FE107

If you can run a WRC analysis, you can run this FEA analysis.

What is FE107?

By Vessel Engineers for Vessel Engineers

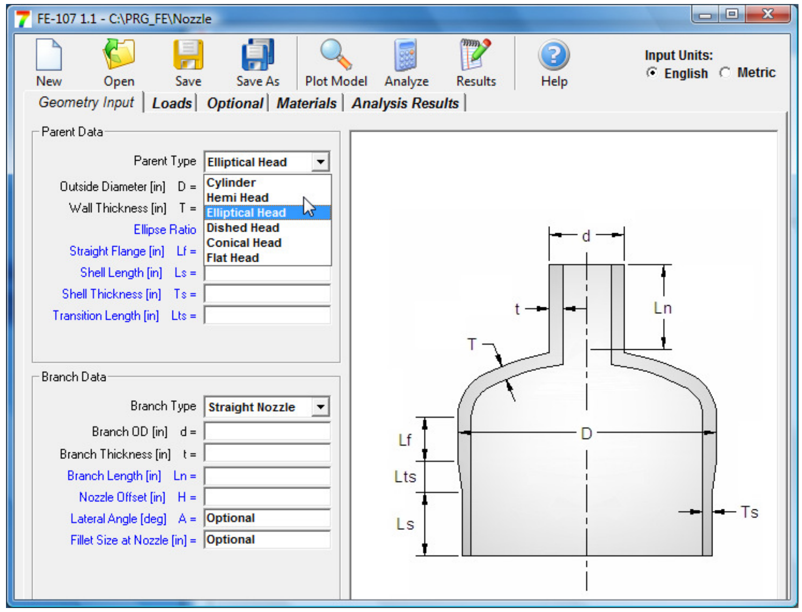
FE107 uses finite element technology to provide stress analysis of nozzle connections on piping and pressure vessels.

FE107 replaces WRC 107 as a calculation tool that can be applied when WRC 107 or WRC 297 correlations or assumptions are limited.

FE107 output is compared directly to WRC 107 and WRC 297 results for comparison. Users can quickly see how finite element methods produce consistent, conservative results for a wide variety of geometries and parameter ranges.

FE107 users don't have to worry about their programs limits of application. If the high stress is in the nozzle – no problem. If the high stress is at the edge of a hillside teardrop repad – no problem, FE107 builds and analyzes this model quickly and easily.

Worried about nozzles in cones, dished heads, or knuckle regions? FE107 lets the user select any of these geometries from its pulldown geometry menu.



Input is FAST and EASY…

ASME Section VIII Division 2 allowables are printed along with flexibilities and allowable loads for forces, moments and pressure.

Are you still using WRC 107 and WRC 297 for design?

WRC 107 and WRC 297 are good resources so long as users are aware of their very significant limitations. While allowable stresses get higher and higher the permissible error on calculated stresses gets lower and lower. It may have been acceptable in the past to introduce stress errors of two or more into calculations, but modern results and allowables are expected to have more reasonable accuracies available only with a finite element solution. WRC 107 is based on the analytical treatment of point loads and rectangular loading surfaces on cylinders. WRC 297 attempted to include the nozzle opening and thickness, but ended up with a calculation that is often grossly in excess. Fundamental limitations of both WRC documents are given in the table below.

Generally, WRC 107 comparisons to FEA results are reasonable when thin shells are analyzed ***AND*** when the model is within the accepted parameters of WRC 107 ***AND*** when the high stress is in the shell ***AND*** when there are no loads through the run, ***AND*** when pressure is not significant.

WRC 297 comparisons in the vessel or header are also reasonable, but tend to become overly conservative when the high stress moves into the branch or nozzle, typically when the t/T ratio becomes less than 1.0 or when a reinforcing pad is used at the intersection.

WRC 107 is often less conservative than finite element results, but parallel FEA calculations through d/D of up to 0.8, where the WRC 107 and FEA curves cross. WRC 107 results becoming much more conservative beyond this range, where the approach used outside of WRC curve parameters is "last curve value."

WRC 107 and 297 have known parameter and geometry limitations. For example, a WRC107 cylinder-to-cylinder analysis does not calculate stress in the nozzle. When t/T < 1, or when a repad is placed on the intersection, the high stress is often in the nozzle and is completely missed in a WRC 107 analysis. **FE107 is applicable to all parameter ranges including laterals, hillsides, repads and barrel-type nozzles.**

The following list summarizes areas where WRC 107 and WRC 297 are considered weak, or where there is good justification for FEA calculations.

