Tutorial on Qualification of Nozzles attached to Spherical/Cylindrical Vessels using CAEPIPE

The following are the steps for qualifying nozzles welded to Spherical/Cylindrical Vessels such as pressure vessels, tanks etc. using CAEPIPE.

General

Often pipe stress engineers face difficulties on the following while analyzing any piping system.

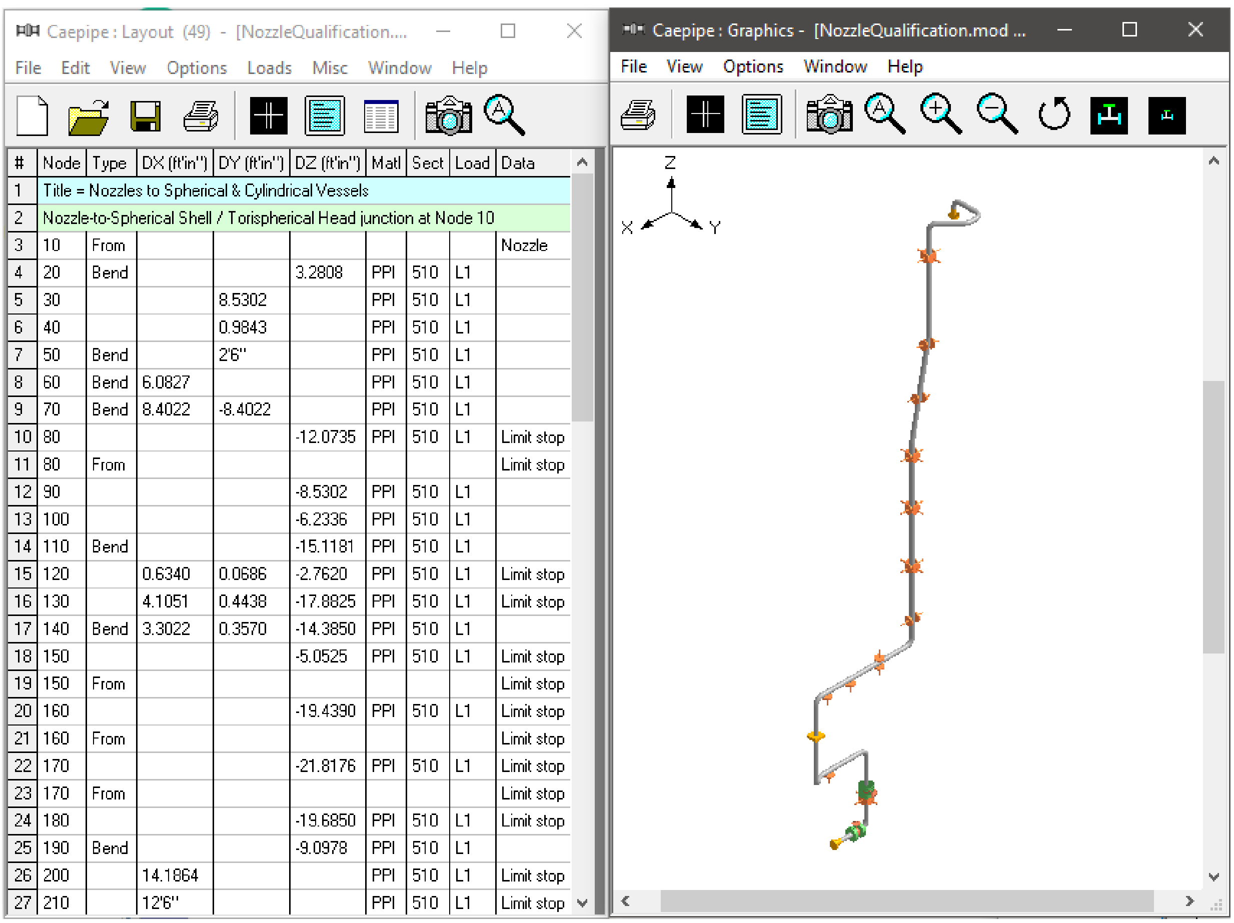
- Obtaining or computing the allowable loads at nozzles attached to Spherical / Cylindrical Vessels and Torispherical Heads, and
- Keeping the external loads imposed by piping on equipment nozzles within allowable limits.

