-31	4173	-1244	1664
35	134	-1102	60	170	305	3216
100	-134	1614	-60	-170	-221	-1314
105	134	-3622	60	170	197	258
110A	-134	3631	-60	-170	-195	-163
110A	134	-3631	60	170	195	163
110B	-134	3763	-60	-156	-182	648
110B	134	-3763	60	156	182	-648
115A	-134	4674	-60	-6	-182	314
115A	134	-4674	60	6	182	-314
115B	-134	4806	-60	7	-168	1372
115B	134	1209	60	-7	168	-1372
120A	-134	211	-60	7	65	-567
120A	134	-211	60	-7	-65	567
120B	-134	322	-60	-3	79	-486
120B	134	-322	60	3	-79	486
125	-134	1636	-60	-212	131	828

Other forces in global coordinates: Empty Weight (W)

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	-126	1380	91	9284	671	1552
30		126	3253	-91	-8701	-749	-1552
100	Valve	134	-1846	60	170	221	1314
105		-134	3390	-60	-170	-197	-258

Displacements: Empty Weight (W)

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.003	0.000	0.000	0.0000	0.0225	-0.0177
10	0.003	-0.064	-0.080	0.0005	0.0230	-0.0175

Displacements: Empty Weight (W)

Node	Displacements (global) X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
15A	0.004	5.745	-4.011	0.0210	0.0315	0.0939
15B	-0.463	6.290	-4.048	0.0277	0.0273	0.0529
20A	-3.118	6.312	-0.382	0.0471	0.0228	0.0028
20B	-2.884	5.856	0.000	0.0928	0.0298	-0.0159
25	-1.071	0.288	0.000	0.0333	0.0226	-0.0502
30	-0.829	-0.035	0.000	0.0265	0.0221	-0.0517
35	-0.713	-0.167	0.000	0.0265	0.0221	-0.0517
40	-0.597	-0.300	0.000	0.0265	0.0221	-0.0517
45	-0.402	-0.446	0.000	0.0078	0.0199	-0.0444
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.713	1.657	0.514	0.0265	0.0221	-0.0651
105	-0.713	2.126	0.667	0.0259	0.0215	-0.0673
110A	-0.713	2.158	0.677	0.0257	0.0214	-0.0674
110B	-0.480	2.420	0.829	0.0171	0.0122	-0.0460
115A	0.786	2.435	1.427	0.0120	-0.0026	-0.0158
115B	0.814	2.425	1.448	0.0093	-0.0088	0.0252
120A	0.814	-0.177	0.550	0.0103	-0.0138	0.0196
120B	0.820	-0.209	0.472	0.0092	-0.0115	-0.0069
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Sustained (W+P)

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		-228	-5198	19	-6025	990	-1704
125		144	-1767	28	55	-42	-1006

Loads on Hangers: Sustained (W+P)

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	-13314	1	-13314
115B		Grinnell	-6058	1	-6058

Loads on Nozzles: Sustained (W+P)

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		84	-47	3657	258	-218	-336

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

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL (MPa)
5	84	-3657	-47	258		-218		336					8.207
10	84	-3502	-47	258	1.00	498	1.00	326	1.00				8.605
10	84	-2817	-47	258	1.00	498	1.00	326	1.00				8.605
15A	84	3141	-47	258		-747		-33					8.915
15A	84	3141	-47	258	1.00	-747	2.61	-33	2.17	8.13	8.13		10.37
15B	3604	-84	-47	-50	1.00	-1976	2.61	-276	2.17	8.13	8.13		15.76
15B	3604	-84	-47	-50		-1976		-276					11.90
20A	8083	-84	-47	-50		-1490		-546					11.65
20A	8083	-47	84	-50	1.00	546	2.61	-1490	2.17	8.13	8.13		13.82
20B	-47	-8546	84	-1458	1.00	3756	2.61	82	2.17	8.13	8.13		22.53
20B	-47	-4768	-84	-1458		-3756		-82					15.31
25	-47	-1781	-84	-1458	1.00	8881	1.00	-406	1.00				25.67

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

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL (MPa)
30	-47	4252	-84	-1458	1.00	8112	1.00	-458	1.00				24.12
35	-47	4484	-84	-1458	1.39	483	2.00	6802	1.00				21.54
35	-19	3442	-228	1704	1.39	323	2.00	6766	1.00				21.51
40	-19	3674	-228	1704		5699		-391					19.33
40	-19	3674	-228	1704	1.00	5699	1.52	-391	1.52				20.97
45	-19	4025	-228	1704	1.00	3659	1.52	-512	1.52				22.87
45	-19	4025	-228	1704		3659		-512					21.04
50	-19	5198	-228	1704		-6025		-990					29.52
35	144	1042	28	35	1.07	-161	1.47	-3162	1.86		2.44		37.72
100	144	1580	28	35	1.00	1327	1.00	-122	1.00		2.44		15.53
105	144	3595	28	35	1.00	283	1.00	-111	1.00				21.15
110A	144	3605	28	35		188		-110					20.54
110A	144	3605	28	35	1.00	188	2.27	-110	1.89	6.59	6.59		21.53
110B	3743	-144	28	-103	1.00	-614	2.27	-29	1.89	6.59	6.59		27.48
110B	3743	144	-28	-103		614		29					24.40
115A	4700	144	-28	-103		255		-41					22.10
115A	4700	144	-28	-103	1.00	255	2.27	-41	1.89	6.59	6.59		23.39
115B	144	-4838	-28	-47	1.00	1317	2.27	97	1.89	6.59	6.59		35.07
115B	144	-1220	28	-47		-1317		-97					28.45
120A	144	271	28	-47		526		11					22.75
120A	144	-271	-28	-47	1.00	-526	2.27	-11	1.89	6.59	6.59		25.39
120B	-341	-233	-28	-27	1.00	-430	2.27	37	1.89	6.59	6.59		24.10
120B	-341	233	28	-27		430		-37					21.94
125	-1680	566	28	-27		-1006		63					25.70

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

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	-47	-1097	-84	-1458	-406	8881
30		-47	3568	-84	-1458	-458	8112
100	Valve	144	1811	28	35	-122	1327
105		144	3363	28	35	-111	283

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

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	-84	3657	47	-258	-336	218
10	84	-3502	-47	258	326	498
10	-84	2817	47	-258	-326	-498
15A	84	3141	-47	258	-33	-747
15A	-84	-3141	47	-258	33	747
15B	84	3604	-47	276	-50	-1976
15B	-84	-3604	47	-276	50	1976
20A	84	8083	-47	546	-50	-1490
20A	-84	-8083	47	-546	50	1490
20B	84	8546	-47	3756	-82	-1458
20B	-84	4768	47	-3756	82	1458
25	84	-1781	-47	-8881	-406	-1458
30	-84	-4252	47	8112	458	1458
35	84	4484	-47	-6802	-483	-1458

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

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
35	-228	-3442	19	6766	323	-1704
40	228	3674	-19	-5699	-391	1704
40	-228	-3674	19	5699	391	-1704
45	228	4025	-19	-3659	-512	1704
45	-228	-4025	19	3659	512	-1704
50	228	5198	-19	6025	-990	1704
35	144	-1042	28	35	161	3162
100	-144	1580	-28	-35	-122	-1327
105	144	-3595	28	35	111	283
110A	-144	3605	-28	-35	-110	-188
110A	144	-3605	28	35	110	188
110B	-144	3743	-28	-29	-103	614
110B	144	-3743	28	29	103	-614
115A	-144	4700	-28	41	-103	255
115A	144	-4700	28	-41	103	-255
115B	-144	4838	-28	47	-97	1317
115B	144	1220	28	-47	97	-1317
120A	-144	271	-28	47	11	-526
120A	144	-271	28	-47	-11	526
120B	-144	387	-28	42	18	-430
120B	144	-387	28	-42	-18	430
125	-144	1767	-28	-55	42	1006

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

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	-84	1097	47	8881	406	1458
30		84	3568	-47	-8112	-458	-1458
100	Valve	144	-1811	28	35	122	1327
105		-144	3363	-28	-35	-111	-283

Displacements: Sustained (W+P)

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.000	0.000	0.000	0.0000	0.0123	-0.0500
10	0.000	-0.177	-0.043	0.0003	0.0126	-0.0499
15A	0.000	2.018	-2.202	0.0117	0.0175	0.0755
15B	-0.378	2.462	-2.225	0.0152	0.0155	0.0428
20A	-2.362	2.485	-0.215	0.0257	0.0138	-0.0014
20B	-2.163	2.213	0.000	0.0623	0.0214	-0.0194
25	-0.829	-1.214	0.000	0.0024	0.0173	-0.0516
30	-0.643	-1.204	0.000	-0.0041	0.0169	-0.0530
35	-0.554	-1.175	0.000	-0.0041	0.0169	-0.0530
40	-0.465	-1.148	0.000	-0.0041	0.0169	-0.0530
45	-0.315	-1.022	0.000	-0.0201	0.0154	-0.0454
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.554	0.660	0.403	-0.0041	0.0169	-0.0665
105	-0.555	1.140	0.521	-0.0042	0.0166	-0.0687
110A	-0.555	1.172	0.528	-0.0042	0.0166	-0.0689

Displacements: Sustained (W+P)

Node	Displacements (global)					
	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
110B	-0.311	1.442	0.562	-0.0070	0.0123	-0.0492
115A	1.154	1.457	0.251	-0.0066	0.0038	-0.0220
115B	1.212	1.481	0.236	-0.0066	0.0010	0.0155
120A	1.212	-0.313	0.098	-0.0006	-0.0032	0.0070
120B	1.184	-0.300	0.086	0.0004	-0.0034	-0.0170
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Expansion (T1)

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		3195	-73	1149	568	-9470	52
125		-2054	6	-430	-989	971	5329

Loads on Hangers: Expansion (T1)

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	114	1	114
115B		Grinnell	638	1	638

Loads on Nozzles: Expansion (T1)

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		-1141	-719	686	-1810	-627	-2321

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm)		Inplane(Nm)		Outplane(Nm)		Flex. Factors			SE (MPa)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
5	-1141	-686	-719	-1810		-627		2321					6.261
10	-1141	-686	-719	-1810	1.00	-490	1.00	2178	1.00				5.980
10	-1141	-686	-719	-1810	1.00	-490	1.00	2178	1.00				5.980
15A	-1141	-686	-719	-1810		4791		-3356					12.64
15A	-1141	-686	-719	-1810	1.00	4791	2.61	-3356	2.17	8.13	8.13		29.87
15B	-686	1141	-719	-3629	1.00	4617	2.61	1536	2.17	8.13	8.13		26.61
15B	-686	1141	-719	-3629		4617		1536					12.46
20A	-686	1141	-719	-3629		-1986		-2624					10.06
20A	-686	-719	-1141	-3629	1.00	2624	2.61	-1986	2.17	8.13	8.13		18.16
20B	-719	686	-1141	-2420	1.00	2637	2.61	3195	2.17	8.13	8.13		20.61
20B	-719	-572	1141	-2420		-2637		-3195					9.871
25	-719	-572	1141	-2420	1.00	-431	1.00	1207	1.00				5.634
30	-719	-572	1141	-2420	1.00	-75	1.00	1917	1.00				6.362
35	-719	-572	1141	-2420	1.39	-2260	2.00	96	1.00				11.57
35	-1149	73	3195	-52	1.39	-109	2.00	780	1.00				1.809
40	-1149	73	3195	-52		758		1067					2.824
40	-1149	73	3195	-52	1.00	758	1.52	1067	1.52				4.298
45	-1149	73	3195	-52	1.00	720	1.52	2761	1.52				16.10
45	-1149	73	3195	-52		720		2761					10.57
50	-1149	73	3195	-52		568		9470					34.66
35	-2054	-644	-430	-684	1.07	2151	1.47	-2368	1.86		2.44		40.42
100	-2054	-644	-430	-684	1.00	3270	1.00	1548	1.00		2.44		27.01
105	-2054	-644	-430	-684	1.00	3529	1.00	1375	1.00				28.21
110A	-2054	-644	-430	-684		3546		1364					28.29
110A	-2054	-644	-430	-684	1.00	3546	2.27	1364	1.89	6.59	6.59		61.37
110B	-644	2054	-430	1265	1.00	3224	2.27	585	1.89	6.59	6.59		54.01

