

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 Allowable Loads” 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.

The screenshot displays the CAEPIPE software interface. On the left, a table lists the piping system components. On the right, a 3D wireframe model of the piping system is shown, including a vertical riser with several tees and a horizontal section at the bottom.

#	Node	Type	DX (ft/in)	DY (ft/in)	DZ (ft/in)	Matl	Sect	Load	Date	
1	Title = Nozzles to Spherical & Cylindrical Vessels									
2	Nozzle-to-Spherical Shell / Torispherical Head junction at Node 10									
3	10	From			3.2808	FPI	510	L1	Nozzle	
4	20	Bend				FPI	510	L1		
5	30			8.5302		FPI	510	L1		
6	40			0.9843		FPI	510	L1		
7	50	Bend			2'6"	FPI	510	L1		
8	60	Bend	6.0827			FPI	510	L1		
9	70	Bend	8.4022	-8.4022		FPI	510	L1		
10	80				-12.0735	FPI	510	L1	Limit stop	
11	80	From							Limit stop	
12	90				-8.5302	FPI	510	L1	Reinf tee	
13	100				-6.2336	FPI	510	L1		
14	110	Bend			-15.1181	FPI	510	L1		
15	120		0.6340	0.0686	-2.7620	FPI	510	L1	Limit stop	
16	130		4.1051	0.4438	-17.8825	FPI	510	L1	Limit stop	
17	140	Bend	3.3022	0.3570	-14.3850	FPI	510	L1		
18	150				-5.0525	FPI	510	L1	Limit stop	
19	150	From							Limit stop	
20	160				-19.4390	FPI	510	L1	Limit stop	
21	160	From							Limit stop	
22	170				-21.8176	FPI	510	L1	Limit stop	
23	170	From							Limit stop	
24	180				-19.6850	FPI	510	L1	Limit stop	
25	190	Bend			-9.0978	FPI	510	L1		
26	200		14.1864			FPI	510	L1	Limit stop	
27	210			12'6"		FPI	510	L1	Limit stop	
28	220		9.8425			FPI	510	L1	Limit stop	
29	230	Bend	4.9213			FPI	510	L1		
30	240				-13.8681	FPI	510	L1	Anchor	
31	250				-18.6253	FPI	510	L1		
32	260	Bend	-4.9180	-2.8412		FPI	510	L1		
33	270			-3.7762		FPI	510	L1	Limit stop	
34	280	Bend	-15.9121			FPI	510	L1		
35	290				-13.5679	FPI	510	L1	Flange	
36	300	Valve			-2.6411	FPI	510	L1	Flange	
37	310				-1.9472	FPI	510	L1	Limit stop	
38	310	From							Limit stop	
39	320				-5.4626	FPI	510	L1		
40	330				-1'3"	FPI	512	L1	Welding tee	

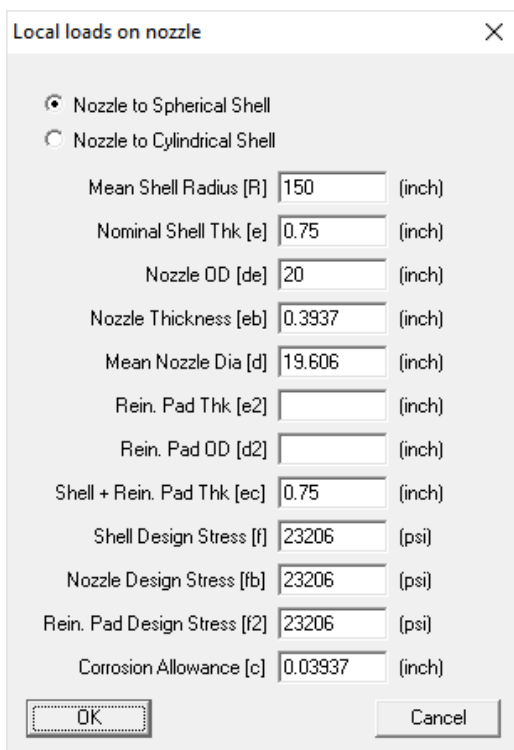
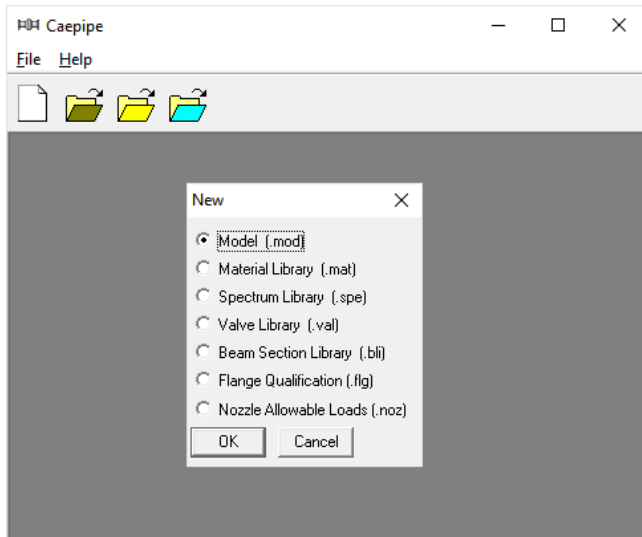
Step 1:

