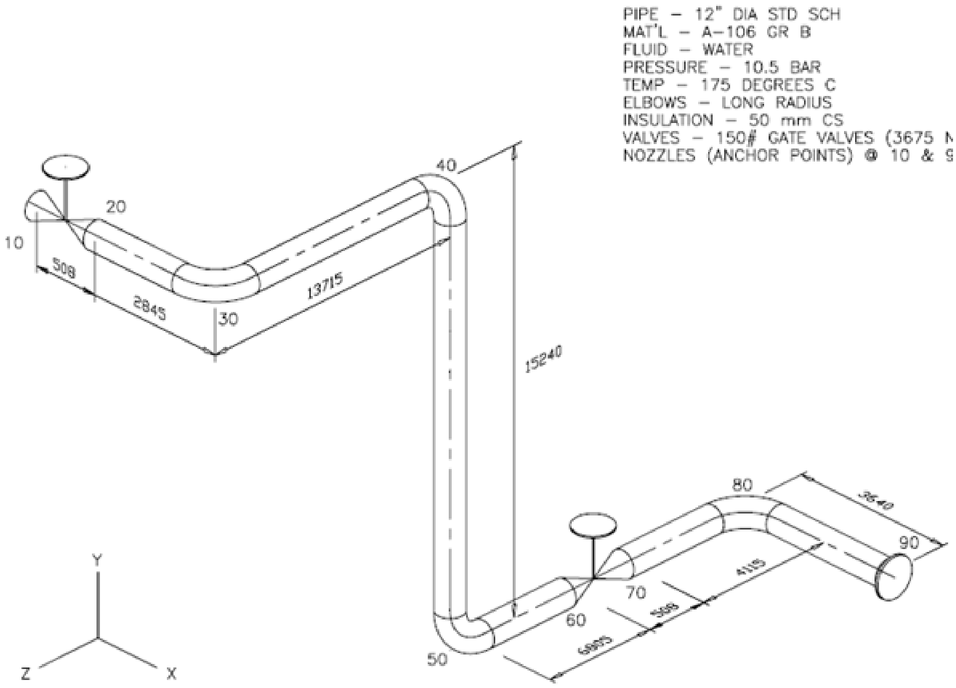
Exercise.02

This exercise is designed to demonstrate adding supports in CAESAR II and demonstrate the Operating case and Restraint load reports and give an indication of what the results mean on the restraint load report, along with a short example on how to combat issues with supports, such as "lift off".

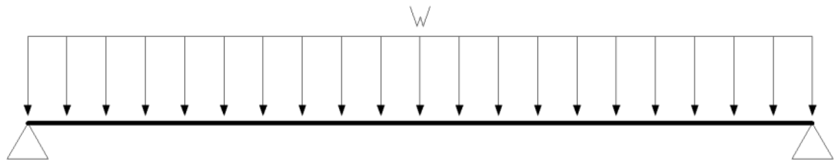


The model shown above will also be in your hand-out. Model the piping system as per this isometric. Anchor at nodes 10 and 90.

Locating Supports

The system is anchored at the termination points (nodes 10 and 90), but we also need to support the weight of the piping system as well.

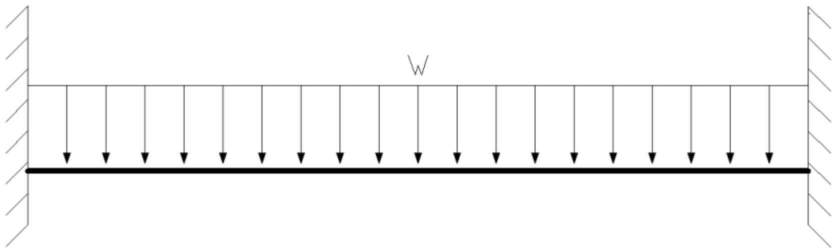
If both supports are pinned (free to rotate), standard beam theory states that the max moment is at the centre of the span, *l.*



This moment is:

$$M_{max} = \frac{wl^2}{8}$$

If both ends are fixed then the max moment is at the end of the span



This has a value of

$$M_{max} = \frac{wl^2}{12}$$

Where

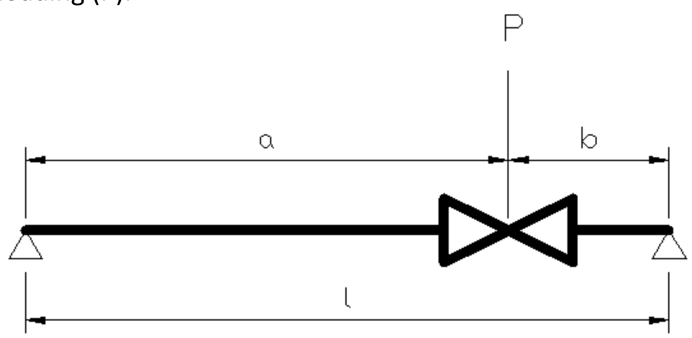
$M_{max} = max\ moment\ in\ the\ beam$
$w =\ uniform\ weight\ of\ pipe\ (fluid, insulation\ etc)$
$l = length\ of\ beam$

As piping systems are neither one nor the other and tend to be somewhere in the middle, a compromise therefore is reached with an approximation thus;

$$M_{max} = \frac{wl^2}{10}$$

Taking into account the maximum moment could be somewhere between the ends and the centre – i.e. anywhere along the span.

This deals with continuous runs of pipe, however there are of course concentrated loads sometimes in the piping system, such as valves, flanges etc. The effects of these items on the pipe stresses can be estimated as well. For pinned connections, the maximum moment is located at the point of loading (P).

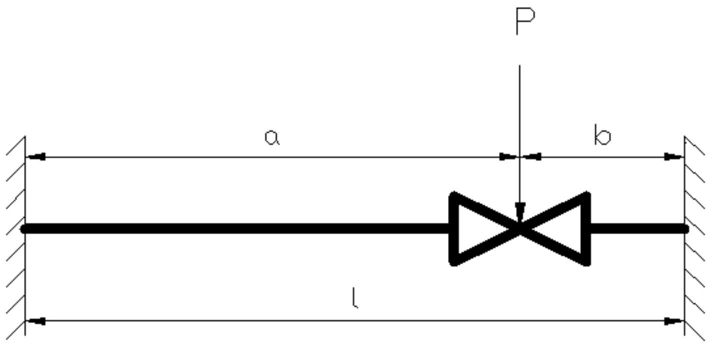


This maximum moment has a value of

$$M_{max} = \frac{Pab}{l}$$

Where a = longer portion of span
b = shorter portion of span

For fixed connections:



He maximum moment here is located at the end nearer the load, and has a value of

$$M_{max} = \frac{Pa^2b}{l^2}$$

In either case (or in some case in between) the additional stress (M/Z) due to the concentrated loads should be added to the stress from the uniform load in order to determine the total stress.

Examining the formulas above, it can be seen that as the shorter span (b) approaches zero in length, the moment, and therefore the stresses approach zero as well.

So, if supports are located as close as possible to concentrated loads, the effects of these loads are reduced as much as possible.

The information on the preceding pages provides a simple rule of thumb to design for weight loading.

First support all concentrated loads in the system as closely as possible, reducing the stresses due to those loads to as close to zero as possible.

Next, we can use

$M_{max} = \frac{wl^2}{10}$ Along with $\sigma = \frac{M}{Z}$

If we knew the allowable stress, we could then use this information to determine a maximum allowable length of pipe – i.e. a distance between supports.

Rearranging the equations above, we can obtain

$$l_{all} = \sqrt{\frac{10Z\sigma_{all}}{w}}$$

$l_{all} = allowable\ pipe\ span for\ weight\ loading$

$Z = section\ modulus\ of\ pipe$

$\sigma_{all} = approximate\ allowable\ stress\ of\ material\ for\ weight\ stresses$

As this calculation will need to be done often, in order to save time calculating l_{all} the **Manufacturer Standardisation Society of the Valve and Fitting Industry** has calculated allowable piping spans for various configurations. These standard spans have been published and are shown on the next page.

These spans assume:

- The pipe is standard wall with insulation
- Maximum moment is $M_{max} = wl^2/10$
- No concentrated loads are present
- There are no changes in direction
- Maximum allowable stress is taken to be approx. 10 MPa
- Max deflection is approx. 2.5mm
- SIFs are not taken into account

It is rare that piping systems are only horizontal runs with no changes in direction etc.; therefore a caveat is taken in that changes in direction reduce the allowable span to ¾ of the standard span.

In addition, the standard span does not apply to risers, since no moment (thus no stress) develops, regardless of length. However it is preferable to locate supports above the centre of gravity of the riser to prevent toppling.

These rules here are simply rules of thumb and can provide a good start point for support locations. Of course, supports should be located with practical considerations taken into account (locations of building steel/pipe racks etc.).