- $d/D > 0.5$
- $t/T < 1.0$
- $(d/D)(D/T)^{0.5} < 2$
- Pad reinforced nozzles
- Hillsides or Laterals
- Area replacement rules for pressure are barely satisfied and large diameter divided by thickness ration (D/T).
- The number of Thermal or Pressure cycles is greater than 5000.
- Design and operating conditions are approximately the same and calculated stresses are within 85% of the allowable.
- The Piping attached to the nozzle is long, flexible, and somewhat unrestrained.

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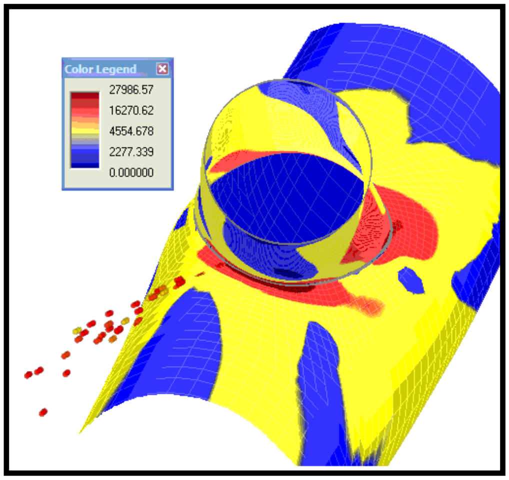
Branch or Nozzle

- Straight (Unreinforced)
- Pad reinforced
- Barrel reinforced (Self-reinforced)

Header or Vessel

- Conical head
- Cylindrical shell
- Elliptical head
- Flat head
- Flanged and dished
- Hemispherical head



Animated Graphical Output…

FEA Stress | Allowables | Flexibilities | FEA vs. WRC | WRC 107 | WRC 297

	Location	ASME Category	Stress	Allowable Stress	% Allowed	3D Plot
1	Header away from Junction	Pl+Pb < 1.5(k)Smh [Pb=0]	19,901.86	30,000.0	66	Plot...
2	Header Next to Nozzle Weld	Pl+Pb < 1.5(k)Smh [Pb=0]	18,061.09	30,000.0	60	Plot...
3	Branch Transition	Pl+Pb < 1.5(k)Smh [Pb=0]	5,717.0	30,000.0	19	Plot...
4	Branch Next to Header Weld	Pl+Pb < 1.5(k)Smh [Pb=0]	17,405.0	30,000.0	58	Plot...
5	Branch away from Junction	Pl+Pb < 1.5(k)Smh [Pb=0]	10,572.92	30,000.0	35	Plot...
6						
7	Header away from Junction	Pl+Pb+Q < 3(k)Smavg	36,927.97	60,000.0	62	Plot...
8	Header Next to Nozzle Weld	Pl+Pb+Q < 3(k)Smavg	56,929.35	60,000.0	95	Plot...
9	Branch Transition	Pl+Pb+Q < 3(k)Smavg	51,144.55	60,000.0	85	Plot...
						ot...
						ot...

FEA Stress | Allowables | Flexibilities | FEA vs. WRC | WRC 107 | WRC 297

The following are the allowable loads which can be applied to the geometry.

	Maximum Individual Occurring	Conservative Simultaneous Occurring	Realistic Simultaneous Occurring
SECONDARY ALLOWABLES			
Axial Force [lb]	309662.90	34744.67	52117.00
In-Plane Moment [ft-lb]	6885981.00	678434.70	1439177.00
Out-of-Plane Moment [ft-lb]	4808190.00	477694.90	1013344.00
Torsional Moment [ft-lb]	4697	0060.30	990090.50

FEA vs. WRC

A comparison between the maximum ASME Code stresses according to FEA, WRC-107, and WRC-297 are table. WRC-107 and WRC-297 results may be subject to error depending on the geometric parameters use More meaningful comparisons are made using the stress indices (see below).

Location	Stress Category	FEA [psi]	WRC 107 [psi]	WRC 297 [psi]	Allowable [psi]
Nozzle	Max PL	21075	N.A.	5077	30000
Nozzle	Max PL+Pb+Q	62809	N.A.	5077	60000
Nozzle	Max PL+Pb+Q+F	7865	N.A.	5077	Varies
Shell or pad	Max PL	22134	31502	32235	30000
Shell or pad	Max PL+Pb+Q	75843	104066	146230	60000
Shell or pad	Max PL+Pb+Q+F	75843	104067	146230	Varies

Easy to Read and Interpret Reports…

Correlates to Real-World Tests…