Tutorial on Reduction of Support Loads with Cold Spring using CAEPIPE

General

Cold spring (cut short or cut long) is used to reduce thermal forces on equipment connected to the piping system. When lengths of pipes are cut short or extended by design, they are pulled together or pushed apart to join them during installation, giving rise to a “cold-sprung” system.

Such an installation process (cold condition) obviously introduces stresses, which are relieved when the system starts up (hot condition). Note however, that the piping codes do not allow credit for any reduction in stresses due to cold spring since the displacement range is unaffected (similar to self-springing). But, codes allow reduction in support loads due to cold spring (which can be helpful at the equipment).

This feature should be used only with a proper understanding of the implications.

The intent of this tutorial is to provide a guideline on reducing the operating load on equipment connections by using the Cold Springs.

Tutorial

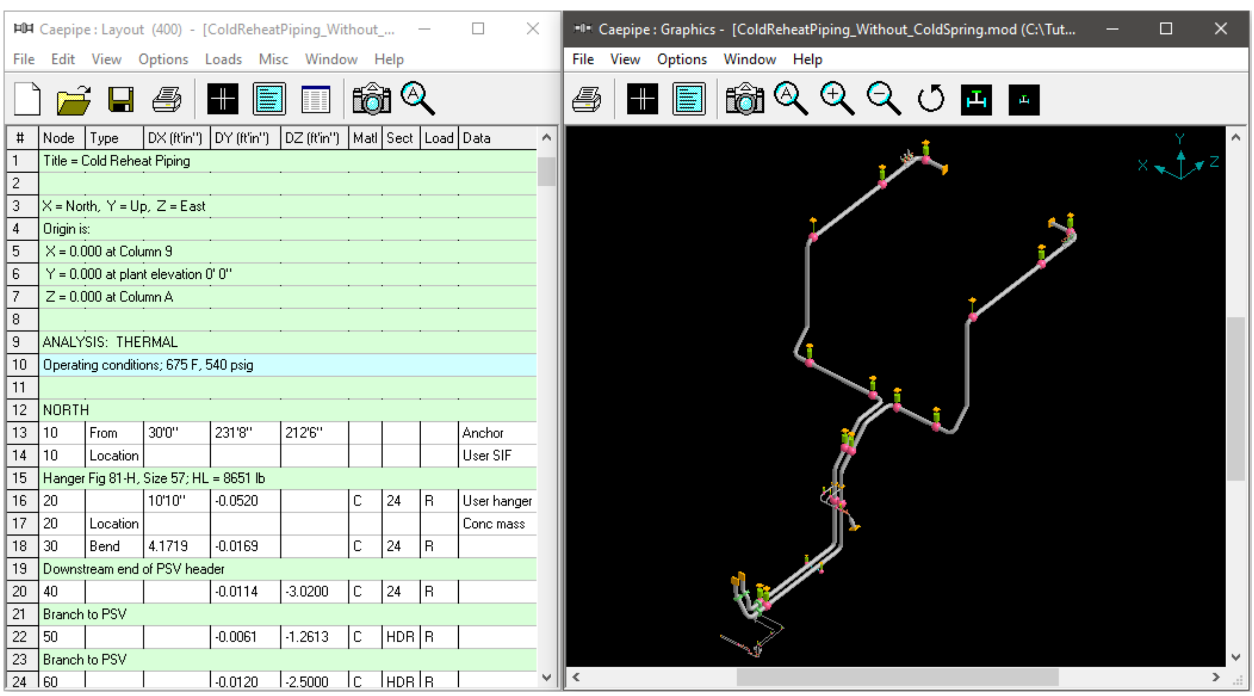
Step 1:

Attached are two sample CAEPIPE stress models of a Cold Reheat Piping system connecting the PSV Header to the Turbine Nozzles with and without Cold Spring.

Model 1: ColdReheatPiping_without_ColdSpring.mod

For this model, let us note the following.