Pipe forces in local coordinates: Expansion (T1)

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SE (MPa)
110B	-644	-2054	430	1265		-3224		-585					25.40
115A	-644	-2054	430	1265		1897		487					16.90
115A	-644	-2054	430	1265	1.00	1897	2.27	487	1.89	6.59	6.59		33.02
115B	-2054	644	430	585	1.00	2219	2.27	-1167	1.89	6.59	6.59		40.22
115B	-2054	-6	-430	585		-2219		1167					19.05
120A	-2054	-6	-430	585		-2196		-503					17.27
120A	-2054	6	430	585	1.00	2196	2.27	503	1.89	6.59	6.59		37.19
120B	-490	1995	430	704	1.00	1838	2.27	-351	1.89	6.59	6.59		30.85
120B	-490	-1995	-430	704		-1838		351					14.49
125	-490	-1995	-430	704		5329		-1194					39.69

Other forces in local coordinates: Expansion (T1)

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	-719	-572	1141	-2420	1207	-431
30		-719	-572	1141	-2420	1917	-75
100	Valve	-2054	-644	-430	-684	1548	3270
105		-2054	-644	-430	-684	1375	3529

Pipe forces in global coordinates: Expansion (T1)

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	1141	686	719	1810	-2321	627
10	-1141	-686	-719	-1810	2178	-490
10	1141	686	719	1810	-2178	490
15A	-1141	-686	-719	-1810	-3356	4791
15A	1141	686	719	1810	3356	-4791
15B	-1141	-686	-719	-1536	-3629	4617
15B	1141	686	719	1536	3629	-4617
20A	-1141	-686	-719	2624	-3629	-1986
20A	1141	686	719	-2624	3629	1986
20B	-1141	-686	-719	2637	-3195	-2420
20B	1141	572	719	-2637	3195	2420
25	-1141	-572	-719	431	1207	-2420
30	1141	572	719	-75	-1917	2420
35	-1141	-572	-719	-96	2260	-2420
35	3195	-73	1149	780	-109	52
40	-3195	73	-1149	-758	1067	-52
40	3195	-73	1149	758	-1067	52
45	-3195	73	-1149	-720	2761	-52
45	3195	-73	1149	720	-2761	52
50	-3195	73	-1149	-568	9470	-52
35	-2054	644	-430	-684	-2151	2368
100	2054	-644	430	684	1548	-3270
105	-2054	644	-430	-684	-1375	3529
110A	2054	-644	430	684	1364	-3546
110A	-2054	644	-430	-684	-1364	3546
110B	2054	-644	430	585	1265	-3224
110B	-2054	644	-430	-585	-1265	3224
115A	2054	-644	430	-487	1265	1897

Pipe forces in global coordinates: Expansion (T1)

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
115A	-2054	644	-430	487	-1265	-1897
115B	2054	-644	430	-585	1167	2219
115B	-2054	6	-430	585	-1167	-2219
120A	2054	-6	430	-585	-503	2196
120A	-2054	6	-430	585	503	-2196
120B	2054	-6	430	-511	-599	1838
120B	-2054	6	-430	511	599	-1838
125	2054	-6	430	989	-971	-5329

Other forces in global coordinates: Expansion (T1)

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	1141	572	719	-431	-1207	2420
30		-1141	-572	-719	75	1917	-2420
100	Valve	-2054	644	-430	-684	-1548	3270
105		2054	-644	430	684	1375	-3529

Displacements: Expansion (T1)

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.028	0.000	0.000	0.0000	0.0848	-0.1440
10	0.526	-0.504	-0.300	-0.0021	0.0868	-0.1445
15A	21.858	-17.046	-12.741	-0.0819	0.0668	-0.0716
15B	22.952	-16.216	-13.585	-0.0823	0.0333	0.0312
20A	16.665	-0.177	-22.107	-0.0684	-0.0870	0.0648
20B	15.617	1.088	-21.367	-0.0105	-0.1162	0.0574
25	6.785	0.701	-10.674	0.0155	-0.1331	0.0040
30	5.344	0.531	-8.949	0.0157	-0.1320	0.0016
35	4.651	0.447	-8.118	0.0157	-0.1320	0.0016
40	3.954	0.365	-7.286	0.0157	-0.1320	0.0016
45	2.752	0.232	-5.818	0.0132	-0.1254	0.0014
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.775	0.142	-11.165	0.0157	-0.1320	-0.0302
105	-0.342	0.385	-12.080	0.0180	-0.1282	-0.0390
110A	-0.452	0.403	-12.138	0.0186	-0.1273	-0.0413
110B	-0.706	1.827	-12.363	0.0610	-0.0705	-0.2479
115A	12.186	12.223	-9.391	0.0641	0.0327	-0.2895
115B	12.212	14.014	-8.952	0.0637	0.0676	-0.1619
120A	-3.971	17.668	-2.339	-0.0106	0.1000	0.0537
120B	-4.523	16.563	-1.936	-0.0170	0.0895	0.1578
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

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

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		2967	-5270	1168	-5457	-8480	-1652
125		-1910	-1761	-402	-934	930	4324

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

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	-13200	1	-13200

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

Node	Tag	Type	Load (N)	No.of	Total (N)
115B		Grinnell	-5420	1	-5420

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

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		-1057	-765	4343	-1552	-845	-2657

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

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	Sopr (MPa)
5	-1057	-4343	-765	-1552		-845		2657					13.74
10	-1057	-4188	-765	-1552	1.00	8	1.00	2504	1.00				13.24
10	-1057	-3503	-765	-1552	1.00	8	1.00	2504	1.00				13.24
15A	-1057	2455	-765	-1552		4044		-3388					18.45
15A	-1057	2455	-765	-1552	1.00	4044	2.61	-3388	2.17	8.13	8.13		33.64
15B	2918	1057	-765	-3680	1.00	2642	2.61	1260	2.17	8.13	8.13		24.62
15B	2918	1057	-765	-3680		2642		1260					17.34
20A	7397	1057	-765	-3680		-3476		-3170					20.51
20A	7397	-765	-1057	-3680	1.00	3170	2.61	-3476	2.17	8.13	8.13		32.36
20B	-765	-7861	-1057	-3878	1.00	6392	2.61	3277	2.17	8.13	8.13		45.05
20B	-765	-5339	1057	-3878		-6392		-3277					23.92
25	-765	-2353	1057	-3878	1.00	8450	1.00	801	1.00				26.31
30	-765	3681	1057	-3878	1.00	8037	1.00	1459	1.00				25.72
35	-765	3913	1057	-3878	1.39	-1776	2.00	6898	1.00				26.55
35	-1168	3514	2967	1652	1.39	214	2.00	7547	1.00				23.34
40	-1168	3747	2967	1652		6457		676					20.88
40	-1168	3747	2967	1652	1.00	6457	1.52	676	1.52				27.67
45	-1168	4097	2967	1652	1.00	4379	1.52	2249	1.52				34.35
45	-1168	4097	2967	1652		4379		2249					25.33
50	-1168	5270	2967	1652		-5457		8480					43.58
35	-1910	398	-402	-649	1.07	1990	1.47	-5530	1.86		2.44		82.49
100	-1910	936	-402	-649	1.00	4596	1.00	1427	1.00		2.44		40.27
105	-1910	2950	-402	-649	1.00	3813	1.00	1265	1.00				47.63
110A	-1910	2961	-402	-649		3735		1254					47.08
110A	-1910	2961	-402	-649	1.00	3735	2.27	1254	1.89	6.59	6.59		81.68
110B	3099	1910	-402	1162	1.00	2610	2.27	557	1.89	6.59	6.59		63.73
110B	3099	-1910	402	1162		-2610		-557					40.70
115A	4056	-1910	402	1162		2152		446					37.91
115A	4056	-1910	402	1162	1.00	2152	2.27	446	1.89	6.59	6.59		56.56
115B	-1910	-4194	402	538	1.00	3536	2.27	-1070	1.89	6.59	6.59		77.87
115B	-1910	-1226	-402	538		-3536		1070					45.21
120A	-1910	265	-402	538		-1670		-492					31.49
120A	-1910	-265	402	538	1.00	1670	2.27	492	1.89	6.59	6.59		46.64
120B	-831	1762	402	677	1.00	1408	2.27	-314	1.89	6.59	6.59		42.50
120B	-831	-1762	-402	677		-1408		314					30.14
125	-2170	-1429	-402	677		4324		-1131					50.79

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

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	-765	-1668	1057	-3878	801	8450
30		-765	2996	1057	-3878	1459	8037

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

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
100	Valve	-1910	1167	-402	-649	1427	4596
105		-1910	2719	-402	-649	1265	3813

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

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	1057	4343	765	1552	-2657	845
10	-1057	-4188	-765	-1552	2504	8
10	1057	3503	765	1552	-2504	-8
15A	-1057	2455	-765	-1552	-3388	4044
15A	1057	-2455	765	1552	3388	-4044
15B	-1057	2918	-765	-1260	-3680	2642
15B	1057	-2918	765	1260	3680	-2642
20A	-1057	7397	-765	3170	-3680	-3476
20A	1057	-7397	765	-3170	3680	3476
20B	-1057	7861	-765	6392	-3277	-3878
20B	1057	5339	765	-6392	3277	3878
25	-1057	-2353	-765	-8450	801	-3878
30	1057	-3681	765	8037	-1459	3878
35	-1057	3913	-765	-6898	1776	-3878
35	2967	-3514	1168	7547	214	-1652
40	-2967	3747	-1168	-6457	676	1652
40	2967	-3747	1168	6457	-676	-1652
45	-2967	4097	-1168	-4379	2249	1652
45	2967	-4097	1168	4379	-2249	-1652
50	-2967	5270	-1168	5457	8480	1652
35	-1910	-398	-402	-649	-1990	5530
100	1910	936	402	649	1427	-4596
105	-1910	-2950	-402	-649	-1265	3813
110A	1910	2961	402	649	1254	-3735
110A	-1910	-2961	-402	-649	-1254	3735
110B	1910	3099	402	557	1162	-2610
110B	-1910	-3099	-402	-557	-1162	2610
115A	1910	4056	402	-446	1162	2152
115A	-1910	-4056	-402	446	-1162	-2152
115B	1910	4194	402	-538	1070	3536
115B	-1910	1226	-402	538	-1070	-3536
120A	1910	265	402	-538	-492	1670
120A	-1910	-265	-402	538	492	-1670
120B	1910	381	402	-468	-581	1408
120B	-1910	-381	-402	468	581	-1408
125	1910	1761	402	934	-930	-4324