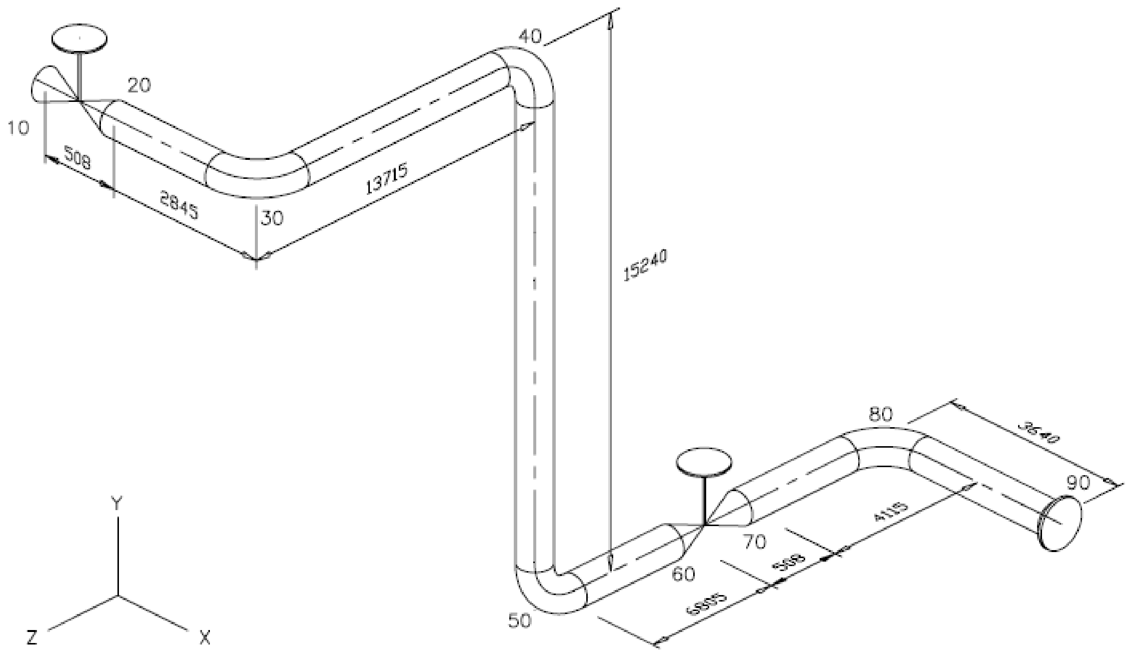
TABLE 3. MAXIMUM HORIZONTAL PIPE HANGER AND SUPPORT SPACING

	1		2		3		4		5	6	7	8	9	10	11
NOMINAL PIPE OR TUBE SIZE	STD WT STEEL PIPE				COPPER TUBE				FIRE PRO-TECTION	CAST IRON & DUCTILE IRON PRESSURE	CAST IRON SOIL	ASBESTOS CEMENT	GLASS	PLASTIC	FIBERGLASS REIN-FORCED
	WATER SERVICE		VAPOR SERVICE		WATER SERVICE		VAPOR SERVICE								
	ft	m	ft	m	ft	m	ft	m							
1/4	7	2.1	8	2.4	5	1.5	5	1.5	FOLLOW REQUIREMENTS OF THE NATIONAL FIRE PROTECTION ASSOCIA-TION. SEE SECTION 14.	12 ft (3.7m) MAX SPACING MIN OF ONE (1) HANGER PER PIPE SECTION CLOSE TO JOINT ON THE BARREL. ALSO AT CHANGE OF DIRECTION AND BRANCH CONNECTIONS.	10 ft (3.0m) MAX SPACING MIN OF ONE (1) HANGER PER PIPE SECTION CLOSE TO JOINT ON THE BARREL. ALSO AT CHANGE OF DIRECTION AND BRANCH CONNECTIONS.	FOLLOW PIPE MANUFACTURER'S RECOMMENDATIONS.	8 ft (2.4m) MAX SPACING, FOLLOW MANUFACTURER'S RECOMMENDATIONS. SEE SECTION 18.	FOLLOW PIPE MANUFACTURER'S RECOMMENDATIONS FOR MATERIAL AND SERVICE TEMPERATURE.	FOLLOW PIPE MANUFACTURER'S RECOMMENDATIONS FOR SPACING AND SERVICE CONDITION.
3/8	7	2.1	8	2.4	5	1.5	6	1.8							
1/2	7	2.1	8	2.4	5	1.5	6	1.8							
3/4	7	2.1	9	2.7	5	1.5	7	2.1							
1	7	2.1	9	2.7	6	1.8	8	2.4							
1 1/4	7	2.1	9	2.7	7	2.1	9	2.7							
1 1/2	9	2.7	12	3.7	8	2.4	10	3.0							
2	10	3.0	13	4.0	8	2.4	11	3.4							
2 1/2	11	3.4	14	4.3	9	2.7	13	4.0							
3	12	3.7	15	4.6	10	3.0	14	4.3							
3 1/2	13	4.0	16	4.9	11	3.4	15	4.6							
4	14	4.3	17	5.2	12	3.7	16	4.9							
5	16	4.9	19	5.8	13	4.0	18	5.5							
6	17	5.2	21	6.4	14	4.3	20	6.1							
8	19	5.8	24	7.3	16	4.9	23	7.0							
10	22	6.1	26	7.9	18	5.5	25	7.6							
12	23	7.0	30	9.1	19	5.8	28	8.5							
14	25	7.6	32	9.8											
16	27	8.2	35	10.7											
18	28	8.5	37	11.3											
20	30	9.1	39	11.9											
24	32	9.8	42	12.8											
30	33	10.1	44	13.4											

NOTE: (1) FOR SPACING SUPPORTS INCORPORATING TYPE 40 SHIELDS, SEE TABLE 5.
(2) DOES NOT APPLY WHERE SPAN CALCULATIONS ARE MADE OR WHERE THERE ARE CONCENTRATED LOADS BETWEEN SUPPORTS SUCH AS FLANGES, VALVES, SPECIALTIES, ETC., OR CHANGES IN DIRECTION REQUIRING ADDITIONAL SUPPORTS.

Adding Supports to Model

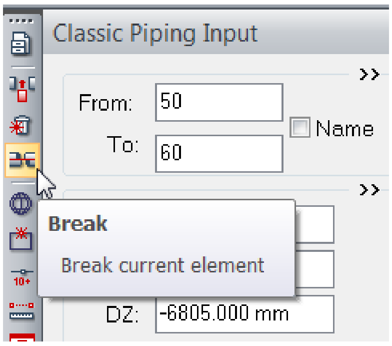
Let us now return to our model SUPT01.



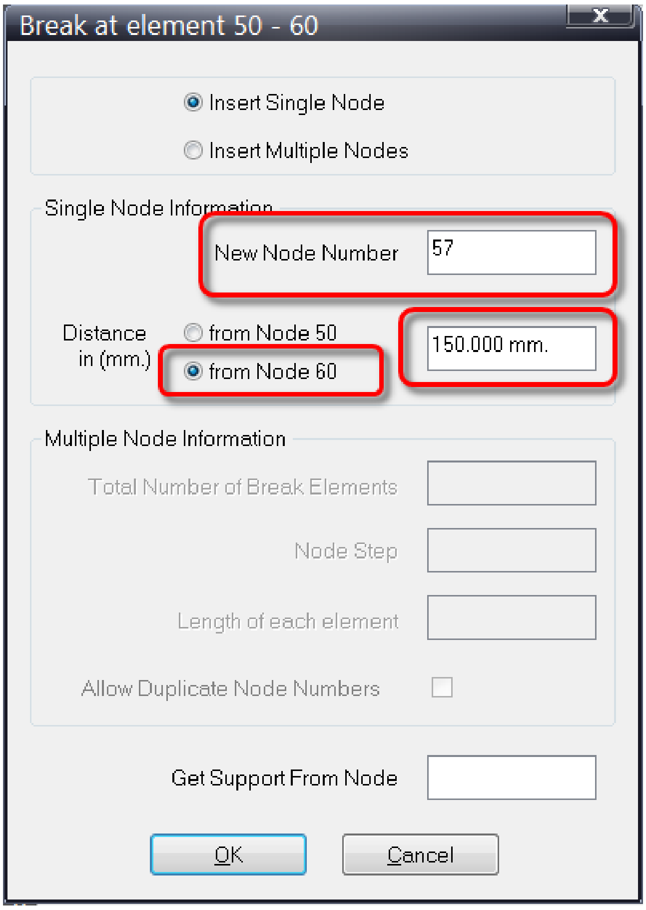
As there is an anchor at node 10, the valve here is supported.

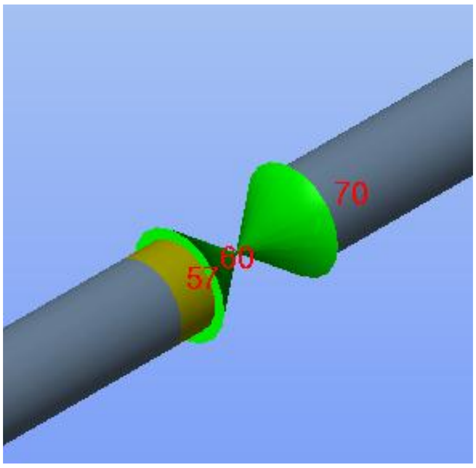
The valve at 60-70 requires supporting. We will create a new node on element 50 to 60, called 57, and locate a +Y support here.

Use the Break command to split the element into two. First select element 50 to 60 and choose the break command.