The above difficulties can be overcome in CAEPIPE by

- Using the module "Nozzle Evaluation" for calculating allowable loads at nozzles welded to Spherical / Cylindrical Vessels and Torispherical Heads.
- Incorporating the local shell flexibility at the nozzle-to-shell junctions while carrying out piping stress analysis.

This tutorial provides stepwise procedure for

1. Computing allowable loads on nozzles to Spherical / Cylindrical Vessels and Torispherical Heads,
2. Modeling the nozzle-to-shell junction as "Nozzle" to incorporate local shell flexibility, and
3. Inputting the nozzle allowable loads thus computed into CAEPIPE stress system as "User Defined Allowable" for equipment qualification.



#	Node	Type	DX (ft'in")	DY (ft'in")	DZ (ft'in")	Matl	Sect	Load	Data
1	Title = Nozzles to Spherical & Cylindrical Vessels								
2	Nozzle-to-Spherical Shell / Torispherical Head junction at Node 10								
3	10	From							Nozzle
4	20	Bend			3.2808	PPI	510	L1	
5	30			8.5302		PPI	510	L1	
6	40			0.9843		PPI	510	L1	
7	50	Bend		2'6"		PPI	510	L1	
8	60	Bend	6.0827			PPI	510	L1	
9	70	Bend	8.4022	-8.4022		PPI	510	L1	
10	80				-12.0735	PPI	510	L1	Limit stop
11	80	From							Limit stop
12	90				-8.5302	PPI	510	L1	
13	100				-6.2336	PPI	510	L1	
14	110	Bend			-15.1181	PPI	510	L1	
15	120		0.6340	0.0686	-2.7620	PPI	510	L1	Limit stop
16	130		4.1051	0.4438	-17.8825	PPI	510	L1	Limit stop
17	140	Bend	3.3022	0.3570	-14.3850	PPI	510	L1	
18	150				-5.0525	PPI	510	L1	Limit stop
19	150	From							Limit stop
20	160				-19.4390	PPI	510	L1	Limit stop
21	160	From							Limit stop
22	170				-21.8176	PPI	510	L1	Limit stop
23	170	From							Limit stop
24	180				-19.6850	PPI	510	L1	Limit stop
25	190	Bend			-9.0978	PPI	510	L1	
26	200		14.1864			PPI	510	L1	Limit stop
27	210		12'6"			PPI	510	L1	Limit stop

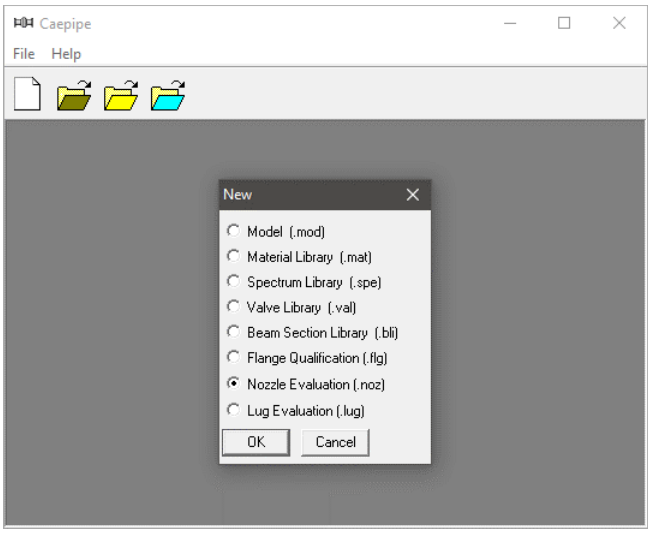
Step 1:

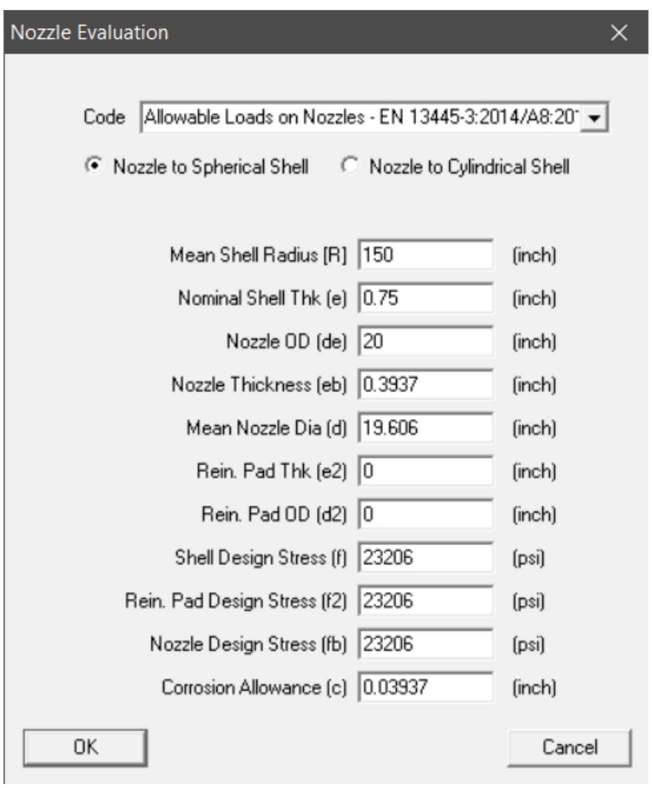
From the attached model (snap shot shown above), assume the following.

1. Node 10 is the intersection of a Nozzle to a Spherical Shell / Torispherical Head of a vessel.
2. Node 420 is the intersection of a side Nozzle to a Cylindrical Vessel.

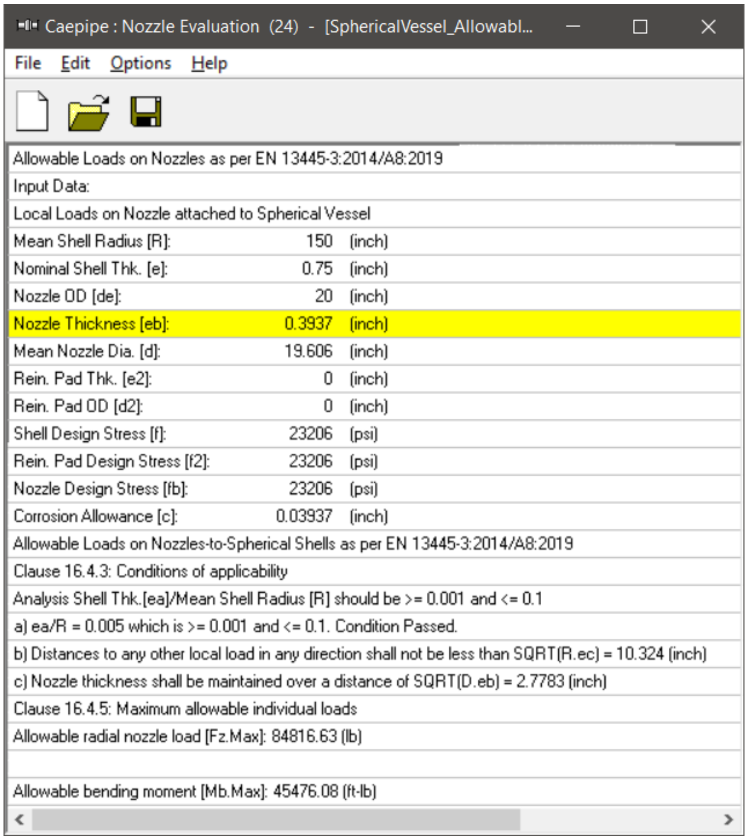
Step 2:

From the equipment drawings provided by the manufacturer for Spherical Shell / Torispherical Head, the following properties are entered into "Nozzle Evaluation" module of CAEPIPE through Main Frame > New > Nozzle Evaluation.