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

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	1057	1668	765	8450	-801	3878
30		-1057	2996	-765	-8037	1459	-3878
100	Valve	-1910	-1167	-402	-649	-1427	4596
105		1910	2719	402	649	1265	-3813

Displacements: Operating (W+P1+T1)

Node	Displacements (global) X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.026	0.000	0.000	0.0000	0.0971	-0.1941
10	0.528	-0.681	-0.343	-0.0018	0.0993	-0.1944
15A	21.861	-15.028	-14.943	-0.0702	0.0843	0.0039
15B	22.573	-13.754	-15.810	-0.0671	0.0488	0.0740
20A	14.302	2.307	-22.322	-0.0427	-0.0731	0.0634
20B	13.454	3.300	-21.367	0.0517	-0.0948	0.0381
25	5.956	-0.513	-10.673	0.0179	-0.1159	-0.0476
30	4.701	-0.673	-8.949	0.0117	-0.1150	-0.0514
35	4.097	-0.728	-8.118	0.0117	-0.1150	-0.0514
40	3.489	-0.782	-7.286	0.0116	-0.1150	-0.0514
45	2.438	-0.790	-5.818	-0.0069	-0.1100	-0.0440
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.220	0.802	-10.762	0.0117	-0.1150	-0.0967
105	-0.897	1.524	-11.559	0.0138	-0.1115	-0.1077
110A	-1.007	1.575	-11.610	0.0144	-0.1107	-0.1102
110B	-1.017	3.270	-11.800	0.0540	-0.0582	-0.2971
115A	13.340	13.680	-9.140	0.0575	0.0365	-0.3115
115B	13.425	15.495	-8.716	0.0572	0.0685	-0.1464
120A	-2.759	17.355	-2.241	-0.0112	0.0968	0.0607
120B	-3.338	16.264	-1.851	-0.0166	0.0861	0.1408
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Seismic (g)

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		3862	2834	6558	8437	10583	1348
125		1297	625	758	1960	729	2735

Loads on Hangers: Seismic (g)

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	1521	1	1521
115B		Grinnell	196	1	196

Loads on Nozzles: Seismic (g)

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		3846	1766	1129	2862	534	3659

Pipe forces in local coordinates: Seismic (g)

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL+SO (MPa)
5	3846	1129	1766	2862		534		3659					17.38
10	3800	1101	1720	2862	1.00	349	1.00	3321	1.00				16.77
10	3594	980	1516	2862	1.00	349	1.00	3321	1.00				16.74
15A	1811	595	336	2862		4163		1962					19.49
15A	1811	595	336	2862	1.00	4163	2.61	1962	2.17	8.13	8.13		28.98
15B	653	1672	459	1897	1.00	3658	2.61	2736	2.17	8.13	8.13		32.75
15B	653	1672	459	1897		3658		2736					21.33
20A	1416	361	1775	1897		2499		4109					21.48
20A	1416	1775	361	1897	1.00	4109	2.61	2499	2.17	8.13	8.13		31.65
20B	1913	1503	247	2586	1.00	4583	2.61	1984	2.17	8.13	8.13		42.36

Pipe forces in local coordinates: Seismic (g)

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL+SO (MPa)
20B	1913	449	247	2586		4583		1984					26.46
25	2806	731	734	2586	1.00	2877	1.00	1974	1.00				33.24
30	4614	1840	2530	2586	1.00	2722	1.00	2161	1.00				31.79
35	4683	1885	2600	2586	1.39	-2557	2.00	2800	1.00				30.88
35	6032	2491	3336	1348	1.39	-650	2.00	1426	1.00				25.95
40	6102	2536	3406	1348		1829		1183					24.65
40	6102	2536	3406	1348	1.00	1829	1.52	1183	1.52				26.81
45	6207	2605	3511	1348	1.00	2935	1.52	2895	1.52				40.17
45	6207	2605	3511	1348		2935		2895					36.51
50	6558	2834	3862	1348		8437		10583					75.96
35	738	647	1374	1383	1.07	2700	1.47	-1353	1.86		2.44		57.75
100	577	550	1218	1383	1.00	834	1.00	1261	1.00		2.44		26.57
105	30	276	650	1383	1.00	755	1.00	1076	1.00				31.97
110A	33	276	647	1383		749		1067					31.48
110A	33	276	647	1383	1.00	749	2.27	1067	1.89	6.59	6.59		36.97
110B	269	73	611	1003	1.00	687	2.27	1244	1.89	6.59	6.59		41.30
110B	269	73	611	1003		687		1244					34.05
115A	300	359	389	1003		301		309					26.27
115A	300	359	389	1003	1.00	301	2.27	309	1.89	6.59	6.59		29.09
115B	401	314	365	337	1.00	254	2.27	941	1.89	6.59	6.59		41.06
115B	401	255	365	337		254		941					32.72
120A	848	372	390	337		1055		289					30.89
120A	848	372	390	337	1.00	1055	2.27	289	1.89	6.59	6.59		38.84
120B	540	800	413	355	1.00	980	2.27	294	1.89	6.59	6.59		36.63
120B	540	800	413	355		980		294					29.52
125	785	1206	758	355		2735		2060					49.66

Other forces in local coordinates: Seismic (g)

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	3011	844	935	2586	1974	2877
30		4408	1707	2325	2586	2161	2722
100	Valve	508	510	1151	1383	1261	834
105		44	293	712	1383	1076	755

Pipe forces in global coordinates: Seismic (g)

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	3846	1129	1766	2862	3659	534
10	3800	1101	1720	2862	3321	349
10	3594	980	1516	2862	3321	349
15A	1811	595	336	2862	1962	4163
15A	1811	595	336	2862	1962	4163
15B	1672	653	459	2736	1897	3658
15B	1672	653	459	2736	1897	3658
20A	361	1416	1775	4109	1897	2499
20A	361	1416	1775	4109	1897	2499
20B	247	1503	1913	4583	1984	2586
20B	247	449	1913	4583	1984	2586
25	734	731	2806	2877	1974	2586

Pipe forces in global coordinates: Seismic (g)

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
30	2530	1840	4614	2722	2161	2586
35	2600	1885	4683	2800	2557	2586
35	3336	2491	6032	1426	650	1348
40	3406	2536	6102	1829	1183	1348
40	3406	2536	6102	1829	1183	1348
45	3511	2605	6207	2935	2895	1348
45	3511	2605	6207	2935	2895	1348
50	3862	2834	6558	8437	10583	1348
35	738	647	1374	1383	2700	1353
100	577	550	1218	1383	1261	834
105	30	276	650	1383	1076	755
110A	33	276	647	1383	1067	749
110A	33	276	647	1383	1067	749
110B	73	269	611	1244	1003	687
110B	73	269	611	1244	1003	687
115A	359	300	389	309	1003	301
115A	359	300	389	309	1003	301
115B	401	314	365	337	941	254
115B	401	255	365	337	941	254
120A	848	372	390	337	289	1055
120A	848	372	390	337	289	1055
120B	646	717	413	199	416	980
120B	906	331	413	371	274	980
125	1360	471	758	2085	152	2735

Other forces in global coordinates: Seismic (g)

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	935	844	3011	2877	1974	2586
30		2325	1707	4408	2722	2161	2586
100	Valve	508	510	1151	1383	1261	834
105		44	293	712	1383	1076	755

Displacements: Seismic (g)

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.094	0.000	0.000	0.0000	0.1337	0.1228
10	0.094	0.430	0.473	0.0033	0.1367	0.1232
15A	0.108	14.782	20.390	0.1294	0.1353	0.0988
15B	0.943	15.313	20.187	0.1712	0.1087	0.1486
20A	16.569	15.310	1.102	0.1837	0.1058	0.1386
20B	16.602	14.486	0.024	0.1335	0.1291	0.1005
25	7.402	6.201	0.018	0.1227	0.1435	0.0443
30	5.843	4.871	0.017	0.1223	0.1433	0.0419
35	5.089	4.228	0.017	0.1223	0.1433	0.0419
40	4.333	3.584	0.015	0.1223	0.1433	0.0419
45	3.026	2.480	0.013	0.1148	0.1367	0.0359
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	5.090	4.458	3.447	0.1223	0.1433	0.0339

Displacements: Seismic (g)

Node	Displacements (global) X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
105	5.090	4.484	4.436	0.1199	0.1405	0.0318
110A	5.090	4.486	4.500	0.1193	0.1398	0.0314
110B	5.114	4.478	5.060	0.1000	0.0984	0.0158
115A	4.260	4.477	6.907	0.0982	0.0344	0.0464
115B	4.175	4.307	7.115	0.0918	0.0410	0.0590
120A	4.172	1.202	4.047	0.0808	0.0624	0.0584
120B	3.979	0.988	3.639	0.0784	0.0541	0.0791
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Wind

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		1215	-156	167	-687	-3782	-643
125		604	9	-116	-305	206	-1019

Loads on Hangers: Wind

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	-165	1	-165
115B		Grinnell	7	1	7

Loads on Nozzles: Wind

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		872	-51	-196	-307	-5	187

Pipe forces in local coordinates: Wind

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL+SO (MPa)
5	872	196	-51	-307		-5		-187					8.035
10	872	196	-51	-307	1.00	-45	1.00	-198	1.00				8.450
10	872	196	-51	-307	1.00	-45	1.00	-198	1.00				8.450
15A	872	196	-51	-307		-1553		-594					12.35
15A	852	215	-51	-307	1.00	-1553	2.61	-594	2.17	8.13	8.13		16.89
15B	215	-852	-51	-614	1.00	-1311	2.61	288	2.17	8.13	8.13		21.01
15B	235	-419	-51	-614		-1311		288					14.63
20A	235	-419	-51	-614		1115		-10					9.907
20A	235	-51	-33	-614	1.00	10	2.61	1115	2.17	8.13	8.13		11.07
20B	-51	-235	-33	1103	1.00	119	2.61	601	2.17	8.13	8.13		22.98
20B	-51	70	348	1103		-119		-601					15.40
25	-51	70	348	1103	1.00	-389	1.00	742	1.00				24.70
30	-51	70	756	1103	1.00	-433	1.00	1165	1.00				23.10
35	-51	70	756	1103	1.39	-1392	2.00	-454	1.00				20.61
35	-167	156	862	643	1.39	-758	2.00	-231	1.00				21.34
40	-167	156	862	643		-278		1017					19.09
40	-167	156	919	643	1.00	-278	1.52	1017	1.52				20.62
45	-167	156	919	643	1.00	-360	1.52	1504	1.52				22.61
45	-167	156	1085	643		-360		1504					20.98
50	-167	156	1085	643		-687		3782					34.14
35	-63	-86	-116	-223	1.07	634	1.47	459	1.86		2.44		33.35
100	-63	-86	-116	-223	1.00	-339	1.00	471	1.00		2.44		13.53
105	-63	-86	-116	-223	1.00	-304	1.00	425	1.00				21.26
110A	-63	-86	-116	-223		-302		422					21.38