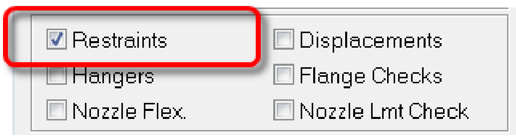


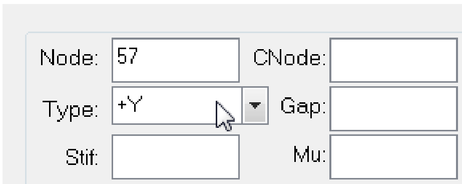
We will locate this support close to the valve (node 60). Specify to break the pipe and insert the new node, number 57, 150mm from node 60:



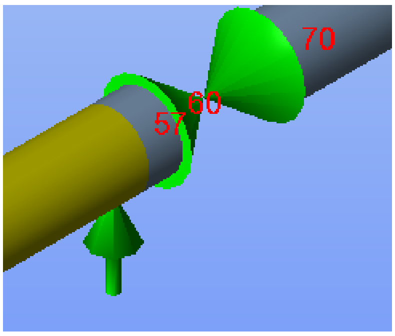


The element will be broken and a new node inserted close to the valve. Locate a +Y support at this node 57.





The +Y support will support the pipe from below, and will **allow movement in the +Y direction.**



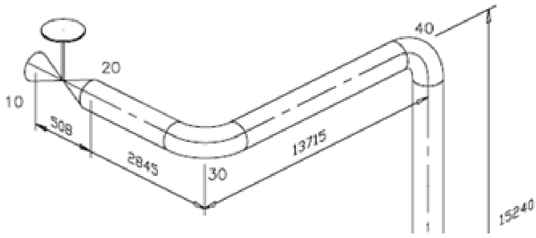
All the concentrated loads are now supported.

We can return and run through the piping system, placing supports as per the standard span.

Check the table on page 48 to determine the maximum span for 12” pipe carrying water

The table on page 48 indicates that the maximum span for 12" pipe in water service is 7m. As discussed previously, for horizontal changes in direction, the support span is amended to ¾ of the standard span. 0.75 x 7 = 5.25m

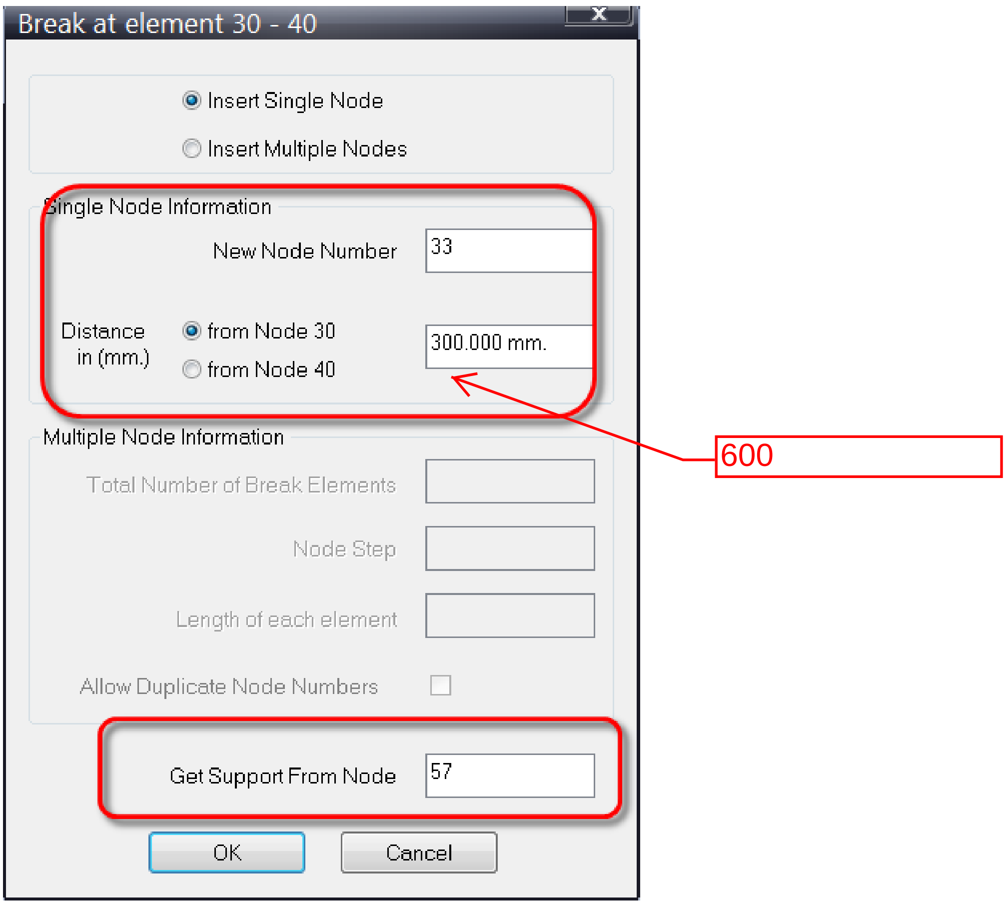
The valve is supported at node 10. After node 10 the piping continues horizontally with a bend. The maximum span therefore is 5.25m. This places our support round the bend.



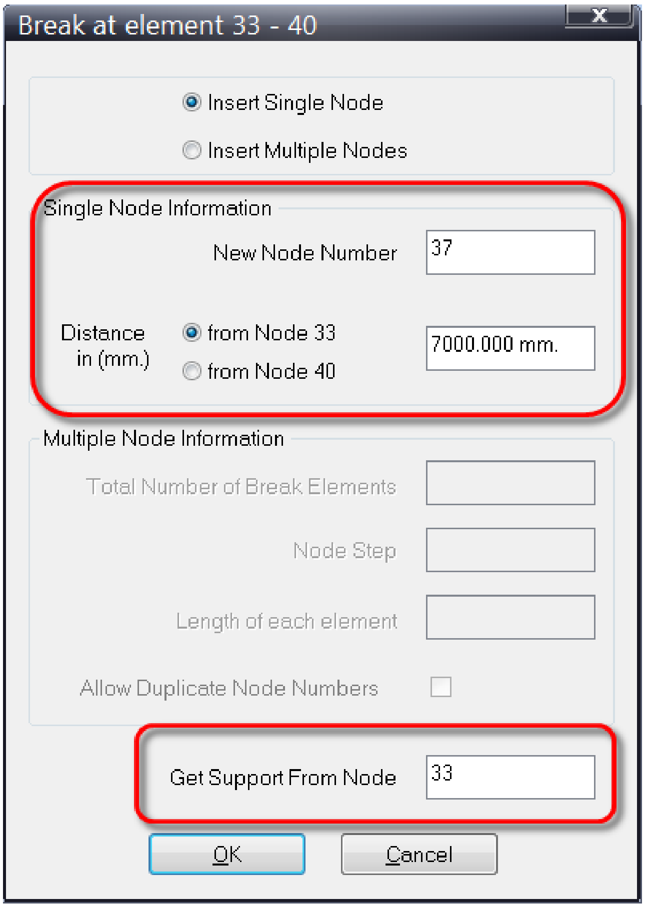
The piping after the bend is 13715mm before the riser. This can almost be split in two exactly with our 7m span spacing. Remember that the standard span does not apply to risers, and as mentioned before we will support the riser from the top, rather than trying to balance it from the bottom. As such we can locate a support near the middle of the 13715mm run, and one close to the bend (node 30).

Break element 30 to 40 and locate a new node number 33. Locate this 600mm from node 30.

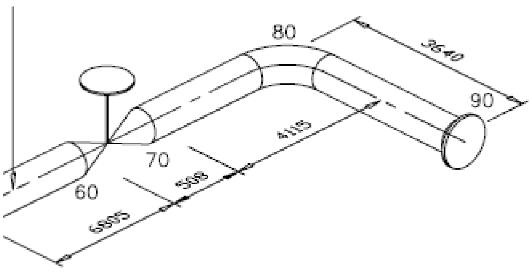
It is possible to add a support in at the new node location. We wish to add a +Y support at node 33, exactly the same support configuration as at node 57. So typing in 57 in the "Get Support from Node" field will place the same support as at 57 at our new node 33.



Repeat and break element 33-40. Break this 7000mm from node 33. Call the new node 37. Place the same +Y support from 33 (or 57) at this point too.

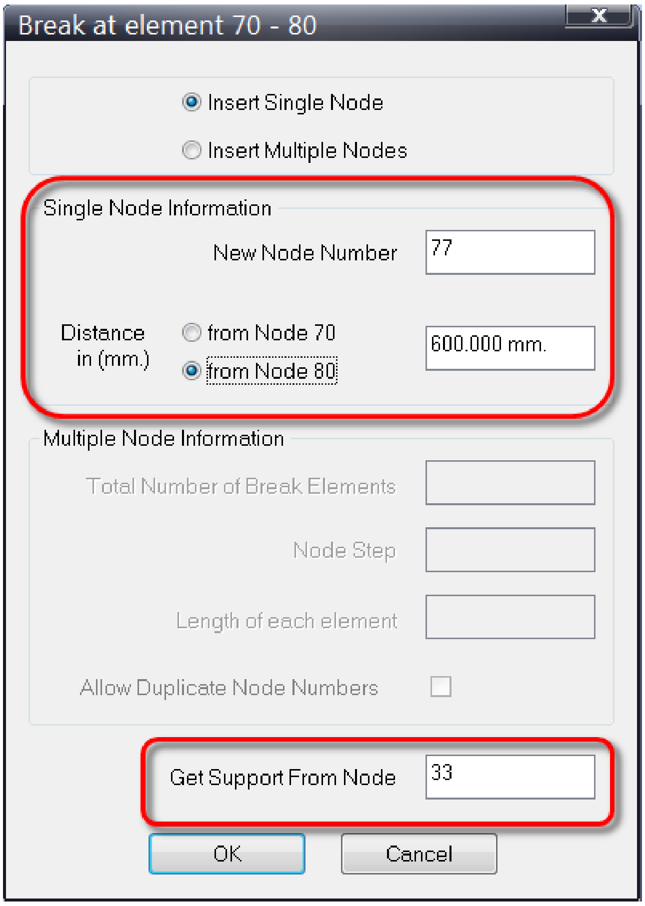


Continue on after the riser. There is already a restraint next to the valve, so we have fulfilled the minimum span up to the valve. After the valve we have horizontal pipe with a bend again. Therefore our maximum span is 5.25m. The length of pipe is 4115mm and then 3640mm after the bend. There is an anchor at the end, so we just need one more support between the valve and the anchor at the end of the pipe.