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

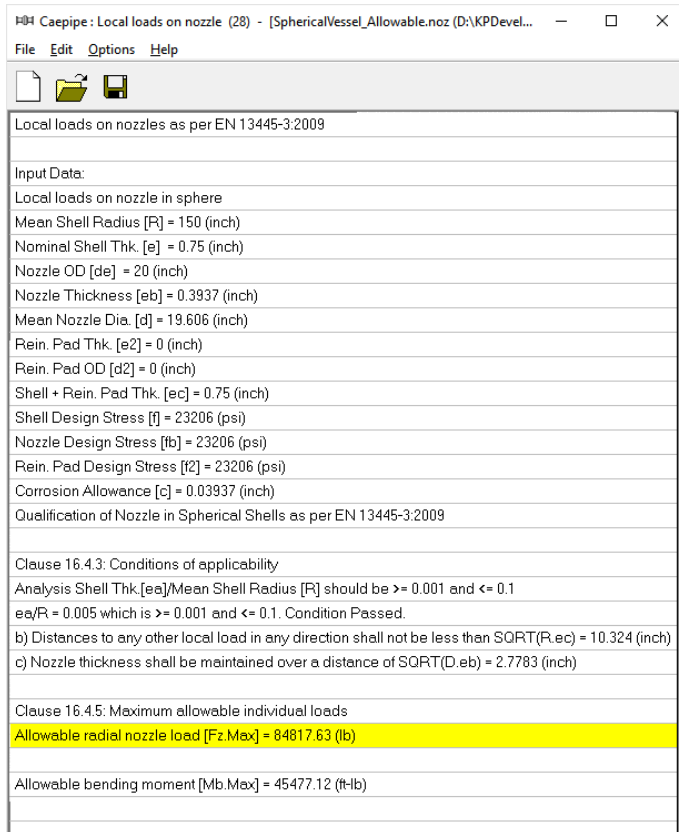
1. Node 10 is the intersection of a Nozzle to a Spherical Shell / Torispherical Head of a vessel.
2. Node 420 is the intersection of a side Nozzle to a Cylindrical Vessel.

Step 2:

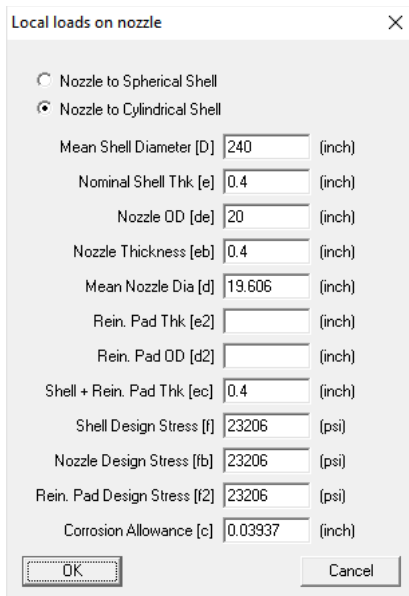
From the equipment drawings provided by the manufacturer for Spherical Shell / Torispherical Head, the following properties are entered into “Nozzle Allowable Loads” module of CAEPIPE through Main Frame > New > Nozzle Allowable Loads.