Pipe forces in local coordinates: Wind

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm) Moment	Torsion(Nm) SIF	Inplane(Nm) Moment	Inplane(Nm) SIF	Outplane(Nm) Moment	Outplane(Nm) SIF	Flex. Factors FFi	Flex. Factors FFo	Flex. Factors FFt	SL+SO (MPa)
110A	-55	-94	-116	-223	1.00	-302	2.27	422	1.89	6.59	6.59		22.46
110B	-94	55	-116	395	1.00	-293	2.27	196	1.89	6.59	6.59		31.21
110B	-103	86	116	395		293		-196					26.65
115A	-103	86	116	395		80		92					22.73
115A	-112	226	116	395	1.00	80	2.27	92	1.89	6.59	6.59		24.41
115B	226	112	116	119	1.00	2	2.27	-369	1.89	6.59	6.59		35.37
115B	235	-113	-116	119		-2		369					28.71
120A	235	-113	-116	119		435		-80					25.96
120A	240	105	116	119	1.00	-435	2.27	80	1.89	6.59	6.59		30.79
120B	160	-208	116	127	1.00	-416	2.27	-70	1.89	6.59	6.59		29.23
120B	155	400	-116	127		416		70					24.97
125	155	400	-116	127		-1019		-346					33.20

Other forces in local coordinates: Wind

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	-51	70	679	1103	742	-389
30		-51	70	679	1103	1165	-433
100	Valve	-63	-86	-116	-223	471	-339
105		-63	-86	-116	-223	425	-304

Pipe forces in global coordinates: Wind

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	-872	-196	51	307	187	5
10	872	196	-51	-307	-198	-45
10	-872	-196	51	307	198	45
15A	872	196	-51	-307	-594	-1553
15A	-852	-215	51	307	594	1553
15B	852	215	-51	-288	-614	-1311
15B	-419	-235	51	288	614	1311
20A	419	235	-51	10	-614	1115
20A	33	-235	51	-10	614	-1115
20B	-33	235	-51	119	-601	1103
20B	348	-70	51	-119	601	-1103
25	-348	70	-51	389	742	1103
30	756	-70	51	-433	-1165	-1103
35	-756	70	-51	454	1392	1103
35	862	-156	167	-231	-758	-643
40	-862	156	-167	278	1017	643
40	919	-156	167	-278	-1017	-643
45	-919	156	-167	360	1504	643
45	1085	-156	167	-360	-1504	-643
50	-1085	156	-167	687	3782	643
35	-63	86	-116	-223	-634	-459
100	63	-86	116	223	471	339
105	-63	86	-116	-223	-425	-304
110A	63	-86	116	223	422	302
110A	-55	94	-116	-223	-422	-302
110B	55	-94	116	196	395	293

Pipe forces in global coordinates: Wind

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
110B	86	103	-116	-196	-395	-293
115A	-86	-103	116	-92	395	80
115A	226	112	-116	92	-395	-80
115B	-226	-112	116	-119	369	2
115B	235	113	-116	119	-369	-2
120A	-235	-113	116	-119	-80	-435
120A	240	105	-116	119	80	435
120B	-240	-105	116	-99	-106	-416
120B	425	54	-116	99	106	416
125	-425	-54	116	305	-206	1019

Other forces in global coordinates: Wind

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	679	-70	51	-389	-742	-1103
30		-679	70	-51	433	1165	1103
100	Valve	-63	86	-116	-223	-471	-339
105		63	-86	116	223	425	304

Displacements: Wind

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.021	0.000	0.000	0.0000	-0.0068	-0.0012
10	0.021	-0.004	0.024	-0.0004	-0.0070	-0.0012
15A	0.026	-1.414	1.716	-0.0139	-0.0204	-0.0283
15B	0.354	-1.683	1.785	-0.0141	-0.0262	-0.0602
20A	7.090	-1.682	0.117	-0.0176	-0.0465	-0.0627
20B	7.090	-1.568	0.000	-0.0165	-0.0604	-0.0454
25	2.928	-0.578	0.000	-0.0121	-0.0592	-0.0211
30	2.288	-0.448	0.000	-0.0118	-0.0585	-0.0200
35	1.980	-0.386	0.000	-0.0118	-0.0585	-0.0200
40	1.672	-0.324	0.000	-0.0118	-0.0585	-0.0200
45	1.148	-0.219	0.000	-0.0107	-0.0542	-0.0172
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	1.980	0.067	-1.382	-0.0118	-0.0585	-0.0167
105	1.980	0.182	-1.789	-0.0111	-0.0574	-0.0159
110A	1.980	0.189	-1.816	-0.0109	-0.0571	-0.0157
110B	1.998	0.226	-2.021	0.0027	-0.0393	0.0018
115A	1.617	0.226	-1.764	0.0060	-0.0070	0.0134
115B	1.558	0.164	-1.744	0.0081	0.0049	0.0157
120A	1.557	-0.428	-0.683	-0.0070	0.0190	-0.0054
120B	1.497	-0.372	-0.590	-0.0085	0.0175	-0.0272
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Loads on Anchors: Wind 2

Node	Tag	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
50		0	0	0	0	0	0
125		0	0	0	0	0	0

Loads on Hangers: Wind 2

Node	Tag	Type	Load (N)	No.of	Total (N)
20B		User hanger	0	1	0
115B		Grinnell	0	1	0

Loads on Nozzles: Wind 2

Node	Tag	Axial (N)	y Shear (N)	z Shear (N)	Torque (Nm)	Circ.Mom (Nm)	Long.Mom (Nm)
5		0	0	0	0	0	0

Pipe forces in local coordinates: Wind 2

Node	Axial (N)	y Shear (N)	z Shear (N)	Torsion(Nm)		Inplane(Nm)		Outplane(Nm)		Flex. Factors			SL+SO (MPa)
				Moment	SIF	Moment	SIF	Moment	SIF	FFi	FFo	FFt	
5	0	0	0	0		0		0					8.207
10	0	0	0	0	1.00	0	1.00	0	1.00				8.605
10	0	0	0	0	1.00	0	1.00	0	1.00				8.605
15A	0	0	0	0		0		0					8.915
15A	0	0	0	0	1.00	0	2.61	0	2.17	8.13	8.13		10.37
15B	0	0	0	0	1.00	0	2.61	0	2.17	8.13	8.13		15.76
15B	0	0	0	0		0		0					11.90
20A	0	0	0	0		0		0					11.65
20A	0	0	0	0	1.00	0	2.61	0	2.17	8.13	8.13		13.82
20B	0	0	0	0	1.00	0	2.61	0	2.17	8.13	8.13		22.53
20B	0	0	0	0		0		0					15.31
25	0	0	0	0	1.00	0	1.00	0	1.00				25.67
30	0	0	0	0	1.00	0	1.00	0	1.00				24.12
35	0	0	0	0	1.39	0	2.00	0	1.00				21.54
35	0	0	0	0	1.39	0	2.00	0	1.00				21.51
40	0	0	0	0		0		0					19.33
40	0	0	0	0	1.00	0	1.52	0	1.52				20.97
45	0	0	0	0	1.00	0	1.52	0	1.52				22.87
45	0	0	0	0		0		0					21.04
50	0	0	0	0		0		0					29.52
35	0	0	0	0	1.07	0	1.47	0	1.86		2.44		37.72
100	0	0	0	0	1.00	0	1.00	0	1.00		2.44		15.53
105	0	0	0	0	1.00	0	1.00	0	1.00				21.15
110A	0	0	0	0		0		0					20.54
110A	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		21.53
110B	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		27.48
110B	0	0	0	0		0		0					24.40
115A	0	0	0	0		0		0					22.10
115A	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		23.39
115B	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		35.07
115B	0	0	0	0		0		0					28.45
120A	0	0	0	0		0		0					22.75
120A	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		25.39
120B	0	0	0	0	1.00	0	2.27	0	1.89	6.59	6.59		24.10
120B	0	0	0	0		0		0					21.94
125	0	0	0	0		0		0					25.70

Other forces in local coordinates: Wind 2

Node	Type	fx (N)	fy (N)	fz (N)	mx (Nm)	my (Nm)	mz (Nm)
25	Valve	0	0	0	0	0	0
30		0	0	0	0	0	0
100	Valve	0	0	0	0	0	0
105		0	0	0	0	0	0

Pipe forces in global coordinates: Wind 2

Node	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
5	0	0	0	0	0	0
10	0	0	0	0	0	0
10	0	0	0	0	0	0
15A	0	0	0	0	0	0
15A	0	0	0	0	0	0
15B	0	0	0	0	0	0
15B	0	0	0	0	0	0
20A	0	0	0	0	0	0
20A	0	0	0	0	0	0
20B	0	0	0	0	0	0
20B	0	0	0	0	0	0
25	0	0	0	0	0	0
30	0	0	0	0	0	0
35	0	0	0	0	0	0
35	0	0	0	0	0	0
40	0	0	0	0	0	0
40	0	0	0	0	0	0
45	0	0	0	0	0	0
45	0	0	0	0	0	0
50	0	0	0	0	0	0
35	0	0	0	0	0	0
100	0	0	0	0	0	0
105	0	0	0	0	0	0
110A	0	0	0	0	0	0
110A	0	0	0	0	0	0
110B	0	0	0	0	0	0
110B	0	0	0	0	0	0
115A	0	0	0	0	0	0
115A	0	0	0	0	0	0
115B	0	0	0	0	0	0
115B	0	0	0	0	0	0
120A	0	0	0	0	0	0
120A	0	0	0	0	0	0
120B	0	0	0	0	0	0
120B	0	0	0	0	0	0
125	0	0	0	0	0	0

Other forces in global coordinates: Wind 2

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
25	Valve	0	0	0	0	0	0
30		0	0	0	0	0	0

Other forces in global coordinates: Wind 2

Node	Type	FX (N)	FY (N)	FZ (N)	MX (Nm)	MY (Nm)	MZ (Nm)
100	Valve	0	0	0	0	0	0
105		0	0	0	0	0	0

Displacements: Wind 2

	Displacements (global)					
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.000	0.000	0.000	0.0000	0.0000	0.0000
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
15A	0.000	0.000	0.000	0.0000	0.0000	0.0000
15B	0.000	0.000	0.000	0.0000	0.0000	0.0000
20A	0.000	0.000	0.000	0.0000	0.0000	0.0000
20B	0.000	0.000	0.000	0.0000	0.0000	0.0000
25	0.000	0.000	0.000	0.0000	0.0000	0.0000
30	0.000	0.000	0.000	0.0000	0.0000	0.0000
35	0.000	0.000	0.000	0.0000	0.0000	0.0000
40	0.000	0.000	0.000	0.0000	0.0000	0.0000
45	0.000	0.000	0.000	0.0000	0.0000	0.0000
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.000	0.000	0.000	0.0000	0.0000	0.0000
105	0.000	0.000	0.000	0.0000	0.0000	0.0000
110A	0.000	0.000	0.000	0.0000	0.0000	0.0000
110B	0.000	0.000	0.000	0.0000	0.0000	0.0000
115A	0.000	0.000	0.000	0.0000	0.0000	0.0000
115B	0.000	0.000	0.000	0.0000	0.0000	0.0000
120A	0.000	0.000	0.000	0.0000	0.0000	0.0000
120B	0.000	0.000	0.000	0.0000	0.0000	0.0000
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Frequencies