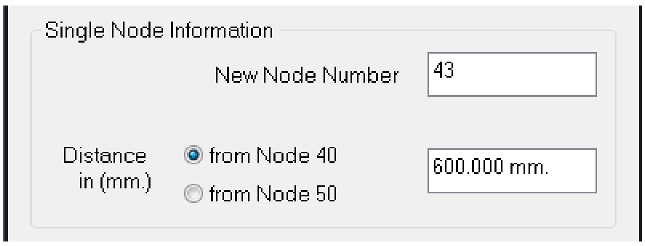
Locate this support on element 70 to 80, close to the bend at node 80. Locate this 600mm from the bend.

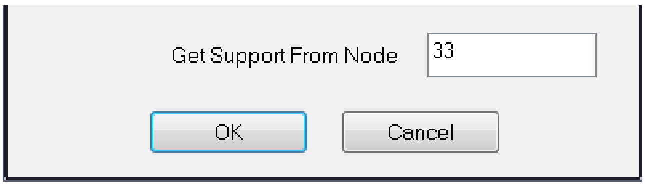
Break element 70 to 80 and create a new node 77, 600mm from node 80 and with a +Y support the same as before.



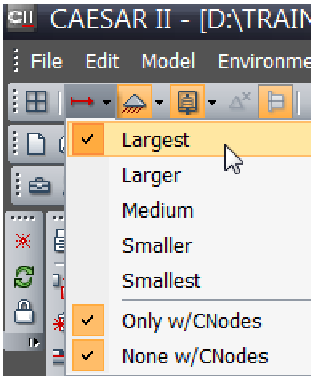
Finally the piping riser needs to be supported. The length of horizontal run at the top and bottom of the riser is less than our span of 7000mm. There is no bending in the riser so in theory we can place a single restraint near the top of the riser.

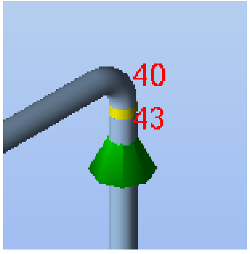
Break element 40-50 and locate a +Y restraint 600mm from the tangent intersection point of the bend. Note that, although this support should satisfy our bending requirements on the horizontal sections, it may have a very large load since it will also support the whole of the riser.

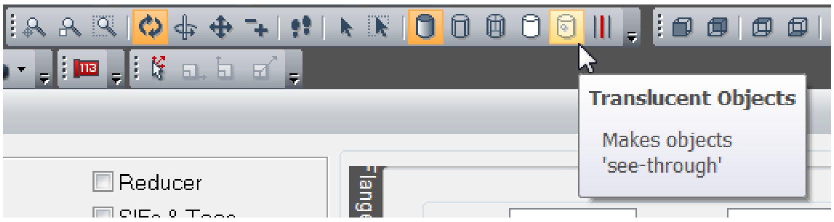


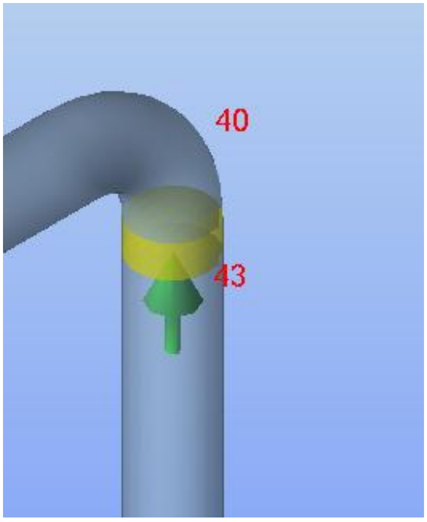


The support located in the riser may be difficult to see, as it is probably hidden by the piping. To view the support either the size of the restraint symbol can be increased, or the pipe can be set to translucent mode.









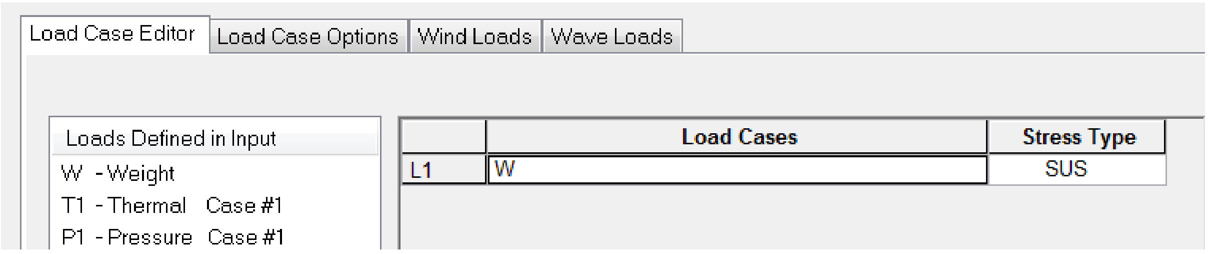
The system is now supported as per the maximum span requirements. We can be sure that the sustained stress case therefore is acceptable, and should be in the order of approximately 10MPa.

Error Check the model.

You should receive only the Centre of Gravity report, and no errors or warnings.

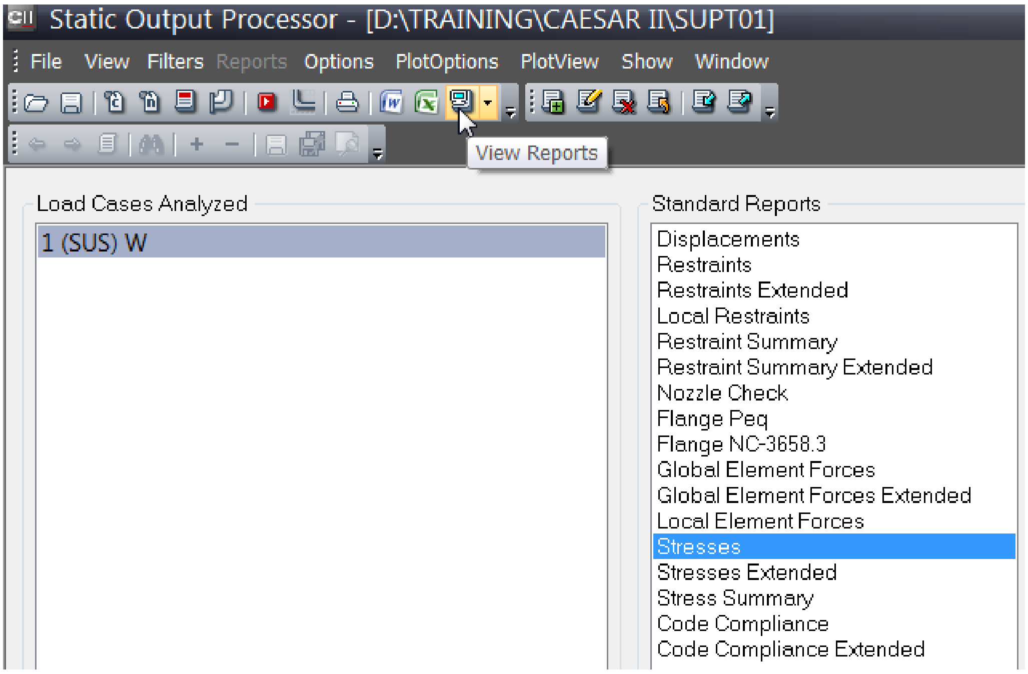
Analyse

Access the Static load cases create only a single load case with weight only. We wish to check the support locations we have just placed are below the acceptable limits



Run the analysis.

View the Sustained Stresses report.



```
CAESAR II 2011 SP1  Ver.5.30.01,  (Build 110228)   Date: JUN 13, 2011   Time: 15:45
Job: D:\TRAINING\CAESAR II\SUPT01
Licensed To: Seat   --  ID #51
STRESSES REPORT: Stresses on Elements
CASE 1 (SUS) W
```

NODE	Bending Stress N./sq.mm.	Torsion Stress N./sq.mm.	SIF In Plane	SIF Out Plane	Code Stress N./sq.mm.	Allowable Stress N./sq.mm.	Ratio %	Piping Code

Bending Stress:	10.7	@Node	37
Torsion Stress:	0.7	@Node	29
Hoop Stress:	0.0	@Node	20
3D Max Intensity:	10.7	@Node	37

37	10.67	0.04	1.000	1.000	$\boxed{10.67}$	137.89	7.74	B31.3
37	10.67	-0.04	1.000	1.000	10.67	137.89	7.74	B31.3
57	9.89	0.06	1.000	1.000	9.89	137.89	7.17	B31.3
57	9.89	-0.06	1.000	1.000	9.89	137.89	7.17	B31.3
60	8.31	0.06	1.000	1.000	8.31	137.89	6.03	B31.3

The highest stress level is 10.7MPa, which is almost exactly at the allowable from the standard span limit (this limit is based on an allowable of 1500 psi ~10.3MPa). The system is supported from a purely weight induced stress perspective.

