Tutorial for Rotating Equipment Compliance using CAEPIPE

(without modeling their connected piping)

This Tutorial provides methodology for performing and producing Rotating Equipment Compliance report for Pump / Compressor / Turbine using CAEPIPE.

General

- Pumps, compressors and turbines in CAEPIPE, referred to as rotating equipment, are each governed by an industry publication — API (American Petroleum Institute) publishes API 610 for pumps and API 617 for compressors, ANSI (American National Standards Institute) publishes an ANSI/HI 9.6.2 for Rotodynamic Pumps, and NEMA (National Electrical Manufacturers Association) publishes the NEMA SM-23 for turbines. These publications provide guidelines for evaluating nozzles connected to equipment among other technical information including the items relevant to piping stress analysis – criteria for piping design and a table of allowable loads.

  Modeling the equipment is straightforward since it is assumed rigid (relative to connected piping) and modeled only through its end points (connection nozzles).

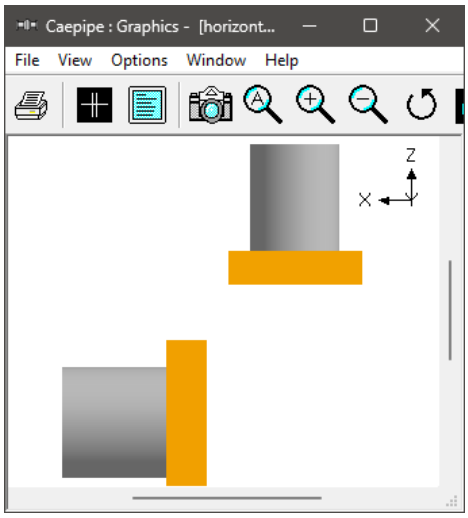
  1. In the CAEPIPE model, anchor all the nozzles (on the equipment) that need to be included in the pipe stress analysis.
  2. Specify these anchored nodes during the respective equipment definition via Misc. menu > Pumps/Compressors/Turbines in the Layout window.

- CAEPIPE does not require you to model all the nozzles or their connected piping. For example, you may model simply one inlet nozzle of a pump with its piping. Or, you may model one pump with both nozzles (with no connected piping) and impose external forces on them (if you have that data). Further, there is no need to connect the two anchors of the pump with a rigid massless element like required in some archaic methods.

Tutorial

Step 1:

Snapshot shown below is a sample CAEPIPE model for Horizontal pump with End Suction Nozzle and Top Discharge Nozzle that needs to be qualified as per API 610 Pump Compliance. As described in General section above, the Horizontal Pump with End Suction nozzle (Node 10) and Top Discharge nozzle (Node 50) is modeled with no connected piping.



Caepipe : Layout (10) - [horizontalpump.mod (c:\tutorials\...

File Edit View Options Loads Misc Window Help

#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = API 610 - Horizontal Pump								
2	with End Suction Nozzle & Top Discharge Nozzle								
3	Suction Nozzle								
4	10	From	0'10-1/2"						Anchor
5	10	Location							Force
6	20		1'0"			1	10	1	
7	Discharge Nozzle								
8	50	From		-1'0-1/4"	1'3"				Anchor
9	50	Location							Force
10	60				1'0"	1	8	1	
11									

Caepipe : Pipe Sections (2) - [horizontalpump.mod (c:\tutorials\rotatingequip...

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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)	Sc
1	10	10"	STD	10.75	0.365							
2	8	8"	STD	8.625	0.322							

Caepipe : Loads (1) - [horizontalpump.mod (c:\tutorials\rotatingequipmentco...