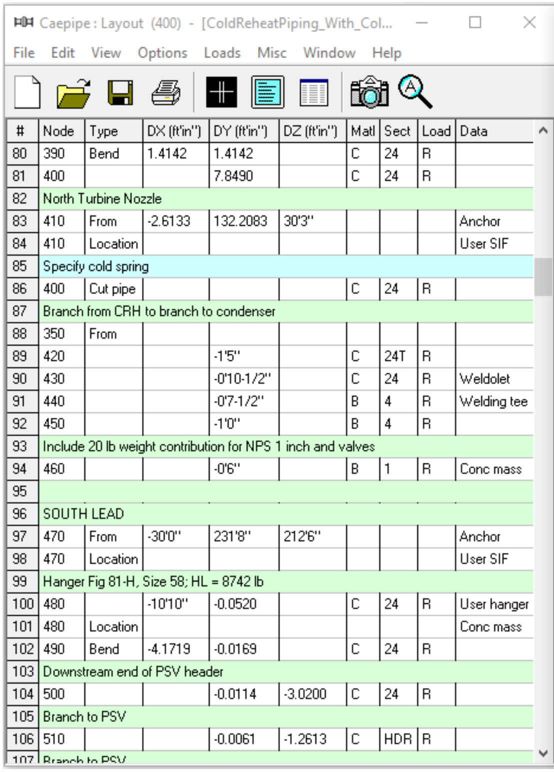
1. Nodes 10 and 470 connect to PSV Headers.
2. Nodes 400 and 870 connect to Turbine Nozzles.
3. No Cold Springs (Cut Pipes) are used in the piping connecting to the Turbine Nozzles.



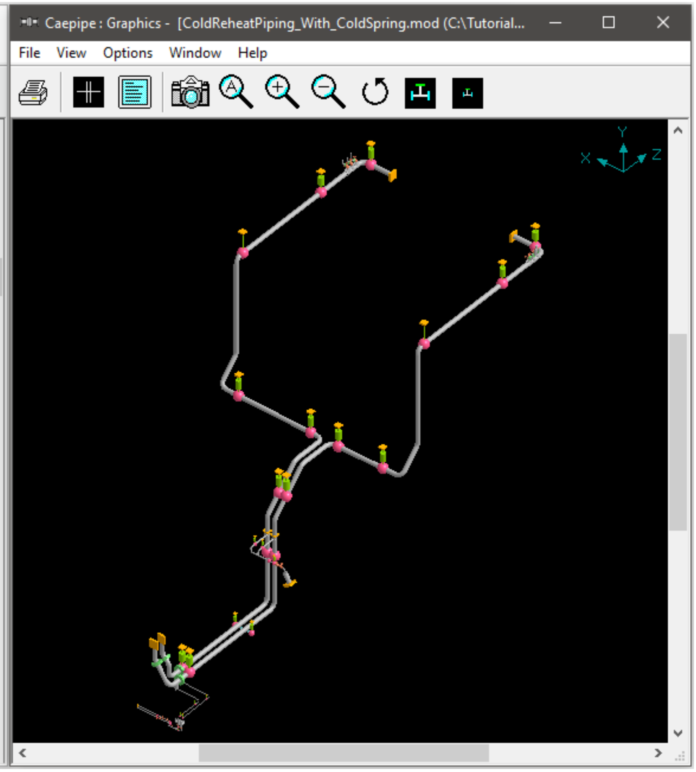
Model 2: ColdReheatPiping_with_ColdSpring.mod

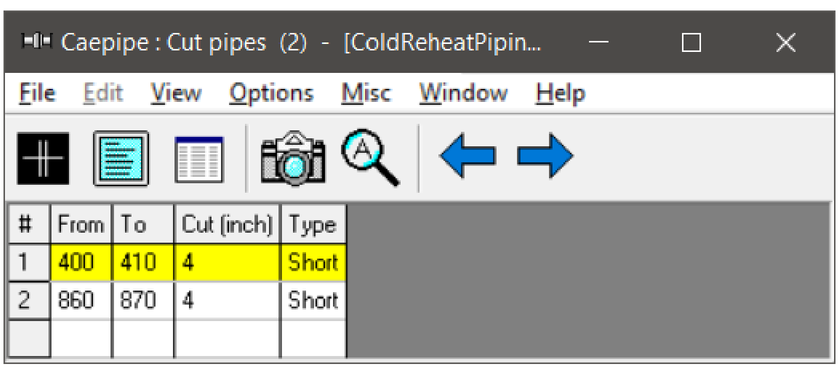
This model is same as Model 1 except that two Cold Springs are added in the piping connecting to the Turbine Nozzles as given below.

1. A Cut Pipe between Nodes 400 & 410 which is cut short by 4 inch
2. A Cut Pipe between Nodes 860 & 870 which is cut short by 4 inch.