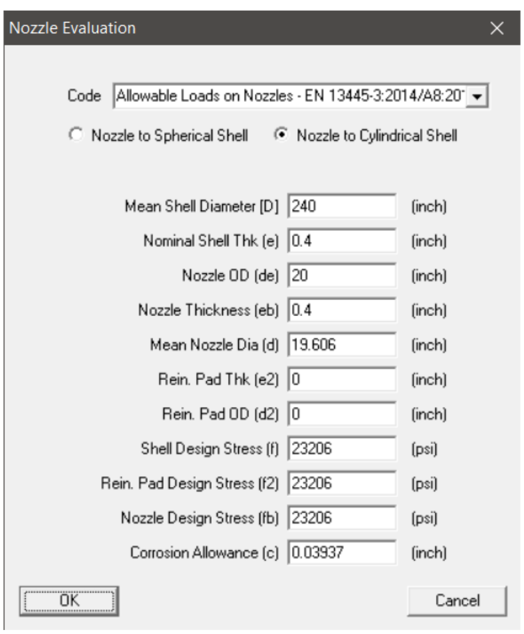




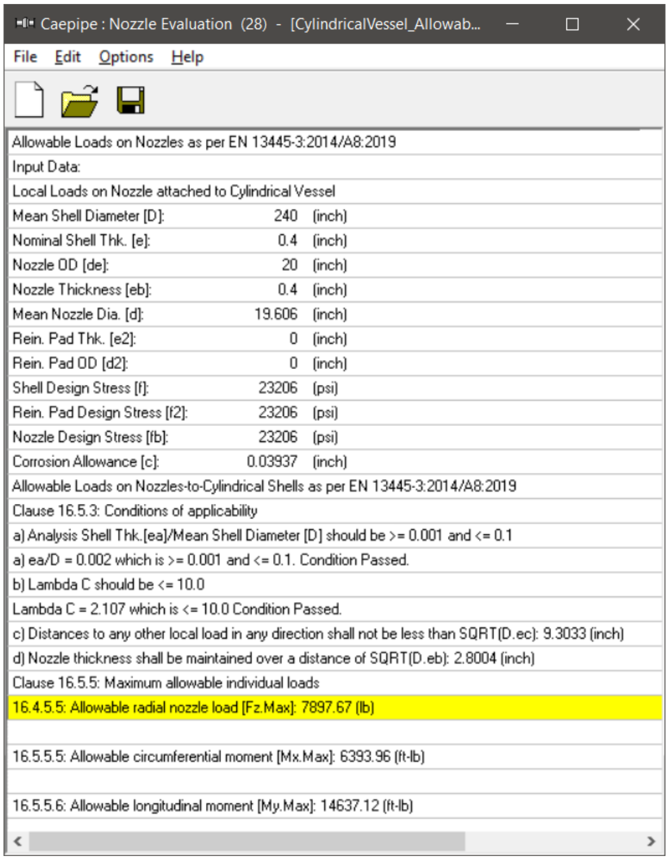
After entering the details, press the button “OK”, save the model and perform the analysis through File > Analyze. This computes the allowable radial nozzle load as well as the allowable bending moment on nozzle welded to Spherical Shell. See snap shot below for details.



In a similar fashion, from the equipment drawings provided by the manufacturer for Cylindrical Vessel, the following properties are entered into “Nozzle Evaluation” module of CAEPIPE through Main Frame > New > Nozzle Allowable Loads.