We can also now view the restraint loads to see how the weight loads are distributed. View the Restraint Summary report.

```
RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 1 (SUS) W
```

NODE	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.

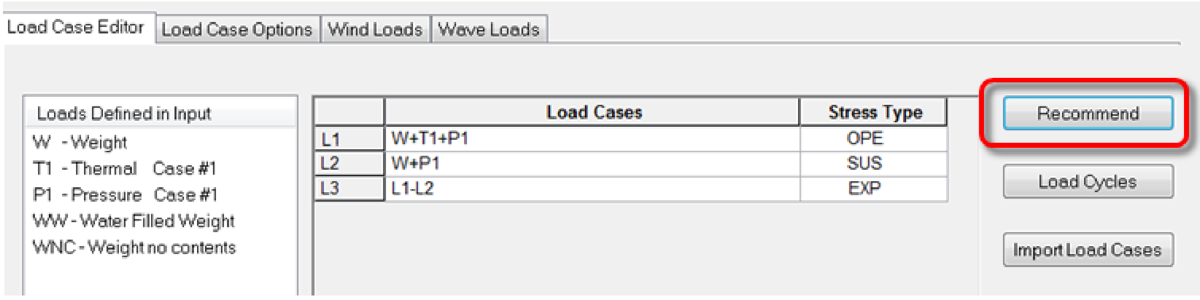
LOAD CASE DEFINITION KEY

CASE 1 (SUS) W

NODE	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10	Rigid ANC						
	1(SUS)	2	-6442	-28	-927	66	-2583
33	Rigid +Y						
	1(SUS)	0	-7337	0	0	0	0
37	Rigid +Y						
	1(SUS)	0	-12054	0	0	0	0
43	Rigid +Y						
	1(SUS)	0	-30705	0	0	0	0
57	Rigid +Y						
	1(SUS)	0	-13746	0	0	0	0
77	Rigid +Y						
	1(SUS)	0	-4792	0	0	0	0
90	Rigid ANC						
	1(SUS)	-2	-3548	28	-257	82	2753

Again this look OK, all restraints are taking a downwards acting load (-FY), although the restraint at node 43 is rather large compared to the others; 30,000N vs. less than half that for the remaining supports.

These loads however are due to weight only. Let us run now the cases required by the piping code B31.3. Return to the Static Load cases and select the recommended cases.



Run the analysis and view the sustained stresses. These will have increased slightly due to the fact that we are now including the pressure term; however the stresses are still well within the allowables determined by the code.

Similarly the Expansion Case stresses are also very low and well within the allowable – the system is flexible unlike the PIPE1 example.

Now we can check the restraint loads in the real world operating case. Remember the Operating case is not required by the code, but it does represent the actual loads in a “real world” scenario, for the purpose of designing restraints.

View the Operating case Restraint Summary.

RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 1 (OPE) W+T1+P1

LOAD CASE DEFINITION KEY

CASE 1 (OPE) W+T1+P1

NODE	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10	Rigid ANC						
	1(OPE)	-60	-5769	1890	-1093	-5646	-1195
33	Rigid +Y						
	1(OPE)	0	-8646	0	0	0	0
37	Rigid +Y						
	1(OPE)	0	-9071	0	0	0	0
43	Rigid +Y						
	1(OPE)	0	-25305	0	0	0	0
57	Rigid +Y						
	1(OPE)	0	-29236	0	0	0	0
77	Rigid +Y						
	1(OPE)	0	0	0	0	0	0
90	Rigid ANC						
	1(OPE)	60	-596	-1890	-1569	-6060	-8071

The loads are different to before as we have included the effects of thermal expansion.

The load on node 77 is 0 (in the FY). This shows that this restraint is not taking any load. What is happening here?

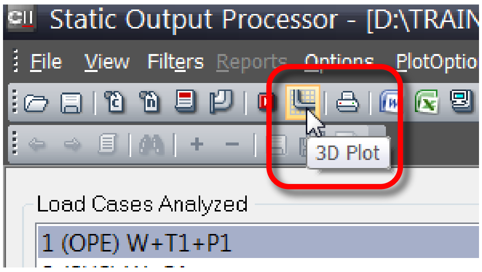
View the displacements report to see what is happening at this point.

DISPLACEMENTS REPORT: Nodal Movements
CASE 1 (OPE) W+T1+P1

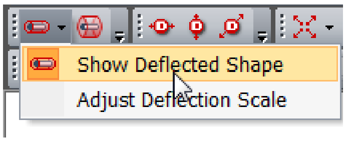
NODE	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
50	-8.503	-26.211	19.297	0.2236	-0.0042	-0.0632
57	-7.822	-0.000	7.796	0.1184	-0.0094	-0.0633
60	-7.797	0.285	7.518	0.1044	-0.0096	-0.0634
70	-7.712	1.200	6.575	0.1024	-0.0096	-0.0634
77	-6.955	2.307	0.052	-0.0221	-0.0154	-0.0635

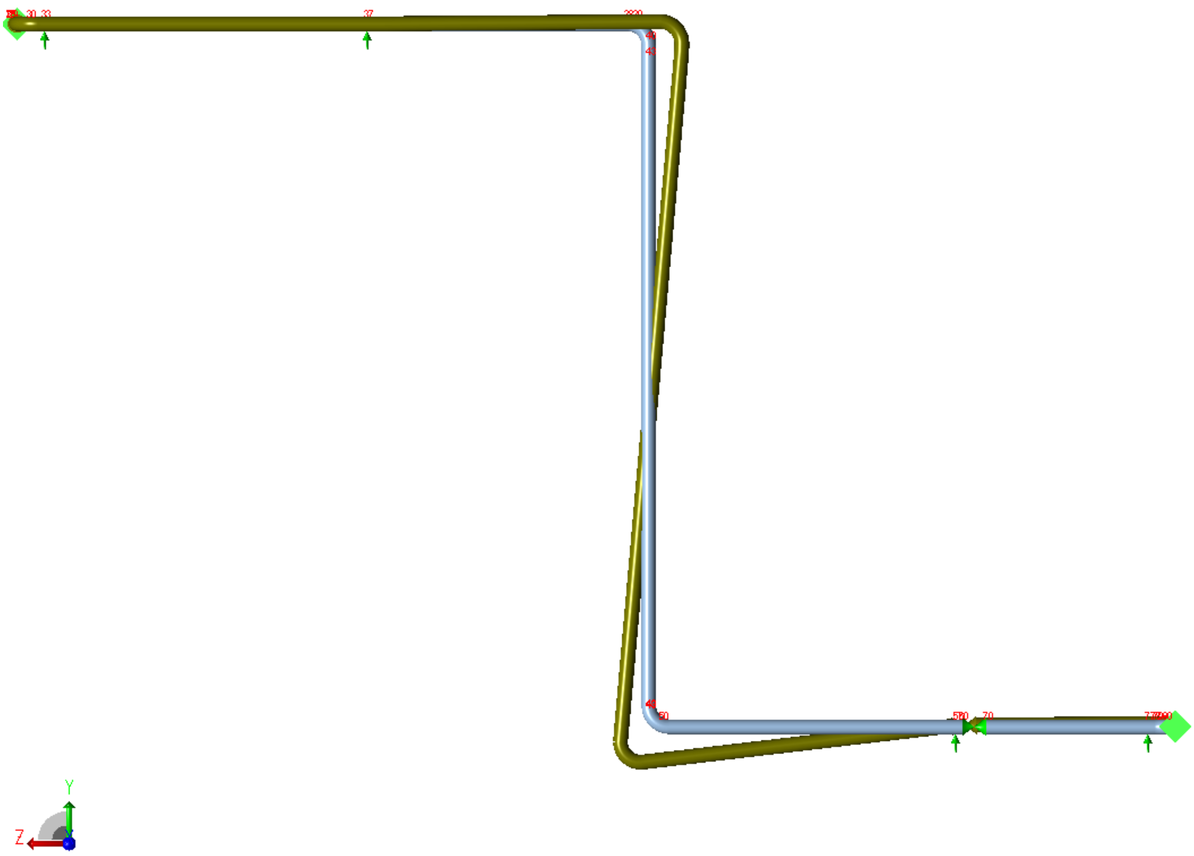
At node 77 the pipe is moving *upwards* 2.3mm. Also notice that at node 50 (the bottom of the riser) the pipe is moving *down* 26mm.