#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
80	390	Bend	1.4142	1.4142		C	24	R	
81	400			7.8490		C	24	R	
82	North Turbine Nozzle								
83	410	From	-2.6133	132.2083	30'3"				Anchor
84	410	Location							User SIF
85	Specify cold spring								
86	400	Cut pipe				C	24	R	
87	Branch from CRH to branch to condenser								
88	350	From							
89	420			-1'5"		C	24T	R	
90	430			-0'10-1/2"		C	24	R	Weldolet
91	440			-0'7-1/2"		B	4	R	Welding tee
92	450			-1'0"		B	4	R	
93	Include 20 lb weight contribution for NPS 1 inch and valves								
94	460			-0'6"		B	1	R	Conc mass
95									
96	SOUTH LEAD								
97	470	From	-30'0"	231'8"	212'6"				Anchor
98	470	Location							User SIF
99	Hanger Fig 81-H, Size 58; HL = 8742 lb								
100	480		-10'10"	-0.0520		C	24	R	User hanger
101	480	Location							Conc mass
102	490	Bend	-4.1719	-0.0169		C	24	R	
103	Downstream end of PSV header								
104	500			-0.0114	-3.0200	C	24	R	
105	Branch to PSV								
106	510			-0.0061	-1.2613	C	HDR	R	
107	Branch to PSV								

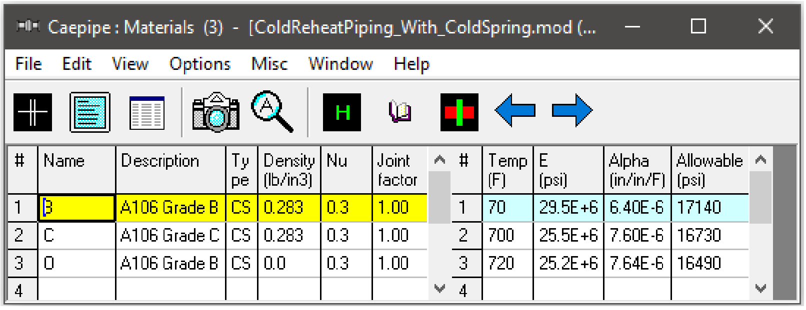




#	From	To	Cut (inch)	Type
1	400	410	4	Short
2	860	870	4	Short

Step 2:

Material, Section and Load properties of the two models are identical. They are given below for reference.


Caepipe : Materials (3) - [ColdReheatPiping_With_ColdSpring.mod (...

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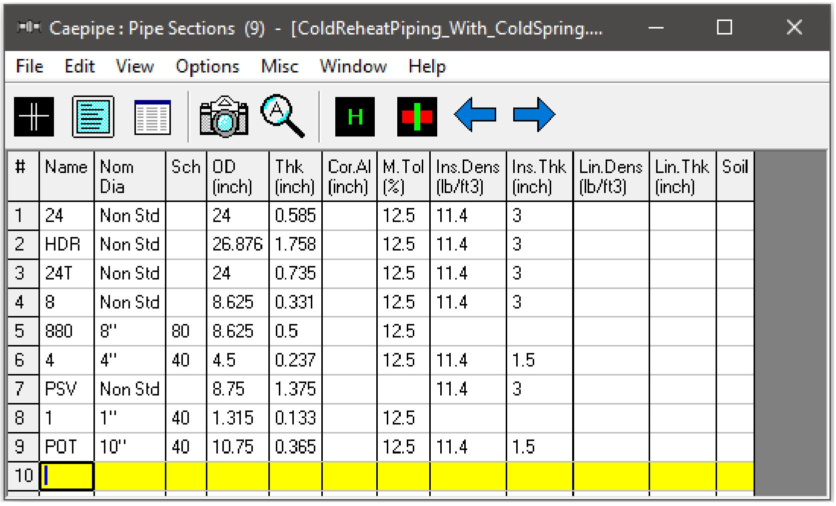
#	Name	Description	Type	Density (lb/in3)	Nu	Joint factor
1	B	A106 Grade B	CS	0.283	0.3	1.00
2	C	A106 Grade C	CS	0.283	0.3	1.00
3	O	A106 Grade B	CS	0.0	0.3	1.00
4						

#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	70	29.5E+6	6.40E-6	17140
2	700	25.5E+6	7.60E-6	16730
3	720	25.2E+6	7.64E-6	16490
4				


Caepipe : Pipe Sections (9) - [ColdReheatPiping_With_ColdSpring....