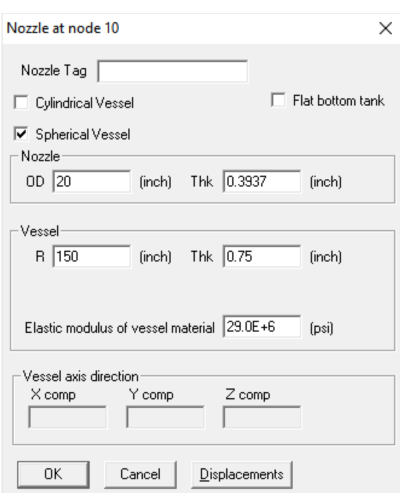
After entering the details, press the button “OK”, save the model and perform the analysis through File > Analyze. This computes the allowable radial nozzle load as well as the allowable bending moments in the circumferential and longitudinal directions as shown below.



For both types of nozzles, the allowable loads in the two shear directions and in the torsional direction can be assumed to be very much larger than the corresponding allowable for the radial load and bending moment directions, as the shell is very stiff in those directions.

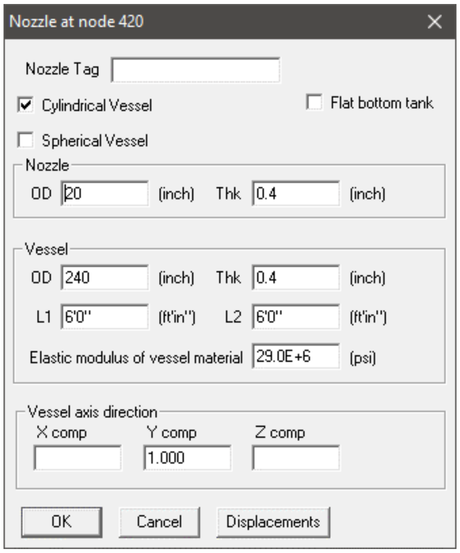
Step 3:

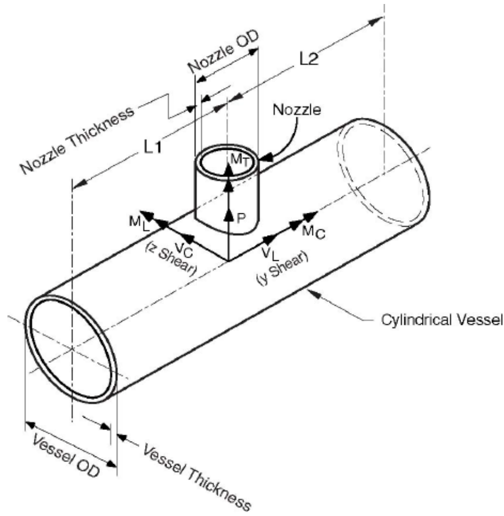
Enter the data type of Node 10 as “Nozzle” and input the properties as shown below.



Step 4:

Similarly, enter the data type of Node 420 as “Nozzle” and input the properties as shown below.