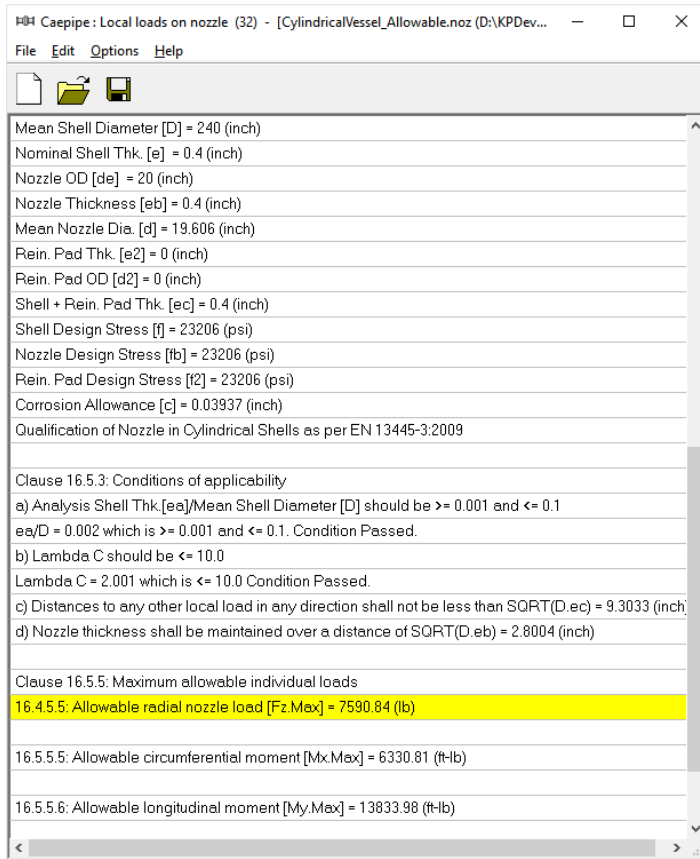
After entering the details, press the button “OK”, save the model and perform the analysis through File > Analyze. This computes the allowable radial nozzle load as well as the allowable bending moment on nozzle welded to Spherical Shell. See snap shot below for details.



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



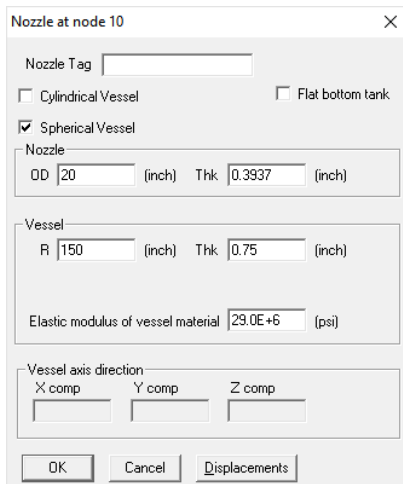
After entering the details, press the button “OK”, save the model and perform the analysis through File > Analyze. This computes the allowable radial nozzle load as well as the allowable bending moments in the circumferential and longitudinal directions as shown below.



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.

Nozzle at node 420

Nozzle Tag

Cylindrical Vessel Flat bottom tank

Spherical Vessel

Nozzle

OD (inch) Thk (inch)

Vessel

OD (inch) Thk (inch)

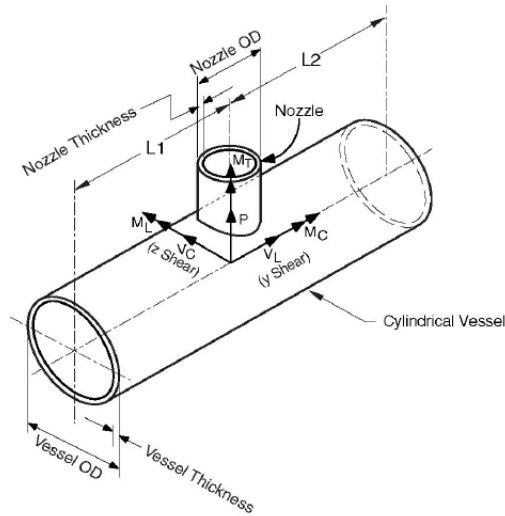
L1 (ft'in") L2 (ft'in")

Elastic modulus of vessel material (psi)

Vessel axis direction

X comp Y comp Z comp

OK Cancel Displacements



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.

Allowables

Node

FX/P (lb)	FY/ML (lb)	FZ/VC (lb)
<input type="text" value="84817.63"/>	<input type="text" value="848176.31"/>	<input type="text" value="848176.31"/>
MX/MT	MY/MC	MZ/ML
<input type="text" value="454771.19"/>	<input type="text" value="45477.12"/>	<input type="text" value="45477.12"/>

OK Cancel

Only for Nozzle, enter Radial (P), y Shear (VL), z Shear (VC), Torque (MT), Circ. Mom (MC) & Long. Mom (ML)

Allowables

Node

FX/P (lb)	FY/ML (lb)	FZ/VC (lb)
<input type="text" value="7590.84"/>	<input type="text" value="75908.40"/>	<input type="text" value="75908.40"/>
MX/MT	MY/MC	MZ/ML
<input type="text" value="138339.80"/>	<input type="text" value="6330.81"/>	<input type="text" value="13833.98"/>