#	Frequency	Period	Participation factors			Modal mass / Total mass		
	(Hz)	(second)	X	Y	Z	X	Y	Z
1	1.706	0.5861	-0.7142	1.9228	-1.2093	0.0292	0.2119	0.0838
2	2.455	0.4073	-0.8013	2.2492	1.5136	0.0368	0.2899	0.1313
3	2.690	0.3717	-2.5039	-1.3428	0.3230	0.3593	0.1033	0.0060
4	4.673	0.2140	0.3889	-0.3474	1.2781	0.0087	0.0069	0.0936
5	6.395	0.1564	-1.0978	0.8783	-0.0957	0.0691	0.0442	0.0005
6	7.033	0.1422	0.5407	1.0975	-0.0498	0.0168	0.0690	0.0001
7	7.672	0.1303	0.1321	-0.1976	0.1461	0.0010	0.0022	0.0012
8	10.024	0.0998	1.2558	0.0829	-0.1343	0.0904	0.0004	0.0010
9	11.761	0.0850	-0.0675	0.9579	-0.1086	0.0003	0.0526	0.0007
10	14.063	0.0711	-0.6784	-0.1013	-1.1818	0.0264	0.0006	0.0800
11	30.957	0.0323	-2.2978	-0.0528	0.0075	0.3026	0.0002	0.0000
12	54.033	0.0185	-0.1696	0.2347	-0.6241	0.0016	0.0032	0.0223
13					Total	0.9420	0.7843	0.4206

Mode 1: 1.71 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.000	0.000	0.000	0.0000	0.0586	0.0445

Mode 1: 1.71 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	0.000	0.156	-0.207	0.0017	0.0600	0.0447
15A	0.000	6.247	-10.202	0.0659	0.0768	0.0436
15B	-0.272	6.526	-10.161	0.0868	0.0618	0.0391
20A	-3.805	6.524	-0.570	0.0930	0.0447	0.0292
20B	-3.691	6.000	0.000	0.0694	0.0413	0.0252
25	-1.299	2.100	0.000	0.0458	0.0283	0.0130
30	-0.996	1.609	0.000	0.0447	0.0275	0.0125
35	-0.851	1.374	0.000	0.0447	0.0275	0.0125
40	-0.707	1.140	0.000	0.0447	0.0275	0.0125
45	-0.467	0.751	0.000	0.0392	0.0242	0.0107
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.851	1.067	0.663	0.0447	0.0275	0.0109
105	-0.851	0.992	0.854	0.0441	0.0268	0.0105
110A	-0.851	0.987	0.866	0.0440	0.0266	0.0104
110B	-0.867	0.960	1.104	0.0344	0.0149	0.0005
115A	-0.789	0.960	2.443	0.0285	-0.0061	-0.0012
115B	-0.794	0.948	2.506	0.0238	-0.0153	0.0055
120A	-0.793	0.246	1.042	0.0215	-0.0222	0.0144
120B	-0.743	0.185	0.902	0.0191	-0.0181	0.0173
125	0.000	0.000	0.000	0.0000	0.0000	0.0000
Mode 2: 2.46 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.000	0.000	0.000	0.0000	-0.0588	0.0446
10	0.000	0.156	0.208	-0.0018	-0.0602	0.0447
15A	0.000	6.171	9.565	-0.0694	-0.0623	0.0418
15B	-0.254	6.433	9.347	-0.0951	-0.0372	0.0362
20A	-3.532	6.429	0.214	-0.0626	0.0048	0.0277
20B	-3.589	6.480	0.005	0.0233	0.0225	0.0153
25	-1.619	3.263	0.003	0.0635	0.0324	0.0067
30	-1.267	2.570	0.003	0.0638	0.0322	0.0063
35	-1.097	2.234	0.003	0.0638	0.0322	0.0063
40	-0.927	1.897	0.000	0.0638	0.0322	0.0063
45	-0.637	1.317	0.000	0.0604	0.0300	0.0054
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-1.097	2.116	0.823	0.0638	0.0322	0.0057
105	-1.097	2.077	1.048	0.0637	0.0314	0.0055
110A	-1.097	2.075	1.062	0.0637	0.0312	0.0055
110B	-1.110	2.058	1.399	0.0570	0.0184	0.0022
115A	-1.243	2.057	3.812	0.0537	-0.0096	0.0062
115B	-1.283	2.005	3.950	0.0464	-0.0226	0.0171
120A	-1.283	0.408	1.828	0.0396	-0.0323	0.0278
120B	-1.195	0.297	1.600	0.0356	-0.0263	0.0292
125	0.000	0.000	0.000	0.0000	0.0000	0.0000
Mode 3: 2.69 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.025	0.000	0.000	0.0000	-0.0065	-0.0491

Mode 3: 2.69 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	-0.025	-0.172	0.023	0.0002	-0.0066	-0.0492
15A	-0.030	-3.986	0.139	0.0088	0.0131	0.0154
15B	-0.484	-3.682	0.029	0.0031	0.0286	0.0971
20A	-12.528	-3.682	0.086	-0.0063	0.0739	0.1171
20B	-12.605	-3.561	0.000	-0.0246	0.1027	0.0839
25	-5.296	-1.592	0.000	-0.0318	0.1079	0.0386
30	-4.127	-1.246	0.000	-0.0318	0.1070	0.0366
35	-3.564	-1.079	0.000	-0.0318	0.1070	0.0366
40	-3.000	-0.912	0.000	-0.0318	0.1070	0.0366
45	-2.045	-0.626	0.000	-0.0295	0.0983	0.0314
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-3.564	-1.995	2.682	-0.0318	0.1070	0.0274
105	-3.564	-2.179	3.429	-0.0318	0.1053	0.0250
110A	-3.564	-2.191	3.478	-0.0318	0.1048	0.0244
110B	-3.523	-2.209	3.692	-0.0421	0.0805	-0.0289
115A	-1.501	-2.208	1.984	-0.0336	0.0254	-0.0546
115B	-1.288	-2.002	1.922	-0.0336	0.0063	-0.0489
120A	-1.286	0.315	0.992	0.0044	-0.0220	-0.0119
120B	-1.262	0.313	0.884	0.0105	-0.0232	0.0182
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 4: 4.67 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.004	0.000	0.000	0.0000	0.0048	-0.0075
10	0.004	-0.026	-0.017	0.0001	0.0049	-0.0075
15A	0.005	-1.259	-0.538	0.0052	-0.0003	-0.0120
15B	0.110	-1.353	-0.468	0.0088	-0.0060	-0.0184
20A	2.068	-1.350	0.073	-0.0026	-0.0190	-0.0172
20B	2.011	-1.247	0.006	-0.0215	-0.0250	-0.0108
25	0.626	-0.154	0.006	0.0007	-0.0090	-0.0043
30	0.537	-0.175	0.006	0.0034	-0.0072	-0.0040
35	0.497	-0.191	0.006	0.0034	-0.0072	-0.0040
40	0.458	-0.206	0.006	0.0034	-0.0072	-0.0040
45	0.370	-0.209	0.005	-0.0018	-0.0108	-0.0035
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.498	-0.121	0.874	0.0034	-0.0072	-0.0034
105	0.498	-0.097	0.833	0.0253	-0.0055	-0.0033
110A	0.498	-0.096	0.831	0.0309	-0.0054	-0.0033
110B	0.506	-0.086	1.504	0.2499	0.0861	-0.0013
115A	0.516	-0.086	17.980	0.4460	0.0527	0.0008
115B	0.510	-0.093	19.943	0.4424	0.0332	0.0022
120A	0.510	-0.143	19.786	0.4367	-0.0374	-0.0031
120B	0.488	-0.121	18.268	0.4394	-0.0541	-0.0093
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 5: 6.39 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.011	0.000	0.000	0.0000	0.0092	-0.0177

Mode 5: 6.39 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	-0.011	-0.062	-0.033	0.0003	0.0094	-0.0178
15A	-0.014	-2.097	-0.813	0.0112	-0.0051	-0.0090
15B	0.014	-2.135	-0.623	0.0193	-0.0189	-0.0034
20A	1.455	-2.127	0.242	-0.0151	-0.0509	-0.0363
20B	1.500	-1.779	0.000	-0.0700	-0.0440	-0.0662
25	-0.726	1.826	0.000	-0.0022	-0.0055	-0.1322
30	-0.765	1.810	0.000	0.0055	-0.0015	-0.1351
35	-0.774	1.783	0.000	0.0055	-0.0015	-0.1351
40	-0.776	1.742	0.000	0.0055	-0.0015	-0.1351
45	-0.716	1.549	0.000	0.0311	0.0120	-0.1158
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.782	8.077	-0.050	0.0055	-0.0015	-0.1074
105	-0.783	8.806	-0.061	0.0054	-0.0016	-0.0972
110A	-0.783	8.850	-0.062	0.0053	-0.0016	-0.0938
110B	-1.240	8.759	-0.052	0.0037	-0.0027	0.2327
115A	-14.786	8.770	0.054	0.0013	-0.0037	0.2980
115B	-15.690	8.088	0.040	-0.0001	-0.0046	0.1003
120A	-15.690	4.449	-0.255	-0.0043	-0.0033	0.1162
120B	-14.992	3.719	-0.249	-0.0056	-0.0016	0.2914
125	0.000	0.000	0.000	0.0000	0.0000	0.0000
Mode 6: 7.03 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.031	0.000	0.000	0.0000	0.0040	-0.0249
10	-0.031	-0.087	-0.014	0.0004	0.0041	-0.0250
15A	-0.038	-2.134	-0.581	0.0148	0.0027	0.0052
15B	-0.211	-2.015	-0.475	0.0187	-0.0005	0.0348
20A	-2.164	-2.006	0.275	-0.0180	-0.0026	-0.0241
20B	-1.644	-1.619	0.000	-0.0770	0.0287	-0.0929
25	-0.100	2.233	0.000	0.0021	0.0114	-0.2161
30	0.016	2.164	0.000	0.0109	0.0098	-0.2215
35	0.068	2.108	0.000	0.0109	0.0098	-0.2215
40	0.117	2.038	0.000	0.0109	0.0098	-0.2215
45	0.169	1.784	0.000	0.0384	0.0026	-0.1900
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.072	10.466	0.395	0.0109	0.0098	-0.2476
105	0.073	12.232	0.463	0.0113	0.0093	-0.2523
110A	0.073	12.349	0.467	0.0115	0.0092	-0.2528
110B	1.163	13.414	0.534	0.0119	0.0021	-0.2757
115A	10.945	13.415	1.054	0.0088	-0.0203	-0.1226
115B	11.016	13.170	0.961	-0.0025	-0.0331	0.1653
120A	11.010	-2.610	-1.557	-0.0278	-0.0316	0.1333
120B	10.869	-2.688	-1.556	-0.0371	-0.0189	-0.1436
125	0.000	0.000	0.000	0.0000	0.0000	0.0000
Mode 7: 7.67 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.008	0.000	0.000	0.0000	0.0031	-0.0009