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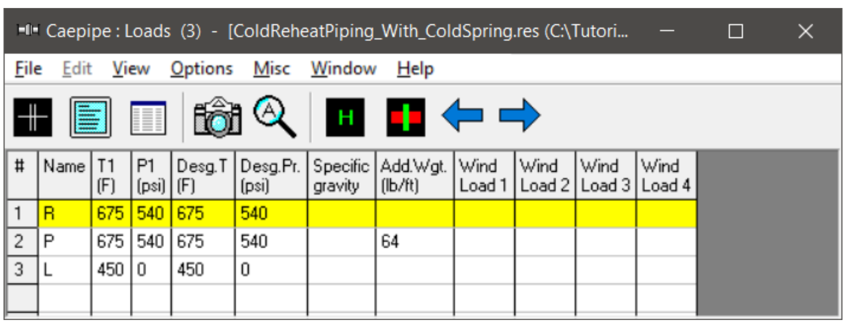
#	Name	Nom Dia	Sch	OD (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Thk (inch)	Lin.Dens (lb/ft3)	Lin.Thk (inch)	Soil
1	24	Non Std		24	0.585		12.5	11.4	3			
2	HDR	Non Std		26.876	1.758		12.5	11.4	3			
3	24T	Non Std		24	0.735		12.5	11.4	3			
4	8	Non Std		8.625	0.331		12.5	11.4	3			
5	880	8"	80	8.625	0.5		12.5					
6	4	4"	40	4.5	0.237		12.5	11.4	1.5			
7	PSV	Non Std		8.75	1.375			11.4	3			
8	1	1"	40	1.315	0.133		12.5					
9	POT	10"	40	10.75	0.365		12.5	11.4	1.5			
10												


Caepipe : Loads (3) - [ColdReheatPiping_With_ColdSpring.res (C:\Tutori...

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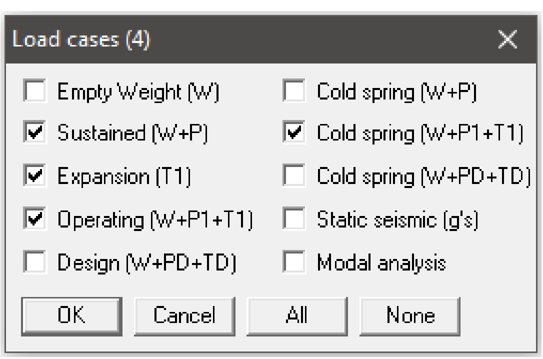
#	Name	T1 (F)	P1 (psi)	Desg.T (F)	Desg.Pr. (psi)	Specific gravity	Add.Wgt. (lb/ft)	Wind Load 1	Wind Load 2	Wind Load 3	Wind Load 4
1	R	675	540	675	540						
2	P	675	540	675	540		64				
3	L	450	0	450	0						

Step 3:

When the Cold Spring (Cut Pipe) is defined in the stress model, Cold Spring load cases will appear automatically in the Loads menu (under Load cases).


Load cases (4)

- [ ] Empty Weight (W)
- [x] Sustained (W+P)
- [x] Expansion (T1)
- [x] Operating (W+P1+T1)
- [ ] Design (W+PD+TD)
- [ ] Cold spring (W+P)
- [x] Cold spring (W+P1+T1)
- [ ] Cold spring (W+PD+TD)
- [ ] Static seismic (g's)
- [ ] Modal analysis

OK Cancel All None

For analysis, select the desired Cold Spring load cases from those shown. Please note, the Hanger selection procedure does not consider the cold spring since the selection is based on the first Operating (W+P1+T1) load case. However, if Cold Spring is used, the hanger loads for the Cold Spring load cases [for example, Cold Spring (W+P1+T1)] will include the effect of the Cold Spring.

Once the required load cases are selected, perform Analyses of both the models using CAEPIPE.

Step 4:

Caepipe : B31.1 (2020) Code compl...

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#	Sustained				Expansion			
	Node	SL (psi)	SH (psi)	SL/SH	Node	SE (psi)	SA (psi)	SE/SA
1	930	8072	16746	0.48	930	33888	34286	0.99
2	780	8120	19107	0.42	1070	21341	35990	0.59
3	470	8036	19107	0.42	1020	14867	37875	0.39
4	10	8005	19107	0.42	1030A	10692	38973	0.27
5	110	7310	19107	0.38	970	10319	38588	0.27
6	1070	6368	16746	0.38	900	9428	37098	0.25
7	570	7139	19107	0.37	890	9370	37047	0.25
8	330	7070	19107	0.37	580A	10070	42673	0.24
9	790	7024	19107	0.37	1040	9049	38756	0.23
10	320	7010	19107	0.37	1000	8380	37074	0.23
11	20	6859	19107	0.36	490B	9933	44652	0.22
12	480	6848	19107	0.36	1030B	8623	38912	0.22
13	120A	6834	19107	0.36	580B	9739	44532	0.22
14	770	6787	19107	0.36	30B	9045	44513	0.20

Caepipe : B31.1 (2020) Code compl...