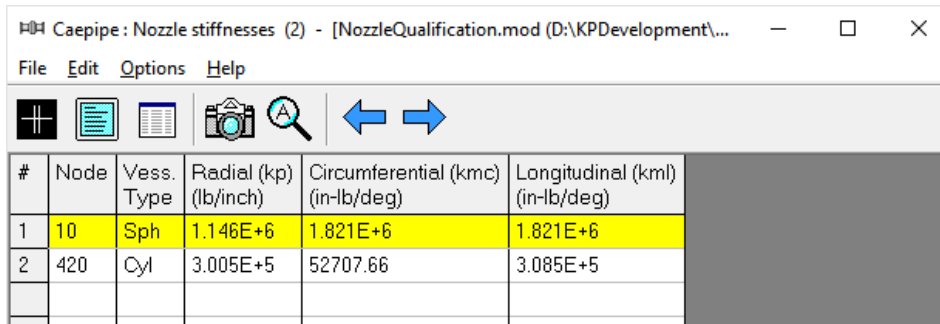
OK Cancel

Only for Nozzle, enter Radial (P), y Shear (VL), z Shear (VC), Torque (MT), Circ. Mom (MC) & Long. Mom (ML)

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.

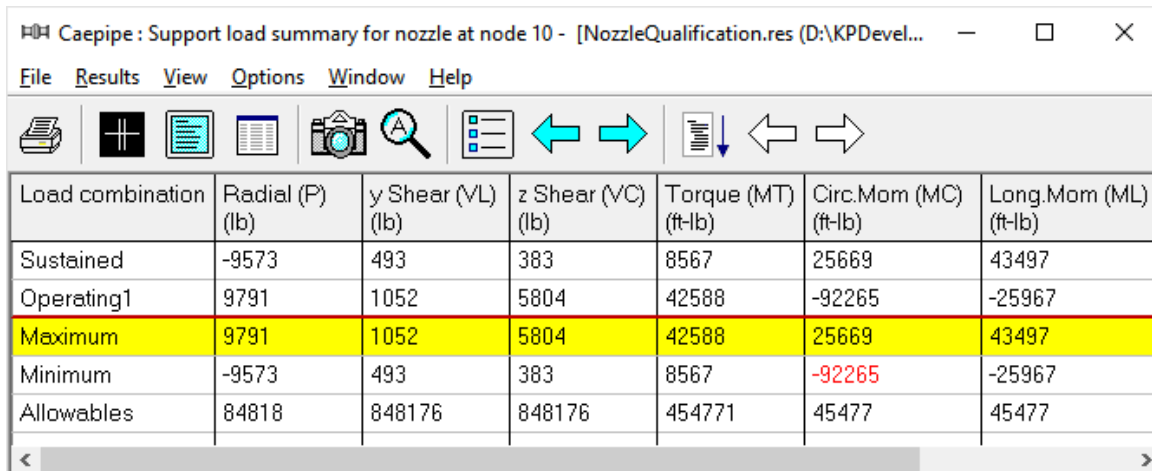


Caepipe : Nozzle stiffnesses (2) - [NozzleQualification.mod (D:\KPDevelopment\...]

#	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

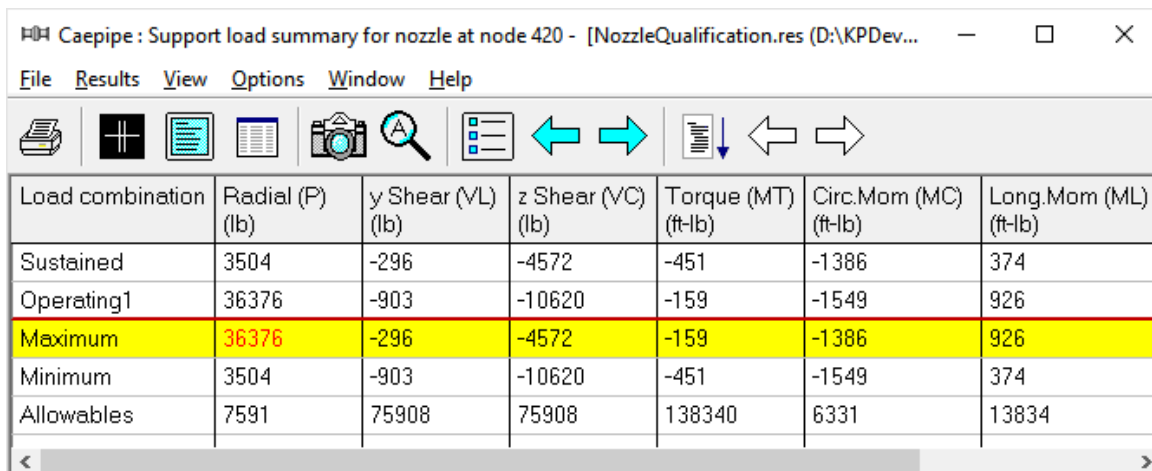
Step 7:

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.



Caepipe : Support load summary for nozzle at node 10 - [NozzleQualification.res (D:\KPDevel...]

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



Caepipe : Support load summary for nozzle at node 420 - [NozzleQualification.res (D:\KPDev...]

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