Mode 7: 7.67 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	0.008	-0.003	-0.011	0.0000	0.0031	-0.0009
15A	0.009	-0.416	-0.174	0.0017	-0.0038	-0.0073
15B	0.095	-0.485	-0.105	0.0046	-0.0097	-0.0161
20A	1.604	-0.483	0.078	-0.0041	-0.0247	-0.0075
20B	1.404	-0.396	0.016	-0.0168	-0.0337	0.0061
25	-0.058	0.190	0.016	0.0112	0.0045	0.0238
30	0.010	0.053	0.016	0.0141	0.0083	0.0245
35	0.051	-0.020	0.016	0.0142	0.0083	0.0245
40	0.092	-0.091	0.015	0.0142	0.0083	0.0245
45	0.136	-0.173	0.012	0.0050	0.0023	0.0210
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	0.051	-1.039	2.770	0.0142	0.0083	0.0261
105	0.051	-1.224	2.822	0.0416	0.0044	0.0261
110A	0.051	-1.236	2.825	0.0487	0.0026	0.0261
110B	-0.026	-1.326	3.398	0.2684	0.0060	0.0147
115A	-0.341	-1.327	20.095	0.3864	-0.3015	-0.0006
115B	-0.317	-1.285	19.694	0.2017	-0.4969	-0.0159
120A	-0.316	0.050	-18.247	-0.2688	-0.4810	-0.0142
120B	-0.329	0.081	-18.670	-0.4255	-0.2836	0.0012
125	0.000	0.000	0.000	-0.0000	0.0000	0.0000

Mode 8: 10.02 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.032	0.000	0.000	0.0000	-0.0256	-0.0204
10	-0.033	-0.072	0.091	0.0007	-0.0261	-0.0205
15A	-0.039	-0.776	0.407	0.0273	0.0545	0.0254
15B	-0.434	-0.474	-0.106	0.0036	0.1174	0.0762
20A	-8.732	-0.469	0.113	-0.0076	0.2953	0.0683
20B	-6.881	-0.298	-0.008	-0.0339	0.3459	0.0291
25	8.561	1.204	-0.008	0.0095	-0.0316	0.0384
30	8.030	1.077	-0.008	0.0138	-0.0655	0.0388
35	7.664	1.002	-0.007	0.0138	-0.0655	0.0388
40	7.284	0.926	-0.007	0.0138	-0.0656	0.0388
45	6.211	0.755	-0.006	0.0214	-0.1489	0.0333
50	0.000	0.000	0.000	0.0000	-0.0000	0.0000
100	7.679	0.144	-2.687	0.0138	-0.0655	0.0581
105	7.679	-0.283	-3.151	0.0194	-0.0659	0.0633
110A	7.679	-0.312	-3.182	0.0208	-0.0658	0.0647
110B	7.108	-0.749	-3.202	0.0806	-0.0377	0.1881
115A	-1.952	-0.747	1.564	0.1152	-0.0321	0.1814
115B	-2.472	-1.107	1.836	0.0949	-0.0409	0.0369
120A	-2.475	0.587	-0.726	0.0135	-0.0291	-0.0281
120B	-2.444	0.604	-0.815	-0.0071	-0.0107	0.0320
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 9: 11.76 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	0.047	0.000	0.000	0.0000	0.0058	-0.0208

Mode 9: 11.76 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	0.047	-0.073	-0.021	0.0012	0.0060	-0.0209
15A	0.057	-2.777	-0.800	0.0473	0.0031	-0.0177
15B	0.224	-2.909	-0.450	0.0567	-0.0026	-0.0329
20A	1.285	-2.875	1.050	-0.0768	0.0046	0.0475
20B	0.520	-1.437	-0.009	-0.2770	-0.0331	0.1356
25	-0.905	10.627	-0.007	0.0785	0.0003	0.2936
30	-0.887	9.583	-0.007	0.1112	0.0026	0.3005
35	-0.868	8.950	-0.007	0.1112	0.0026	0.3005
40	-0.849	8.332	-0.007	0.1112	0.0026	0.3005
45	-0.757	6.878	-0.005	0.1867	0.0150	0.2577
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.868	-3.202	-0.811	0.1112	0.0026	0.3050
105	-0.867	-5.350	-0.797	0.1034	0.0019	0.3013
110A	-0.867	-5.489	-0.797	0.1014	0.0020	0.2990
110B	-1.439	-6.348	-0.572	0.0262	-0.0255	0.0449
115A	0.768	-6.363	-1.308	-0.0364	-0.0002	-0.0961
115B	1.139	-6.005	-1.408	-0.0259	0.0154	-0.0885
120A	1.145	-0.459	0.342	-0.0001	0.0260	-0.0650
120B	1.005	-0.252	0.411	0.0083	0.0161	-0.0367
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 10: 14.06 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.012	0.000	0.000	0.0000	-0.0025	-0.0028
10	-0.012	-0.010	0.009	0.0000	-0.0026	-0.0028
15A	-0.014	-0.036	0.053	0.0001	0.0050	0.0049
15B	-0.084	0.019	-0.012	-0.0025	0.0110	0.0130
20A	-1.150	0.019	-0.126	0.0013	0.0268	0.0019
20B	-0.911	-0.010	-0.105	0.0057	0.0314	-0.0090
25	-1.325	-0.475	-0.104	0.0078	-0.0807	-0.0174
30	-2.254	-0.560	-0.104	0.0082	-0.0920	-0.0177
35	-2.712	-0.597	-0.104	0.0082	-0.0920	-0.0177
40	-3.159	-0.635	-0.096	0.0082	-0.0920	-0.0177
45	-3.468	-0.631	-0.079	-0.0065	0.0089	-0.0152
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-2.724	-0.068	-18.263	0.0082	-0.0921	-0.0238
105	-2.724	0.105	-18.989	0.0356	-0.1057	-0.0253
110A	-2.725	0.117	-19.039	0.0427	-0.1064	-0.0256
110B	-2.547	0.262	-18.626	0.3399	-0.0020	-0.0565
115A	0.168	0.262	3.441	0.5548	-0.0217	-0.0551
115B	0.331	0.379	5.266	0.4601	-0.0816	-0.0136
120A	0.332	-0.061	-1.341	0.1048	-0.0840	0.0108
120B	0.340	-0.083	-1.741	0.0199	-0.0166	-0.0021
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 11: 30.96 Hz

Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-9.395	0.000	0.000	0.0000	-0.0029	-0.1124

Mode 11: 30.96 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
10	-9.446	-0.398	0.010	0.0001	-0.0029	-0.1121
15A	-10.714	-1.280	0.024	0.0025	0.0061	0.1877
15B	-12.538	0.527	-0.032	0.0008	0.0121	0.1357
20A	-0.133	0.561	0.025	-0.0018	0.0281	-0.2302
20B	1.287	0.580	0.003	0.0020	-0.0125	-0.1719
25	0.028	0.098	0.003	0.0085	-0.0107	-0.0408
30	-0.078	0.007	0.003	0.0079	-0.0085	-0.0351
35	-0.124	-0.038	0.003	0.0079	-0.0085	-0.0351
40	-0.167	-0.078	0.000	0.0079	-0.0085	-0.0351
45	-0.209	-0.122	0.000	0.0025	-0.0014	-0.0301
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-0.127	-0.330	0.109	0.0079	-0.0085	-0.0265
105	-0.127	-0.152	0.051	0.0073	-0.0082	-0.0248
110A	-0.127	-0.140	0.047	0.0072	-0.0082	-0.0245
110B	-0.079	-0.073	0.035	0.0025	-0.0085	-0.0066
115A	-0.004	-0.075	-0.003	-0.0026	-0.0040	0.0009
115B	-0.009	-0.079	-0.024	-0.0016	-0.0017	0.0002
120A	-0.009	0.000	0.000	-0.0004	0.0013	-0.0014
120B	-0.011	0.003	0.007	0.0000	0.0008	-0.0003
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Mode 12: 54.03 Hz						
Node	X (mm)	Y (mm)	Z (mm)	XX (deg)	YY (deg)	ZZ (deg)
5	-0.893	0.000	0.000	-0.0000	-0.6010	0.2485
10	-0.898	0.894	2.187	-0.0322	-0.6061	0.2458
15A	-0.879	3.058	8.100	-1.2702	1.0025	-0.3215
15B	1.518	0.332	-10.256	-0.9853	1.3932	-0.1871
20A	-1.399	-0.143	-9.588	0.9168	0.6558	0.0635
20B	1.637	-6.703	-2.084	0.4985	0.3132	0.1526
25	2.594	-2.450	-1.247	-0.4353	-0.2869	0.1864
30	-0.642	2.345	-1.197	-0.4184	-0.2817	0.1879
35	-2.314	4.640	-1.110	-0.4183	-0.2816	0.1879
40	-3.810	6.877	-1.026	-0.4183	-0.2816	0.1879
45	-5.513	9.349	-0.851	-0.1140	-0.0872	0.1611
50	0.000	0.000	0.000	0.0000	0.0000	0.0000
100	-2.490	2.647	2.191	-0.4183	-0.2816	0.3473
105	-2.499	0.064	0.171	-0.3982	-0.2888	0.3724
110A	-2.499	-0.115	0.036	-0.3931	-0.2894	0.3741
110B	-3.629	-1.553	-2.099	-0.1280	-0.1765	0.1095
115A	-0.173	-1.638	-0.040	0.1336	-0.0565	-0.1387
115B	0.194	-1.414	0.355	0.1391	-0.0264	-0.0323
120A	0.216	-0.083	0.020	0.0414	0.0057	-0.0098
120B	0.203	-0.057	-0.038	0.0209	0.0168	-0.0040
125	0.000	0.000	0.000	0.0000	0.0000	0.0000

Dynamic susceptibility

Mode	Frequency (Hz)	Maxima Nodes Velocity	Stress	Susceptibility (psi / ips)
10	14.063	110A	35	1857
8	10.024	20A	35	1130
9	11.761	25	35	1074
6	7.033	115B	35	1073
4	4.673	115B	110B	612
12	54.033	45	45	589
5	6.395	120B	35	582
2	2.455	15A	20B	450
7	7.672	115A	110B	440
3	2.690	20B	50	417
1	1.706	15A	45	310
11	30.957	15B	15B	256

Dynamic stresses for mode 10: 14.06 Hz, susceptibility = 1857

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	2.0782E+01	1.00	2.0782E+01
10	5.2055E-04	1.4752E+01	1.00	1.4753E+01
15A	2.5348E-03	1.9814E+02	2.61	5.1617E+02
15B	3.3400E-03	8.2085E+01	2.61	2.1384E+02
20A	4.5538E-02	3.4855E+02	2.61	9.0800E+02
20B	3.5879E-02	1.0039E+02	2.61	2.6153E+02
25	5.5416E-02	3.8157E+03	1.00	3.8160E+03
30	9.1445E-02	5.3028E+03	1.00	5.3033E+03
35	1.0935E-01	6.6017E+04	2.00	1.2298E+05
40	1.2686E-01	1.0545E+04	1.52	1.6059E+04
45	1.3878E-01	1.2780E+04	1.52	1.9462E+04
50	0.0000E+00	1.3281E+04	1.00	1.3281E+04
100	7.1901E-01	9.7100E+03	1.00	9.7110E+03
105	7.4761E-01	1.3600E+03	1.00	1.3601E+03
110A	7.4958E-01	1.2372E+03	2.27	2.8028E+03
110B	7.4013E-01	9.3711E+03	2.27	2.1230E+04
115A	1.3565E-01	2.3089E+03	2.27	5.2307E+03
115B	2.0786E-01	1.2194E+03	2.27	2.7624E+03
120A	5.2855E-02	9.3328E+02	2.27	2.1143E+03
120B	6.9927E-02	2.9680E+03	2.27	6.7239E+03
125	0.0000E+00	2.4391E+03	1.00	2.4391E+03