Viewing the 3D Plot can confirm this:



View the deflected shape (you may wish to increase the deflection scale to exaggerate the deflected shape)





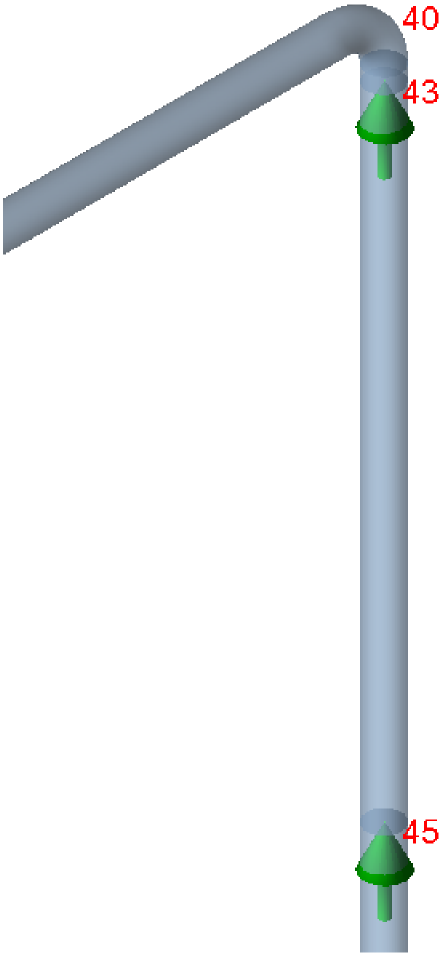
The 3D plot shows that the thermal expansion is causing the riser to expand downwards at the bottom (node 50). This in turn is causing the pipe to pivot at node 57 – giving the large operating load at node 57. The pipe pivoting at 57 causes lift off at node 77 – so we see a 0 load.

The restraint at the top of the riser (at 43) is the datum point of expansion and so all the thermal expansion is from this point. That is why there is no expansion at the top and a lot of expansion at the bottom. We need to rectify this situation.

Fix Model

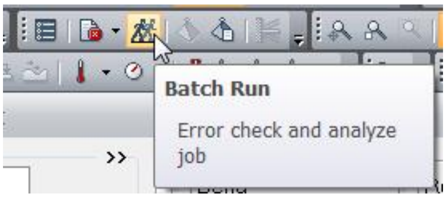
As we know, the riser is expanding due to thermal expansion. The datum point for this expansion is the support located at node 43, at the top of the riser, so all the expansion is going downwards – causing the lift off issue. To rectify this we can attempt to move the datum point of the expansion, so that the expansion is more evenly distributed.

Insert an additional restraint on the riser. Call this node number 45 and locate this restraint 6000mm below node 43. Insert another +Y support at this location. This should have two effects:



1. Give a better distribution of the weight loads of the riser
2. Cause less thermal expansion downwards at node 50.

Re-run the analysis, the batch run command can be used as we have only made a small change by adding a support.



Review the stresses is the SUS and EXP cases. These stresses should still be acceptable.

Review the restraint report for the sustained and operating cases to see how the new restraint has affected the results.

```
RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 2 (SUS) W+P1
```

NODE	Load Case		FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10		Rigid ANC						
	2(SUS)		2	-6442	-30	-927	73	-2583
33		Rigid +Y						
	2(SUS)		0	-7336	0	0	0	0
37		Rigid +Y						
	2(SUS)		0	-12055	0	0	0	0
43		Rigid +Y						
	2(SUS)		0	-8816	0	0	0	0
45		Rigid +Y						
	2(SUS)		0	-21905	0	0	0	0
57		Rigid +Y						
	2(SUS)		0	-13706	0	0	0	0
77		Rigid +Y						
	2(SUS)		0	-4816	0	0	0	0
90		Rigid ANC						
	2(SUS)		-2	-3546	30	-252	90	2748

The sustained case shows that we have a better distribution of the weight of the pipe on the riser, as the new restraint is taking some load. The load on node 43 at the top of the riser is now distributed between 43 and 45 (43 has dropped from 30kN to 9kN).

```
RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 1 (OPE) W+T1+P1
```

NODE	Load Case		FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10		Rigid ANC						
	1(OPE)		-79	-5301	1917	-2400	-5472	501
33		Rigid +Y						
	1(OPE)		0	-10938	0	0	0	0
37		Rigid +Y						
	1(OPE)		0	-4794	0	0	0	0
43		Rigid +Y						
	1(OPE)		0	0	0	0	0	0
45		Rigid +Y						
	1(OPE)		0	-29880	0	0	0	0
57		Rigid +Y						
	1(OPE)		0	-24813	0	0	0	0
77		Rigid +Y						
	1(OPE)		0	0	0	0	0	0
90		Rigid ANC						
	1(OPE)		79	-2897	-1917	-1291	-5940	-111

The operating case however still shows lift zero load at node 77, and now also zero load at node 43.

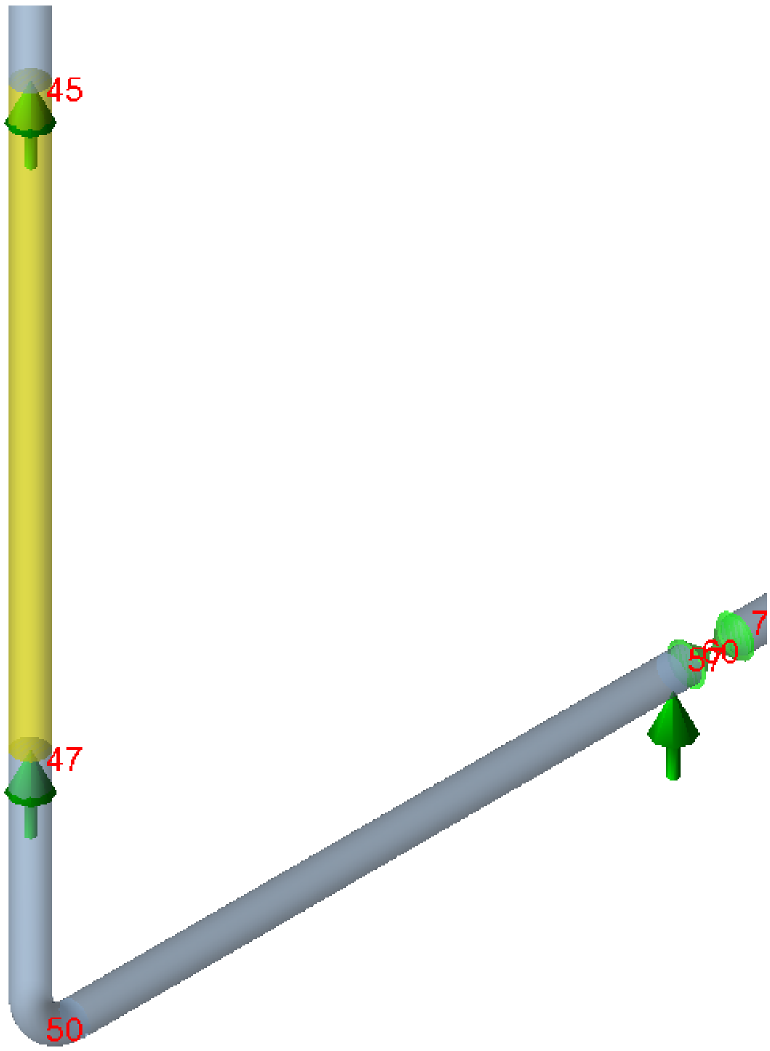
Checking the displacements also confirms this; there is still a positive displacement at nodes 77 and now at 43. Node 50 is still moving downwards, although only 15mm now.

```
DISPLACEMENTS REPORT: Nodal Movements
CASE 1 (OPE) W+T1+P1
```

NODE	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
40	4.620	11.362	-24.859	-0.0949	0.0120	-0.0395
43	4.521	11.097	-24.616	-0.0997	0.0119	-0.0398
45	-0.099	-0.000	-6.613	-0.2157	0.0094	-0.0473
50	-7.328	-15.792	19.348	0.1130	0.0030	-0.0422
57	-7.382	-0.000	7.847	0.0699	-0.0032	-0.0343
60	-7.373	0.164	7.569	0.0597	-0.0035	-0.0341
70	-7.342	0.686	6.626	0.0583	-0.0035	-0.0341
77	-6.916	0.803	0.103	-0.0224	-0.0108	-0.0296

We will attempt to further distribute the thermal expansion of the riser by adding a third restraint, located near the bottom.

Break element 45-50 and create node 47. Locate node 47 6000mm below node 45 and locate a +Y support at this point.



Rerun the analysis and check that the stress levels have not been adversely affected.

As before, view the SUS and OPE loads on the restraints to see how the new restraint has affected the analysis.

RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 2 (SUS) W+P1

NODE	Load Case		FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10		Rigid ANC						
	2(SUS)		2	-6442	-31	-927	77	-2584
33		Rigid +Y						
	2(SUS)		0	-7336	0	0	0	0
37		Rigid +Y						
	2(SUS)		0	-12056	0	0	0	0
43		Rigid +Y						
	2(SUS)		0	-8815	0	0	0	0
45		Rigid +Y						
	2(SUS)		0	-9263	0	0	0	0
47		Rigid +Y						
	2(SUS)		0	-12653	0	0	0	0
57		Rigid +Y						
	2(SUS)		0	-13683	0	0	0	0
77		Rigid +Y						
	2(SUS)		0	-4830	0	0	0	0

The sustained report shows that we have further improved the weight distribution among the restraints.

```
RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 1 (OPE) W+T1+P1
```

NODE	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
10	Rigid ANC						
	1(OPE)	-90	-4802	1929	-3681	-5372	2242
33	Rigid +Y						
	1(OPE)	0	-13253	0	0	0	0
37	Rigid +Y						
	1(OPE)	0	-544	0	0	0	0
43	Rigid +Y						
	1(OPE)	0	0	0	0	0	0
45	Rigid +Y						
	1(OPE)	0	0	0	0	0	0
47	Rigid +Y						
	1(OPE)	0	-34679	0	0	0	0
57	Rigid +Y						
	1(OPE)	0	-19557	0	0	0	0
77	Rigid +Y						
	1(OPE)	0	-1767	0	0	0	0

The Operating case now shows a negative load on restraint at node 77. There is no more lift off here at 77. However the operating loads at node 43 and 45 are now zero. All the thermal expansion that was going downwards with only the one restraint at the top of the riser has now been forced upwards instead, causing the pipe to lift off at the top of the riser (43 and 45).