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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	1	70	0	70	0			Y			
2											

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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	10	10"	STD	10.75	0.365							
2	8	8"	STD	8.625	0.322							

Caepipe : Materials (1) - [horizontalpump.mod (c:\tutorials\rotatingequipmentcompliance\api610)]

File Edit View Options Misc Window Help

#	Name	Description	Type	Density (lb/in3)	Nu	Joint factor	Yield (psi)	Tensile (psi)
1		A53 Grade B	CS	0.0	0.3	1.00		
2								

#	Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
1	-100	30.2E+6	5.65E-6	15000
2	70	29.5E+6	6.07E-6	15000
3	200	28.8E+6	6.38E-6	15000
4	300	28.3E+6	6.60E-6	15000
5	400	27.7E+6	6.82E-6	15000
6	500	27.3E+6	7.02E-6	15000
7	600	26.7E+6	7.23E-6	15000
8	650	26.1E+6	7.34E-6	15000
9	700	25.5E+6	7.44E-6	14400
10	750	24.9E+6	7.55E-6	13000
11	800	24.2E+6	7.65E-6	10800

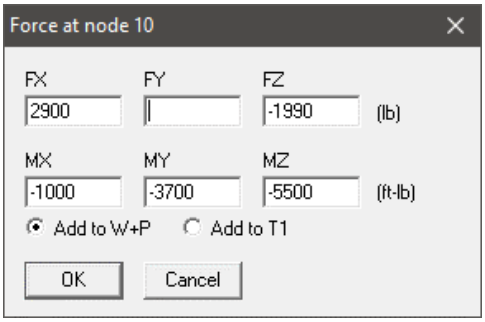
Step 2:

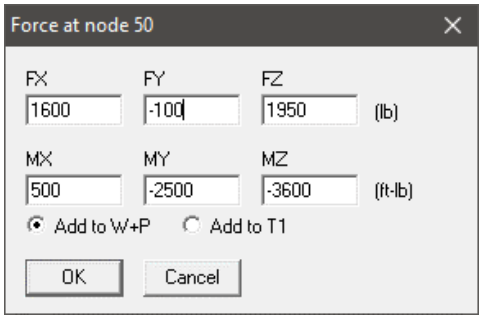
For CAEPIPE to determine the nozzle properties and their orientation, a pipe spool is added to Pump Suction nozzle and Discharge nozzle with its Nominal Size (NS) and Thickness defined as given below.

1. Pipe Spool at Suction Nozzle = 10” NS Pipe with STD Schedule
2. Pipe Spool at Discharge Nozzle = 8” NS Pipe with STD Schedule

Step 3:

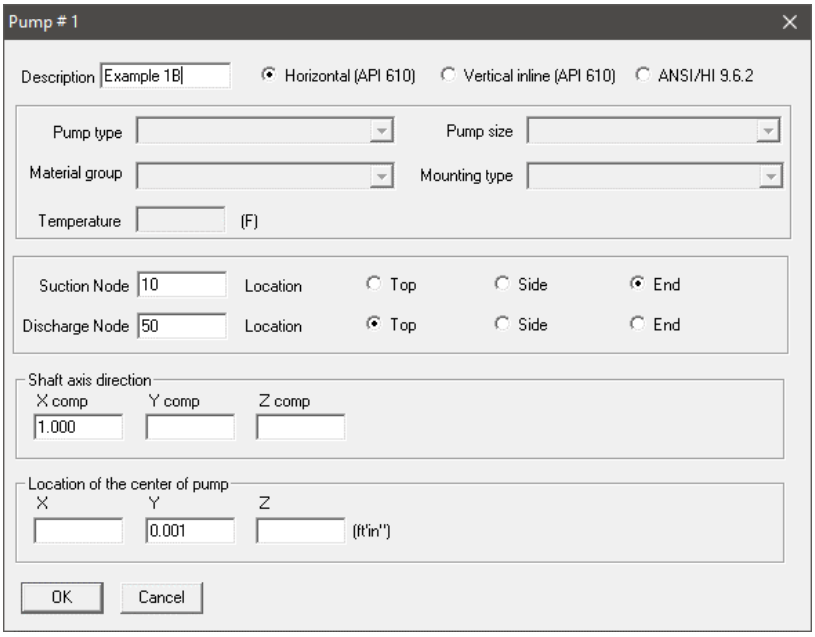
Forces and Moments obtained from separate piping stress analyses at Pump Suction nozzle (Node 10) and Discharge nozzle (Node 50) are applied using the “Force” data type through Layout window > Misc > Data types.