Dynamic stresses for mode 8: 10.02 Hz, susceptibility = 1130

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	2.0913E+02	1.00	2.0913E+02
10	4.5615E-03	1.5469E+02	1.00	1.5471E+02
15A	3.4497E-02	1.7558E+03	2.61	4.5740E+03
15B	1.7592E-02	6.0672E+02	2.61	1.5805E+03
20A	3.4381E-01	8.7404E+02	2.61	2.2770E+03
20B	2.7114E-01	7.4089E+02	2.61	1.9301E+03
25	3.4035E-01	1.3955E+04	1.00	1.3957E+04
30	3.1898E-01	1.3419E+04	1.00	1.3421E+04

Dynamic stresses for mode 8: 10.02 Hz, susceptibility = 1130

Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	3.0432E-01	1.2250E+04	2.00	2.4476E+04
40	2.8906E-01	9.0614E+03	1.52	1.3800E+04
45	2.4632E-01	9.7768E+03	1.52	1.4889E+04
50	0.0000E+00	1.7495E+04	1.00	1.7495E+04
100	1.0594E-01	2.1040E+03	1.00	2.1042E+03
105	1.2457E-01	2.1293E+03	1.00	2.1295E+03
110A	1.2587E-01	2.1364E+03	2.27	4.8401E+03
110B	3.0692E-01	2.7434E+03	2.27	6.2151E+03
115A	9.8481E-02	2.4427E+03	2.27	5.5338E+03
115B	8.4393E-02	2.5509E+03	2.27	5.7790E+03
120A	3.6755E-02	1.2031E+03	2.27	2.7255E+03
120B	1.0417E-01	1.4509E+03	2.27	3.2869E+03
125	0.0000E+00	2.1624E+03	1.00	2.1624E+03

Dynamic stresses for mode 9: 11.76 Hz, susceptibility = 1074

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	5.4250E+01	1.00	5.4250E+01
10	2.9858E-03	4.4021E+01	1.00	4.4025E+01
15A	1.1378E-01	1.1600E+02	2.61	3.0218E+02
15B	1.9801E-02	3.2671E+02	2.61	8.5111E+02
20A	6.5312E-02	3.9028E+03	2.61	1.0167E+04
20B	6.0172E-02	1.8671E+03	2.61	4.8641E+03
25	4.1989E-01	1.4284E+04	1.00	1.4286E+04
30	3.7888E-01	1.1958E+04	1.00	1.1959E+04
35	3.5400E-01	1.7896E+04	2.00	3.3339E+04
40	3.2974E-01	8.3430E+03	1.52	1.2706E+04
45	2.7241E-01	8.8003E+03	1.52	1.3402E+04
50	0.0000E+00	1.8397E+04	1.00	1.8397E+04
100	1.3004E-01	7.7278E+02	1.00	7.7285E+02
105	2.1295E-01	3.4625E+03	1.00	3.4628E+03
110A	2.1838E-01	3.6386E+03	2.27	8.2432E+03
110B	6.0956E-02	5.2388E+03	2.27	1.1868E+04
115A	5.9709E-02	1.2848E+02	2.27	2.9107E+02
115B	2.4284E-01	4.4338E+02	2.27	1.0045E+03
120A	2.2531E-02	6.1204E+02	2.27	1.3866E+03
120B	4.3882E-02	6.0690E+02	2.27	1.3749E+03
125	0.0000E+00	4.6222E+02	1.00	4.6222E+02

Dynamic stresses for mode 6: 7.03 Hz, susceptibility = 1073

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	4.5796E+01	1.00	4.5796E+01
10	3.4811E-03	3.2899E+01	1.00	3.2902E+01
15A	8.7078E-02	5.4274E+02	2.61	1.4139E+03
15B	2.0451E-02	2.8187E+02	2.61	7.3429E+02
20A	8.5869E-02	1.8795E+03	2.61	4.8962E+03
20B	9.0861E-02	6.1102E+02	2.61	1.5918E+03
25	8.8003E-02	3.4186E+03	1.00	3.4189E+03
30	8.5211E-02	3.7065E+03	1.00	3.7069E+03

Dynamic stresses for mode 6: 7.03 Hz, susceptibility = 1073

Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	8.3024E-02	1.3237E+04	2.00	2.4660E+04
40	8.0380E-02	3.0587E+03	1.52	4.6582E+03
45	7.0565E-02	3.3525E+03	1.52	5.1056E+03
50	0.0000E+00	5.2546E+03	1.00	5.2546E+03
100	4.1234E-01	2.8036E+03	1.00	2.8039E+03
105	4.8192E-01	9.4394E+02	1.00	9.4404E+02
110A	4.8652E-01	8.9142E+02	2.27	2.0195E+03
110B	5.0395E-02	1.2576E+02	2.27	2.8490E+02
115A	4.3290E-01	5.0262E+03	2.27	1.1387E+04
115B	5.1988E-01	4.9447E+03	2.27	1.1202E+04
120A	1.1967E-01	5.6275E+03	2.27	1.2749E+04
120B	4.4506E-01	5.6195E+03	2.27	1.2731E+04
125	0.0000E+00	8.9778E+03	1.00	8.9778E+03

Dynamic stresses for mode 4: 4.67 Hz, susceptibility = 612

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	4.0305E+01	1.00	4.0305E+01
10	1.2273E-03	3.6228E+01	1.00	3.6232E+01
15A	5.3920E-02	1.4278E+02	2.61	3.7195E+02
15B	1.8941E-02	9.7032E+01	2.61	2.5278E+02
20A	8.1450E-02	3.1383E+02	2.61	8.1755E+02
20B	9.3180E-02	2.1425E+02	2.61	5.5814E+02
25	2.5396E-02	1.1619E+03	1.00	1.1620E+03
30	2.2240E-02	1.4178E+03	1.00	1.4179E+03
35	2.0974E-02	4.9228E+03	2.00	9.1707E+03
40	1.9757E-02	6.8107E+02	1.52	1.0372E+03
45	1.6720E-02	7.4458E+02	1.52	1.1339E+03
50	0.0000E+00	1.1941E+03	1.00	1.1941E+03
100	3.4733E-02	1.2245E+03	1.00	1.2247E+03
105	3.3017E-02	2.0340E+02	1.00	2.0342E+02
110A	3.2930E-02	1.4003E+02	2.27	3.1725E+02
110B	6.2460E-02	6.2257E+03	2.27	1.4104E+04
115A	7.0815E-01	2.9313E+02	2.27	6.6408E+02
115B	7.8518E-01	7.6574E+02	2.27	1.7348E+03
120A	7.7902E-01	7.4993E+02	2.27	1.6989E+03
120B	7.1950E-01	2.2631E+02	2.27	5.1270E+02
125	0.0000E+00	9.9453E+03	1.00	9.9453E+03

Dynamic stresses for mode 12: 54.03 Hz, susceptibility = 589

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	4.8800E+03	1.00	4.8800E+03
10	9.3012E-02	2.6049E+03	1.00	2.6052E+03
15A	3.4086E-01	2.7715E+04	2.61	7.2201E+04
15B	4.0817E-01	2.6504E+04	2.61	6.9044E+04
20A	3.8147E-01	1.9562E+04	2.61	5.0960E+04
20B	2.7165E-01	2.7807E+04	2.61	7.2441E+04
25	1.4048E-01	1.2505E+04	1.00	1.2506E+04
30	9.5732E-02	2.5051E+04	1.00	2.5053E+04

Dynamic stresses for mode 12: 54.03 Hz, susceptibility = 589				
Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	2.0415E-01	3.5656E+04	2.00	7.1243E+04
40	3.0952E-01	3.1217E+04	1.52	4.7542E+04
45	4.2731E-01	5.6139E+04	1.52	8.5495E+04
50	0.0000E+00	4.8802E+04	1.00	4.8802E+04
100	1.3529E-01	1.7693E+04	1.00	1.7695E+04
105	7.2040E-03	3.2879E+03	1.00	3.2882E+03
110A	4.7380E-03	2.3125E+03	2.27	5.2389E+03
110B	1.6504E-01	1.3508E+04	2.27	3.0601E+04
115A	6.9744E-03	2.1335E+03	2.27	4.8333E+03
115B	5.7404E-02	7.5779E+02	2.27	1.7167E+03
120A	3.3410E-03	1.5108E+02	2.27	3.4227E+02
120B	8.4200E-03	7.8342E+02	2.27	1.7748E+03
125	0.0000E+00	4.3039E+02	1.00	4.3039E+02

Dynamic stresses for mode 5: 6.39 Hz, susceptibility = 582				
Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	7.7721E+01	1.00	7.7721E+01
10	2.7544E-03	6.5216E+01	1.00	6.5222E+01
15A	8.8548E-02	3.5754E+02	2.61	9.3142E+02
15B	2.4547E-02	4.3473E+01	2.61	1.1325E+02
20A	5.8086E-02	1.1388E+03	2.61	2.9666E+03
20B	9.1613E-02	6.0158E+02	2.61	1.5672E+03
25	7.7372E-02	3.3011E+03	1.00	3.3014E+03
30	7.7378E-02	3.6614E+03	1.00	3.6617E+03
35	7.6523E-02	7.6396E+03	2.00	1.4232E+04
40	7.5103E-02	3.1052E+03	1.52	4.7290E+03
45	6.7189E-02	3.4260E+03	1.52	5.2176E+03
50	0.0000E+00	5.1283E+03	1.00	5.1283E+03
100	3.1800E-01	2.9596E+03	1.00	2.9599E+03
105	3.4668E-01	5.2999E+03	1.00	5.3004E+03
110A	3.4845E-01	5.4128E+03	2.27	1.2263E+04
110B	4.8860E-02	5.5242E+03	2.27	1.2515E+04
115A	5.8214E-01	3.3534E+03	2.27	7.5972E+03
115B	3.1845E-01	3.2743E+03	2.27	7.4178E+03
120A	1.7545E-01	3.6126E+03	2.27	8.1842E+03
120B	6.0820E-01	3.4923E+03	2.27	7.9118E+03
125	0.0000E+00	1.0211E+04	1.00	1.0211E+04

Dynamic stresses for mode 2: 2.46 Hz, susceptibility = 450				
Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	4.8000E+02	1.00	4.8000E+02
10	1.0235E-02	4.5590E+02	1.00	4.5595E+02
15A	4.4814E-01	4.2868E+02	2.61	1.1168E+03
15B	3.6812E-01	4.1829E+02	2.61	1.0897E+03
20A	1.3930E-01	1.1761E+03	2.61	3.0638E+03
20B	2.9161E-01	1.1948E+03	2.61	3.1125E+03
25	1.4339E-01	2.5819E+02	1.00	2.5822E+02
30	1.1282E-01	1.1363E+02	1.00	1.1364E+02

Dynamic stresses for mode 2: 2.46 Hz, susceptibility = 450

Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	9.7973E-02	2.8864E+02	2.00	5.3771E+02
40	8.3123E-02	2.3611E+02	1.52	3.5957E+02
45	5.7596E-02	8.5076E+02	1.52	1.2956E+03
50	0.0000E+00	2.6153E+03	1.00	2.6153E+03
100	8.9408E-02	3.3524E+02	1.00	3.3527E+02
105	9.1589E-02	3.5590E+02	1.00	3.5593E+02
110A	9.1757E-02	3.5679E+02	2.27	8.0831E+02
110B	7.0312E-02	6.6205E+01	2.27	1.4998E+02
115A	1.5786E-01	1.9280E+02	2.27	4.3678E+02
115B	1.7441E-01	3.9450E+02	2.27	8.9373E+02
120A	7.3751E-02	1.4667E+02	2.27	3.3228E+02
120B	7.9504E-02	1.2430E+02	2.27	2.8159E+02
125	0.0000E+00	1.0632E+03	1.00	1.0632E+03