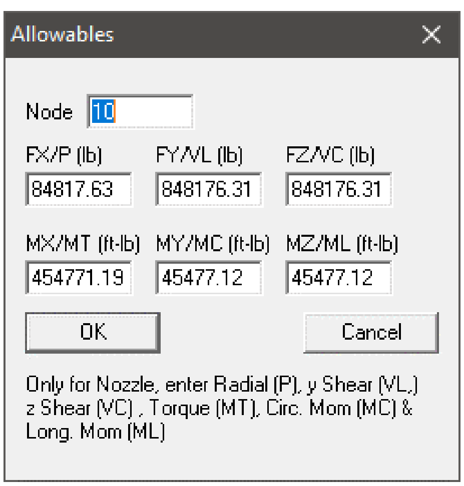


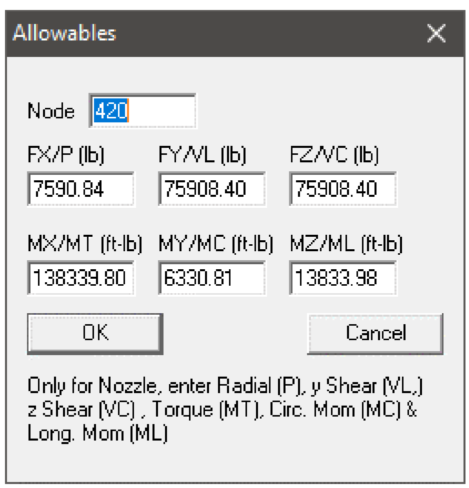


From the snap shot shown above, Lengths L1 and L2 on either side of the nozzle, which are the distances from the nozzle center line to the nearest location on vessel where the "ovalization deformation" of the vessel is stopped such as at a stiffener on the inner or outer surface of the vessel, or at 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.

Step 5:

Input the allowable loads on the two Nozzles computed in Step 2 above in CAEPIPE through Layout window > Misc > User Allowables.

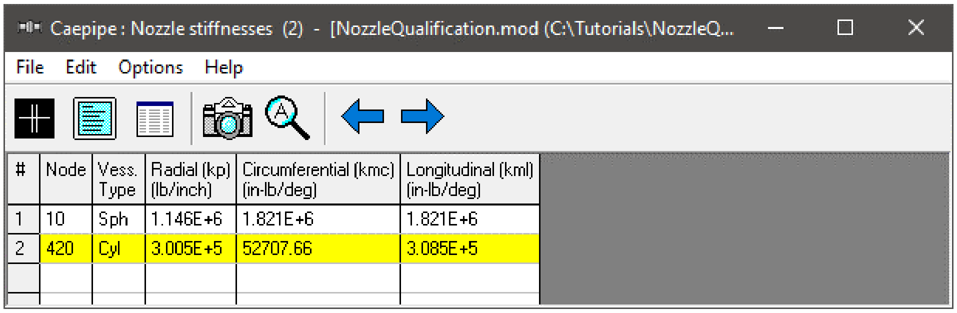




The allowable loads for the two shear and torsional directions are assumed to be ten (10) times the corresponding allowables for the radial and bending directions.

Step 6:

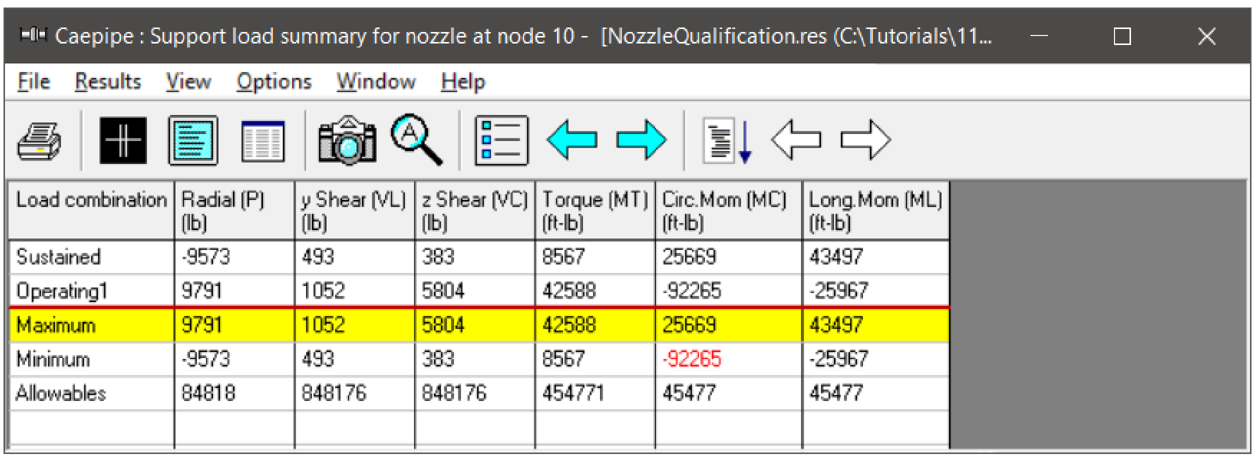
Save the model and perform the analysis through Layout window > File > Analyze. CAEPIPE will include in the pipe stress analysis the local shell stiffnesses internally computed at both nozzle-to-spherical and nozzle-to-cylindrical shell junctions. These local shell stiffnesses can be seen in CAEPIPE through Layout window > View > List > Nozzle stiffnesses.