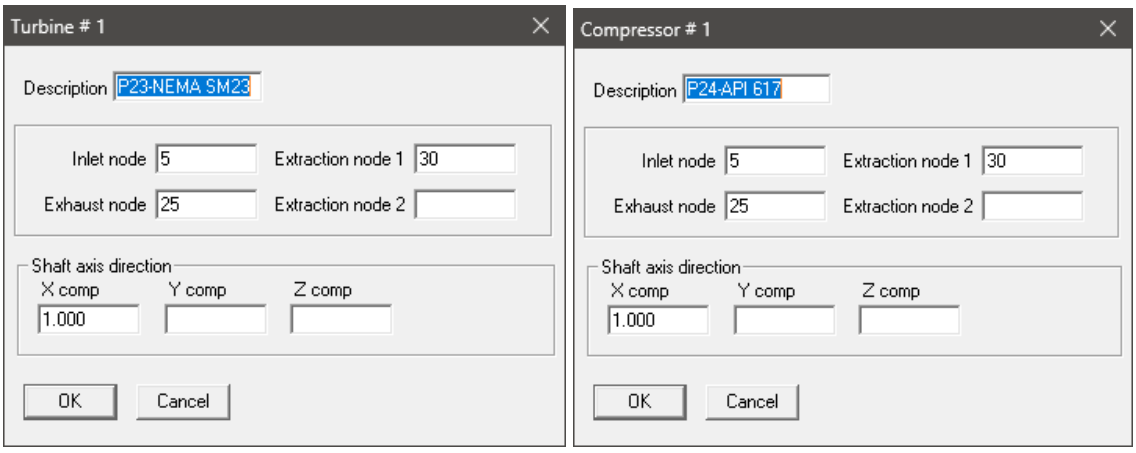


Step 4:

The details of the pump are input (as shown below) in CAEPIPE through Layout window > Misc > Pumps.



In a similar fashion, the details of Turbine/Compressor can be input in CAEPIPE through Layout window > Misc > Turbine/Compressor in their respective mod files. Refer the snap shot shown below for details.

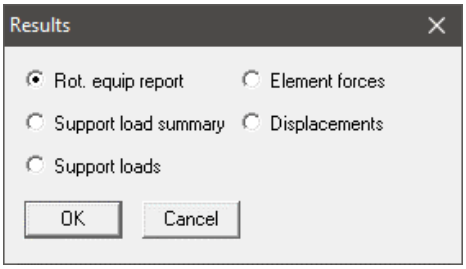


Step 5:

Save the model and perform the analysis through Layout window > File > Analyze. CAEPIPE will perform rotating equipment compliance report along with other load cases defined in the piping system.

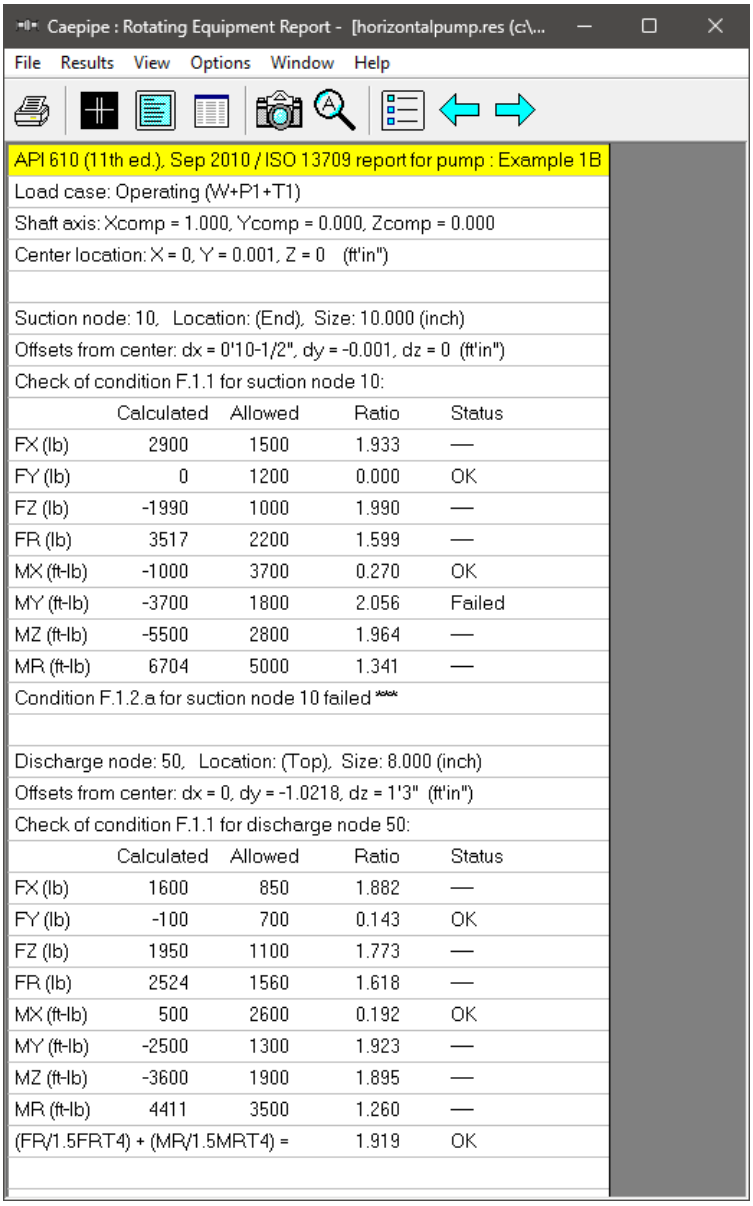
Step 6:

Upon successful analysis, CAEPIPE will now show an option “Rot. equip report” along with other options in results dialog as shown below.



Step 7:

Select the option “Rot. equip report” and press the button “OK” to view the Rotating Equipment Compliance report as shown below.



API 610 (11th ed.), Sep 2010 / ISO 13709 report for pump : Example 1B

Load case: Operating (W+P1+T1)

Shaft axis: Xcomp = 1.000, Ycomp = 0.000, Zcomp = 0.000

Center location: X = 0, Y = 0.001, Z = 0 (ft'in")

Suction node: 10, Location: (End), Size: 10.000 (inch)

Offsets from center: dx = 0'10-1/2", dy = -0.001, dz = 0 (ft'in")

Check of condition F.1.1 for suction node 10:

	Calculated	Allowed	Ratio	Status
FX (lb)	2900	1500	1.933	—
FY (lb)	0	1200	0.000	OK
FZ (lb)	-1990	1000	1.990	—
FR (lb)	3517	2200	1.599	—
MX (ft-lb)	-1000	3700	0.270	OK
MY (ft-lb)	-3700	1800	2.056	Failed
MZ (ft-lb)	-5500	2800	1.964	—
MR (ft-lb)	6704	5000	1.341	—

Condition F.1.2.a for suction node 10 failed ***

Discharge node: 50, Location: (Top), Size: 8.000 (inch)

Offsets from center: dx = 0, dy = -1.0218, dz = 1'3" (ft'in")

Check of condition F.1.1 for discharge node 50:

	Calculated	Allowed	Ratio	Status
FX (lb)	1600	850	1.882	—
FY (lb)	-100	700	0.143	OK
FZ (lb)	1950	1100	1.773	—
FR (lb)	2524	1560	1.618	—
MX (ft-lb)	500	2600	0.192	OK
MY (ft-lb)	-2500	1300	1.923	—
MZ (ft-lb)	-3600	1900	1.895	—
MR (ft-lb)	4411	3500	1.260	—
(FR/1.5FRT4) + (MR/1.5MRT4) =			1.919	OK

A similar procedure as described above can be followed for producing Compliance report for API 610 - Vertical Pump, ANSI/HI 9.6.2 Rotodynamic Pumps, NEMA SM-23 - Turbine and API 617 - Compressor.

Total of eight (8) sample models are available in different folders (listed below) for the above stated compliances.

1. **API610**: Contains sample models for Horizontal and Vertical pumps as per API 610.
2. **ANSI_HI962**: Contains sample models for Horizontal, Vertical In-line, Vertical Turbine Short Set and Axial Split pumps as per ANSI/HI 9.6.2.
3. **NEMA_SM23**: Contains sample model for Turbine as per NEMA SM-23
4. **API617**: Contains sample model for Compressor as per API 617