Dynamic stresses for mode 7: 7.67 Hz, susceptibility = 440

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	2.4793E+01	1.00	2.4793E+01
10	4.4320E-04	2.0361E+01	1.00	2.0363E+01
15A	1.7762E-02	1.7745E+02	2.61	4.6227E+02
15B	5.5711E-03	1.1470E+02	2.61	2.9881E+02
20A	6.3232E-02	3.7590E+02	2.61	9.7924E+02
20B	5.7453E-02	1.2457E+02	2.61	3.2453E+02
25	7.8086E-03	1.7608E+03	1.00	1.7610E+03
30	2.1057E-03	2.0309E+03	1.00	2.0311E+03
35	2.1555E-03	8.7433E+03	2.00	1.6288E+04
40	5.0972E-03	1.1234E+03	1.52	1.7109E+03
45	8.6759E-03	1.3824E+03	1.52	2.1053E+03
50	0.0000E+00	1.1041E+03	1.00	1.1041E+03
100	1.1646E-01	4.7817E+02	1.00	4.7822E+02
105	1.2111E-01	2.7010E+03	1.00	2.7012E+03
110A	1.2139E-01	2.8301E+03	2.27	6.4115E+03
110B	1.3378E-01	7.4033E+03	2.27	1.6772E+04
115A	7.9125E-01	3.4926E+03	2.27	7.9123E+03
115B	7.7701E-01	4.3155E+03	2.27	9.7767E+03
120A	7.1839E-01	4.6565E+03	2.27	1.0549E+04
120B	7.3516E-01	4.5862E+03	2.27	1.0390E+04
125	0.0000E+00	1.2521E+04	1.00	1.2521E+04

Dynamic stresses for mode 3: 2.69 Hz, susceptibility = 417

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	8.2084E+01	1.00	8.2084E+01
10	6.8319E-03	5.1620E+01	1.00	5.1625E+01
15A	1.5703E-01	1.2216E+03	2.61	3.1824E+03
15B	1.9089E-02	1.0637E+03	2.61	2.7710E+03
20A	4.9325E-01	6.5168E+02	2.61	1.6977E+03
20B	5.1567E-01	4.7290E+02	2.61	1.2319E+03
25	2.1771E-01	2.3326E+02	1.00	2.3329E+02
30	1.6973E-01	4.6720E+02	1.00	4.6725E+02

Dynamic stresses for mode 3: 2.69 Hz, susceptibility = 417

Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	1.4659E-01	1.0166E+03	2.00	1.8938E+03
40	1.2346E-01	6.4371E+02	1.52	9.8032E+02
45	8.4187E-02	1.6357E+03	1.52	2.4910E+03
50	0.0000E+00	3.6363E+03	1.00	3.6363E+03
100	1.3160E-01	1.2022E+03	1.00	1.2023E+03
105	1.5997E-01	1.2096E+03	1.00	1.2098E+03
110A	1.6182E-01	1.2071E+03	2.27	2.7346E+03
110B	2.0091E-01	8.8062E+02	2.27	1.9950E+03
115A	9.7937E-02	2.8052E+02	2.27	6.3552E+02
115B	1.0925E-01	6.8933E+02	2.27	1.5617E+03
120A	4.0991E-02	6.3864E+02	2.27	1.4468E+03
120B	6.1884E-02	6.2935E+02	2.27	1.4258E+03
125	0.0000E+00	1.1694E+03	1.00	1.1694E+03

Dynamic stresses for mode 1: 1.71 Hz, susceptibility = 310

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	4.7820E+02	1.00	4.7820E+02
10	1.0202E-02	4.6116E+02	1.00	4.6120E+02
15A	4.7097E-01	1.8037E+02	2.61	4.6988E+02
15B	4.0018E-01	4.2305E+02	2.61	1.1021E+03
20A	1.5145E-01	3.2125E+02	2.61	8.3689E+02
20B	2.7733E-01	4.1477E+02	2.61	1.0805E+03
25	9.7232E-02	5.2942E+02	1.00	5.2948E+02
30	7.4489E-02	5.7342E+02	1.00	5.7347E+02
35	6.3650E-02	6.0086E+02	2.00	1.2005E+03
40	5.2814E-02	5.3407E+02	1.52	8.1335E+02
45	3.4829E-02	1.0268E+03	1.52	1.5637E+03
50	0.0000E+00	1.3393E+03	1.00	1.3393E+03
100	4.9449E-02	3.3606E+02	1.00	3.3610E+02
105	5.1515E-02	3.2969E+02	1.00	3.2973E+02
110A	5.1689E-02	3.2924E+02	2.27	7.4588E+02
110B	5.5250E-02	2.2816E+02	2.27	5.1688E+02
115A	1.0108E-01	1.1113E+02	2.27	2.5176E+02
115B	1.0550E-01	2.7958E+02	2.27	6.3338E+02
120A	4.2157E-02	1.2587E+02	2.27	2.8517E+02
120B	4.6601E-02	7.9314E+01	2.27	1.7968E+02
125	0.0000E+00	6.4035E+02	1.00	6.4035E+02

Dynamic stresses for mode 11: 30.96 Hz, susceptibility = 256

Node	Displacement	Nominal Stress	SIF	Intensified Stress
5	0.0000E+00	1.4657E+02	1.00	1.4657E+02
10	1.5657E-02	3.1442E+02	1.00	3.1445E+02
15A	5.0396E-02	4.9223E+03	2.61	1.2823E+04
15B	4.9364E-01	9.4259E+03	2.61	2.4555E+04
20A	5.3255E-03	9.3600E+02	2.61	2.4383E+03
20B	5.5588E-02	7.4784E+02	2.61	1.9482E+03
25	4.0261E-03	7.4734E+02	1.00	7.4742E+02
30	3.0935E-03	1.1563E+03	1.00	1.1564E+03

Dynamic stresses for mode 11: 30.96 Hz, susceptibility = 256

Node	Displacement	Nominal Stress	SIF	Intensified Stress
35	5.1069E-03	5.1585E+03	2.00	9.6099E+03
40	7.2534E-03	8.7763E+02	1.52	1.3366E+03
45	9.5417E-03	1.1912E+03	1.52	1.8141E+03
50	0.0000E+00	1.0587E+03	1.00	1.0587E+03
100	1.3699E-02	9.3794E+02	1.00	9.3804E+02
105	6.2917E-03	4.3810E+02	1.00	4.3815E+02
110A	5.8242E-03	4.2227E+02	2.27	9.5664E+02
110B	3.4236E-03	2.8320E+02	2.27	6.4158E+02
115A	2.1201E-04	1.8561E+01	2.27	4.2049E+01
115B	3.2312E-03	8.8391E+01	2.27	2.0025E+02
120A	9.4466E-05	1.9893E+01	2.27	4.5067E+01
120B	5.2769E-04	2.9938E+01	2.27	6.7824E+01
125	0.0000E+00	2.2153E+01	1.00	2.2153E+01

Weight & Center of gravity

Empty weight = 2538.2 (kg)
Insulation weight = 386.05 (kg)
Content weight = 134.28 (kg)
Lining weight = 0 (kg)
Additional weight = 0 (kg)
Total weight = 3058.5 (kg)
Center of Gravity for Total weight
X = 6456.92, Y = 4741.34, Z = 2737.32 (mm)

Bill of materials: Materials

#	Name	Description
1	312	a312 tp316

Bill of materials: Pipes

#	Material	OD (mm)	Thk (mm)	Total length (mm)	Total weight (kg)
1	312	168.27	7.112	11394.6	329.35
2	312	219.07	8.1788	2100	91.344
3	312	273.05	9.271	18146	1119.1

Bill of materials: Bends

#	Material	OD (mm)	Thk (mm)	Radius (mm)	Angle (deg)	Count	Total weight (kg)
1	312	168.27	7.112	228.6	76.04	1	8.7687
2	312	168.27	7.112	228.6	90.00	2	20.758
3	312	273.05	9.271	381	90.00	2	73.817

Bill of materials: Reducers

#	Material	OD1 (mm)	Thk1 (mm)	OD2 (mm)	Thk2 (mm)	Length (mm)	Count	Total weight (kg)
1	312	273.05	9.271	219.07	8.1788	530	1	27.676

Bill of materials: Valves

#	OD (mm)	Thk (mm)	Weight (kg)	Add.Weight (kg)	Count	Total weight (kg)
1	168.27	7.112	151.56	0	1	151.56
2	273.05	9.271	459.23	0	1	459.23

Bill of materials: Itemized Element Weights

#	From	To	Type	Length (mm)	OD (mm)	Thk (mm)	Mat.Den (kg/m3)	Fluid.Den (kg/m3)	Ins.Den (kg/m3)	Ins.Thk (mm)	Lin.Den (kg/m3)	Lin.Thk (mm)	Empty.Wt (kg)	Flu (kg
1	5	10		200	273.05	9.271	8027	99.9	176.2	65			12.334	1.0
2	10	15A		7699	273.05	9.271	8027	99.9	176.2	65			474.8	39
3	15A	15B	Bend	598.47	273.05	9.271	8027	99.9	176.2	65			36.908	3.0
4	15B	20A		5788	273.05	9.271	8027	99.9	176.2	65			356.95	29
5	20A	20B	Bend	598.47	273.05	9.271	8027	99.9	176.2	65			36.908	3.0
6	20B	25		3859	273.05	9.271	8027	99.9	176.2	65			237.99	19
7	25	30	Valve	622.3	273.05	27.813	8027	99.9	176.2	65			459.23	3.1
8	30	35		300	273.05	9.271	8027	99.9	176.2	65			18.501	1.5
9	35	40		300	273.05	9.271	8027	99.9	176.2	65			18.501	1.5
10	40	45	Reducer	530	246.06	8.7249	8027	99.9	176.2	65			27.676	2.1
11	45	50		2100	219.07	8.1788	8027	99.9	176.2	65			91.344	6.7
12	35	100		1400	168.27	7.112	8027	99.9	176.2	65			40.465	2.6
13	100	105	Valve	403.23	168.27	21.336	8027	99.9	176.2	65			151.56	0.7
14	105	110A		26.4	168.27	7.112	8027	99.9	176.2	65			0.76306	0.0
15	110A	110B	Bend	359.08	168.27	7.112	8027	99.9	176.2	65			10.379	0.6
16	110B	115A		2492.8	168.27	7.112	8027	99.9	176.2	65			72.052	4.6
17	115A	115B	Bend	359.08	168.27	7.112	8027	99.9	176.2	65			10.379	0.6
18	115B	120A		3882.7	168.27	7.112	8027	99.9	176.2	65			112.22	7.2
19	120A	120B	Bend	303.38	168.27	7.112	8027	99.9	176.2	65			8.7687	0.5
20	120B	125		3592.7	168.27	7.112	8027	99.9	176.2	65			103.84	6.6