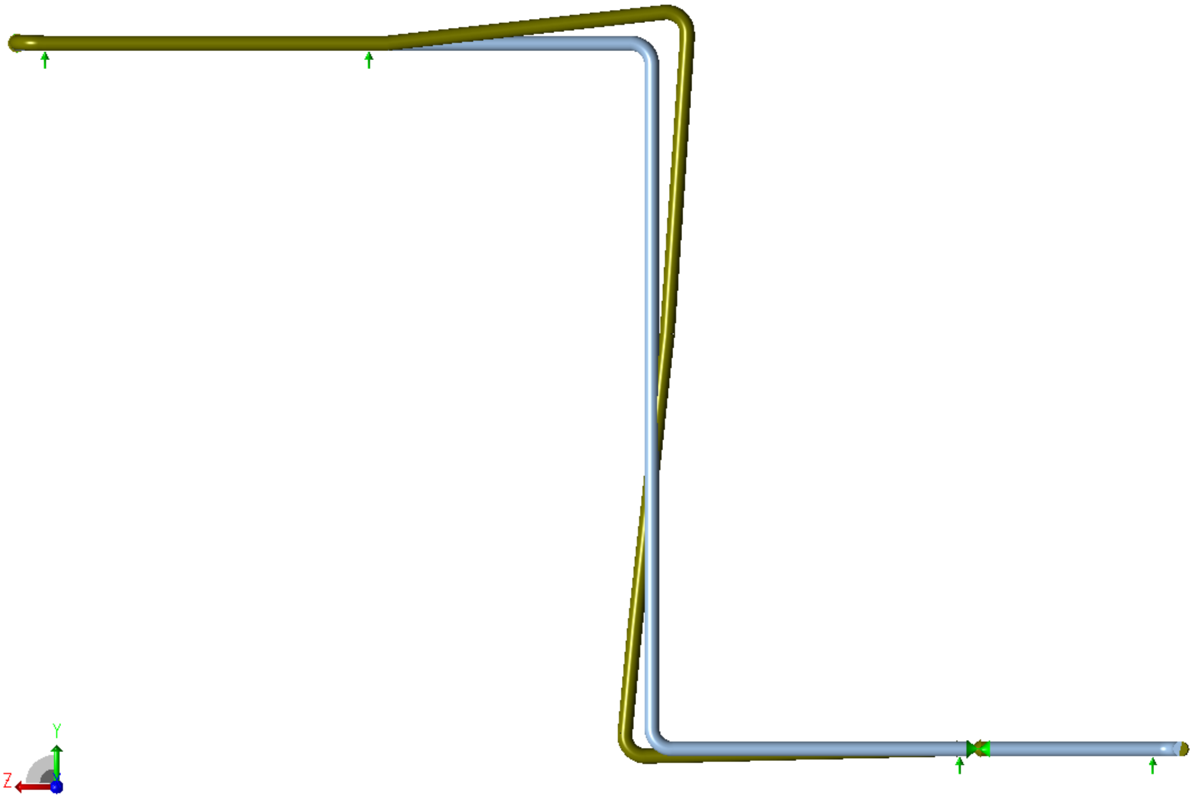
The displacements report confirms this

```
DISPLACEMENTS REPORT: Nodal Movements
CASE 1 (OPE) W+T1+P1
```

NODE	DX mm.	DY mm.	DZ mm.	RX deg.	RY deg.	RZ deg.
40	3.629	22.414	-25.561	-0.0310	0.0168	-0.0352
43	3.541	22.150	-25.476	-0.0371	0.0167	-0.0355
45	-0.560	11.060	-11.186	-0.2071	0.0143	-0.0415
47	-4.881	-0.000	12.097	-0.2089	0.0118	-0.0397
50	-6.688	-5.410	19.377	-0.0006	0.0069	-0.0310
57	-7.142	-0.000	7.876	0.0290	0.0001	-0.0188
60	-7.142	0.064	7.598	0.0231	-0.0002	-0.0185
70	-7.140	0.264	6.654	0.0223	-0.0002	-0.0185
77	-6.895	-0.000	0.132	-0.0142	-0.0082	-0.0115

The pipe is lifting off 22mm at the top of the riser.

The 3D plot can also confirm the situation:

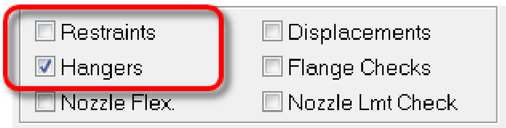


So we have a situation where we are supporting the weight of the system adequately in the SUS load case, but we have an issue with the thermal expansion. If we replace the rigid +Y restraints along the riser with Variable Spring Hangers (VSH), these hangers should allow thermal growth whilst also supporting the required weight for the SUS condition.

Place Spring Hangers

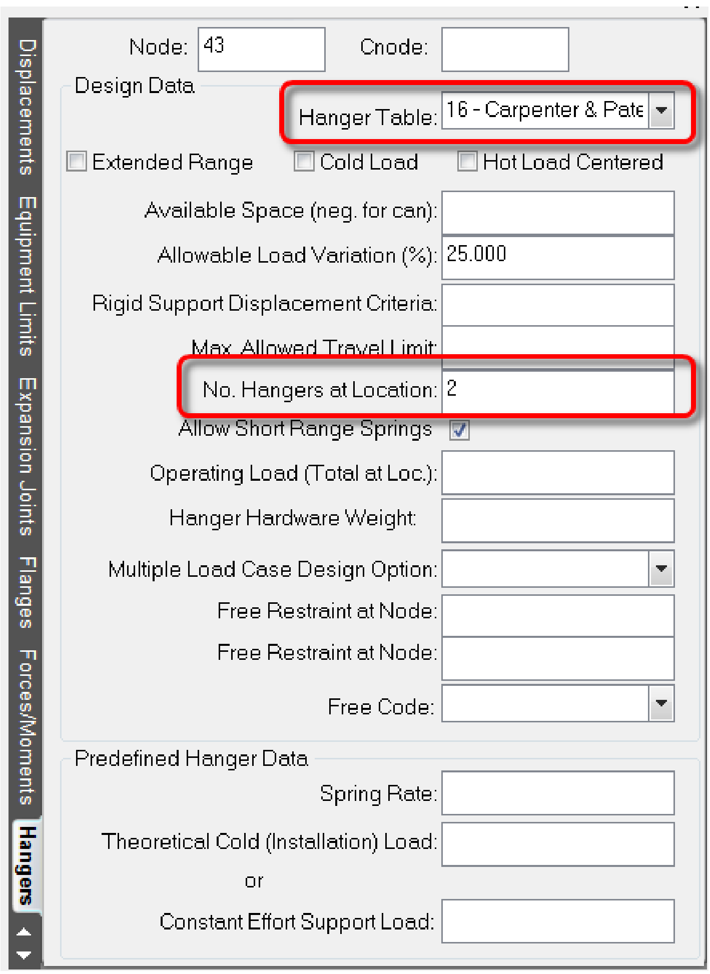
Return to the input at locate element 40-43. Remove the restraint at node 43 by double clicking the restraint check box.

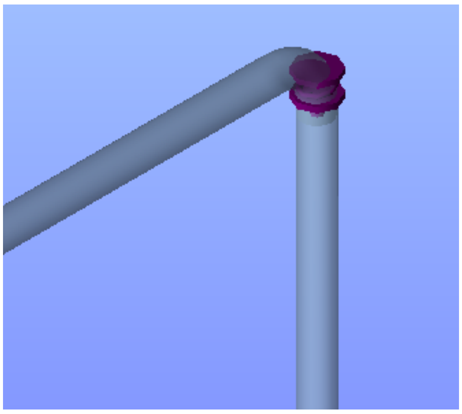
Place a hanger here instead. Double click the Hangers check box

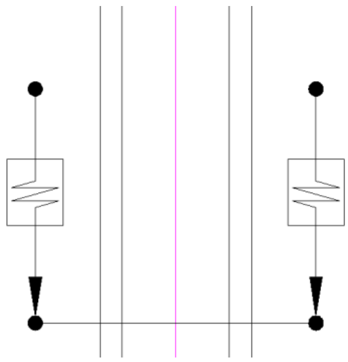


Select the Hanger table as Carpenter & Paterson. Carpenter & Paterson are a UK manufacturer whose database of available spring hangers is programmed into CAESAR II. CAESAR II will automatically calculate the required load and movement at the location, and then review the database to select an appropriate spring for the calculated load and movements.