File Results View Options Window Help

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Caepipe : B31.1 (2020) Code Compl...

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#	Node	Press. Allow. (psi)	Sustained			Expansion		
			SL (psi)	SH (psi)	SL/SH	SE (psi)	SA (psi)	SE/SA
1	10 20	540 829	8005 6858	19107 19107	0.42 0.36	8237 6305	40878 42025	0.20 0.15
2	20 30A	540 829	6859 6410	19107 19107	0.36 0.34	6305 6241	42025 42473	0.15 0.15
3	30A 30B	540 837	5514 4370	19107 19107	0.29 0.23	6223 9045	43369 44513	0.14 0.20
4	30B 40	540 829	5395 5398	19107 19107	0.28 0.28	5570 5566	43488 43486	0.13 0.13
5	40 50	540 2292	1747 1838	19107 19107	0.09 0.10	1674 1599	47137 47046	0.04 0.03
6	50 60	540 2292	1843 2003	19107 19107	0.10 0.10	1599 1451	47041 46881	0.03 0.03
7	60 70	540 2292	2004 2084	19107 19107	0.10 0.11	1451 1303	46880 46800	0.03 0.03
8	70 80	540 2292	2084 2085	19107 19107	0.11 0.11	1303 1227	46799 46799	0.03 0.03

Caepipe : B31.1 (2020) Code Compl...

File Results View Options Window Help

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2	20 30A	540 829	6859 6410	19107 19107	0.36 0.34	6305 6241	42025 42473	0.15 0.15
3	30A 30B	540 837	5514 4370	19107 19107	0.29 0.23	6223 9045	43369 44513	0.14 0.20
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8	70 80	540 2292	2084 2085	19107 19107	0.11 0.11	1303 1227	46799 46799	0.03 0.03
9	80	540	6523	19107	0.34	4079	42361	0.10

From the Sorted Stresses and Cold Compliance results (shown above) obtained from the two models, it is noted that the stresses for Sustained and Expansion Load cases are identical between the two models.

This confirms the statement that the piping codes do not allow credit for any reduction in stresses due to cold spring since the displacement range is unaffected.

Step 5:

Caepipe : Support load summary for anchor at node 410 - [ColdReheatPiping_Without_C...

File Results View Options Window Help

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	9	-2372	398	-399	-1733	-4458
Operating1	101	-1089	-2402	27440	-4508	-19682
Maximum	101	-1089	398	27440	-1733	-4458
Minimum	9	-2372	-2402	-399	-4508	-19682
Allowables	0	0	0	0	0	0

Caepipe : Support load summary for anchor at node 410 - [ColdReheatPiping_With_Cold...

File Results View Options Window Help

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	9	-2372	398	-399	-1733	-4458
Cold spring1	109	-604	-665	4606	7407	-19529
Maximum	109	-604	398	4606	7407	-4458
Minimum	9	-2372	-665	-399	-1733	-19529
Allowables	0	0	0	0	0	0

Caepipe : Support load summary for anchor at node 870 - [ColdReheatPiping_Without_C...

File Results View Options Window Help

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	-3	-2835	19	1099	1438	-9097
Operating1	824	-1347	-3459	35495	12301	-1056
Maximum	824	-1347	19	35495	12301	-1056
Minimum	-3	-2835	-3459	1099	1438	-9097
Allowables	0	0	0	0	0	0

Caepipe : Support load summary for anchor at node 870 - [ColdReheatPiping_With_Cold...

File Results View Options Window Help

Load combination	FX (lb)	FY (lb)	FZ (lb)	MX (ft-lb)	MY (ft-lb)	MZ (ft-lb)
Sustained	-3	-2835	19	1099	1438	-9097
Cold spring1	647	-1236	-718	3791	29424	-7810
Maximum	647	-1236	19	3791	29424	-7810
Minimum	-3	-2835	-718	1099	1438	-9097
Allowables	0	0	0	0	0	0

Now from the Support Load Summary results obtained from the two models (shown above), it is to be noted that the Forces and Moment MX for Cold Spring 1 [= Operating 1 (W+P1+T1) + Cold Spring] for the model with Cold Springs are considerably low compared to the Forces and Moment MX for Operating 1 (W+P1+T1) for the model without Cold Springs.

This effectively confirms that the operating load on equipment connections can be reduced using the Cold Springs.