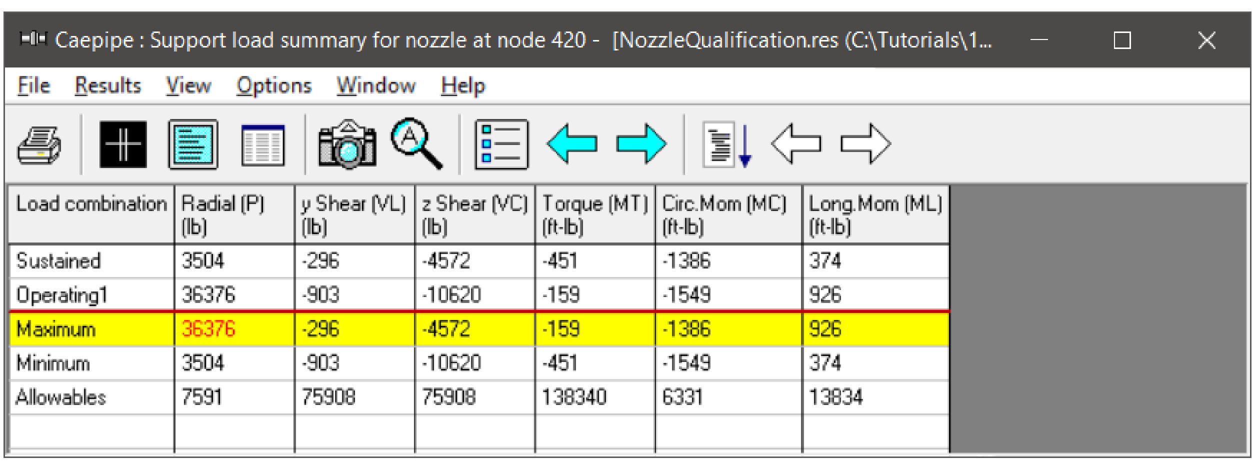
#	Node	Vess. Type	Radial (kp) (lb/inch)	Circumferential (kmc) (in-lb/deg)	Longitudinal (kml) (in-lb/deg)
1	10	Sph	1.146E+6	1.821E+6	1.821E+6
2	420	Cyl	3.005E+5	52707.66	3.085E+5

Step 7:

Upon successful analysis, from the “Support load summary” results, it is to be noted that the CAEPIPE has included the “User Allowables” entered in the stress system for equipment qualification as shown below.



Load combination	Radial (P) (lb)	y Shear (VL) (lb)	z Shear (VC) (lb)	Torque (MT) (ft-lb)	Circ.Mom (MC) (ft-lb)	Long.Mom (ML) (ft-lb)
Sustained	-9573	493	383	8567	25669	43497
Operating1	9791	1052	5804	42588	-92265	-25967
Maximum	9791	1052	5804	42588	25669	43497
Minimum	-9573	493	383	8567	-92265	-25967
Allowables	84818	848176	848176	454771	45477	45477



Load combination	Radial (P) (lb)	y Shear (VL) (lb)	z Shear (VC) (lb)	Torque (MT) (ft-lb)	Circ.Mom (MC) (ft-lb)	Long.Mom (ML) (ft-lb)
Sustained	3504	-296	-4572	-451	-1386	374
Operating1	36376	-903	-10620	-159	-1549	926
Maximum	36376	-296	-4572	-159	-1386	926
Minimum	3504	-903	-10620	-451	-1549	374
Allowables	7591	75908	75908	138340	6331	13834