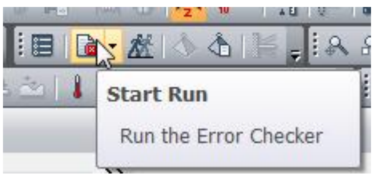
Notice that 2 hangers are located at this location also. The graphics will not change in CAESAR II, but this will locate 2 hangers at this location, and the selected spring will be based upon this shared load.







Error check the model. You should now notice two further notes during the error check.

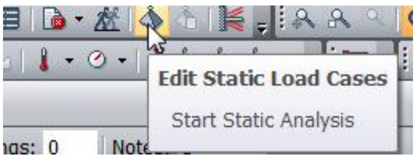


```
    Number of HANGERS in this job     =      1
Number of HANGERS to design         =      1
Number of Pre-Designed HANGERS      =      0

    The LOAD CASES below should be defined at analysis
level to properly perform the HANGER DESIGN:

COMBINATION LOAD CASE 1   WEIGHT LOADS
COMBINATION LOAD CASE 2   SPR. DESIGN OPERATING CASE #1
COMBINATION LOAD CASE 3...Any cases with the designed
hangers installed.
```

The first not simply shows the number of hangers in the job, and how many of these hangers will be designed by CAESAR II at run time.

The second message states that new load case combinations are required for the hanger design. A load case for weight loads is required, so that CAESAR II knows how much weight the hanger(s) need to support. Secondly, a hanger design operating case is required. This case determines the thermal expansion at each restraint location to determine the movement at the spring hanger locations as well. The values of weight from the previous weight load case are used. These two cases together are used by CAESAR II's spring selection algorithm to select the appropriate spring from the in-built catalogue.

Access the load case editor to create these new load cases.



Click the Recommend button in the load case editor. CAESAR II knows that there are hangers present that require designing, so will recommend the correct load cases for hanger design – cases 1 and 2.

Cas...	Load Case	Description
1	W(HGR)	WEIGHT FOR HANGER LOADS
2	W+T1+P1(HGR)	OPERATING FOR HANGER TRAVEL
3	W+T1+P1+H(OPE)	OPERATING CASE CONDITION 1
4	W+P1+H(SUS)	SUSTAINED CASE CONDITION 1
5	L3-L4(EXP)	EXPANSION CASE CONDITION 1

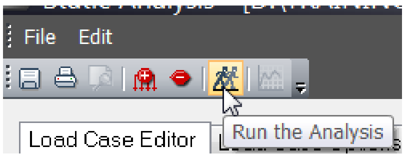
Accept these cases. Note the stress type for these cases are HGR type. The results for these hanger cases are supressed by default (theses are pre-analysis cases and the figures do not actually mean anything other than for the spring hanger selection).

Case 1 W (HGR)
This case performs a Weight Analysis only with all support locations as rigid restraints. This tells the spring selection algorithm how much weight needs to be supported at each location (usually in the Operating condition)

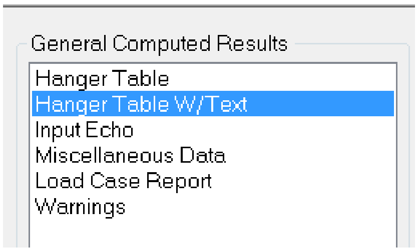
Case 2 W+T1+P1 (HGR)

The case uses the support weight values derived from case 1 as upward forces for an Expansion analysis. That is, the values of W cancel each other out (support load versus actual weight), and the system is then subject to temperature T1 in order to establish the thermal movement at each restraint location. Given the Weight to be supported and the thermal movement at the same location, the spring and its associated stiffness values can be selected and incorporated into the subsequent load cases.

Run the analysis



CAESAR II will have selected and sized a spring hanger during the analysis. Check the Hanger Table with text to view the hanger properties of the selected hanger.




```
 CAESAR II  HANGER REPORT         (TABLE DATA FROM DESIGN RUNS)

                                             THEORETICAL  ACTUAL
      NO.  FIG.       VERTICAL    HOT      INSTALLED   INSTALLED SPRING HORIZONTAL
 NODE REQD NO.  SIZE  MOVEMENT    LOAD       LOAD        LOAD     RATE   MOVEMENT

-------+---+-----+----+---(mm.)--+--(N. )-+--(N. )---+--(N. )--(KN./mm.)--(mm.)-
     43   2 DV70    11    22.234    6723.      8046.         0.       0.  25.725
         CARPNTR&PATRSON                                LOAD  VARIATION =   20%
         ** VARIABLE SUPPORT SPRING DESIGNED ...................   MID RANGE
            MINIMUM ALLOWED SINGLE SPRING LOAD .......... (N. )    5292.986
            MAXIMUM ALLOWED SINGLE SPRING LOAD .......... (N. )    9460.985
            RECOMMENDED INSTALLATION CLEARANCE .......... (mm.)     305.054
-------+---+-----+----+----------+--------+----------+---------+-------+--------
```

As can be seen, CAESAR II has determined that the hanger will need to support a hot load (i.e. OPE) of 6723N. There are two springs at this location, so this 6723N is the total load shared between two supports (i.e. the total load is 6723N x 2).

CAESAR has taken these properties and browsed the inbuilt Carpenter & Paterson database and selected a DV70 Size 11 spring.

Verify the sustained and expansion stresses – these should still be acceptable (13% and 19%).

Now check the OPE restraint loads.

```
RESTRAINT SUMMARY REPORT: Loads On Restraints
CASE 3 (OPE) W+T1+P1+H
```

NODE	Load Case		FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
CASE 3 (OPE) W+T1+P1+H								
10		Rigid ANC						
	3(OPE)		-90	-4797	1932	-3690	-5381	2256
33		Rigid +Y						
	3(OPE)		0	-13272	0	0	0	0
37		Rigid +Y						
	3(OPE)		0	-510	0	0	0	0
43		Prog Design VSH						
	3(OPE)		0	-13447	0	0	0	0
45		Rigid +Y						
	3(OPE)		0	0	0	0	0	0
47		Rigid +Y						
	3(OPE)		0	-21251	0	0	0	0
57		Rigid +Y						
	3(OPE)		0	-19559	0	0	0	0

The hanger at node 43 is now taking load. This load is 13447N (which is 6723N x 2), however there is still no load being taken at node 45.

Return to the input and replace the rigid +Y support at node 45 with a spring hanger. As before, select the Carpenter & Paterson catalogue, and place 2 hangers at this location before re-running the analysis.

As before the SUS and EXP stresses are acceptable.

The OPE case Restraint summary now shows that all the restraints are taking load. The new spring hanger is taking some of the load of the riser – this is now distributed evenly.

CASE 3 (OPE) W+T1+P1+H

NODE	Load Case	FX N.	FY N.	FZ N.	MX N.m.	MY N.m.	MZ N.m.
33	Rigid +Y						
	3(OPE)	0	-13272	0	0	0	0
37	Rigid +Y						
	3(OPE)	0	-510	0	0	0	0
43	Prog Design VSH						
	3(OPE)	0	-8815	0	0	0	0
45	Prog Design VSH						
	3(OPE)	0	-9263	0	0	0	0
47	Rigid +Y						
	3(OPE)	0	-16620	0	0	0	0
57	Rigid +Y						
	3(OPE)	0	-19559	0	0	0	0
77	Rigid +Y						
	3(OPE)	0	-1766	0	0	0	0
90	Rigid ANC						
	3(OPE)	90	-4022	-1932	-720	-5877	3759

CAESAR II has again run the two hanger cases and used the results from these to select appropriate hangers for placing at the two hanger locations. These can be seen from the Hanger Table with text.

```
 CAESAR II   HANGER REPORT          (TABLE DATA FROM DESIGN RUNS)

                                           THEORETICAL  ACTUAL
      NO.  FIG.        VERTICAL    HOT     INSTALLED   INSTALLED  SPRING HORIZONTAL
 NODE REQD NO.   SIZE  MOVEMENT    LOAD     LOAD        LOAD       RATE   MOVEMENT

-------+---+-----+----+---(mm.)--+--(N.  )-+--(N.  )---+--(N.  )--(KN./mm.)--(mm.)-
     43   2 DV70      9   22.234    4408.      5186.          0.        0.  25.725
          CARPNTR&PATRSON                                LOAD  VARIATION =    18%
          ** VARIABLE SUPPORT SPRING DESIGNED ...................    MID RANGE
             MINIMUM ALLOWED SINGLE SPRING LOAD ........... (N. )     3114.000
             MAXIMUM ALLOWED SINGLE SPRING LOAD ........... (N. )     5566.004
             RECOMMENDED INSTALLATION CLEARANCE ........... (mm.)      329.946
-------+---+-----+----+----------+--------+----------+---------+-------+--------
     45   2 82       10   11.117    4631.      5644.          0.        0.  11.220
          ANVIL                                          LOAD  VARIATION =    22%
          ** VARIABLE SUPPORT SPRING DESIGNED ................... SHORT RANGE
             MINIMUM ALLOWED SINGLE SPRING LOAD ........... (N. )     4047.680
             MAXIMUM ALLOWED SINGLE SPRING LOAD ........... (N. )     6938.880
             RECOMMENDED INSTALLATION CLEARANCE ........... (mm.)      282.575
-------+---+-----+----+----------+--------+----------+---------+-------+--------
```