FE107 - for Vessel Engineers

FE107 uses finite element technology to provide stress analysis of nozzle connections on piping and pressure vessel. FE107 replaces WRC 107 as a calculation tool that can be applied when WRC 107 correlational methods are limited. FE107 is useful for piping and pressure vessel engineers and designers.

FE107 can be applied to a wide range of geometries.

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

WRC 107 and WRC 297 - problems discussed

WRC 107 and WRC 297 are very good documents for engineering practice. It is based on an analytical treatment of openings in cylindrical shell and hemispherical heads. This said, there are fundamental assumptions in WRC 107 and correlations that are used in the correlations that limit the application of WRC 107 in industrial applications. Commonly, computer programs do not provide warnings or guidance when the limitations are violated.

In general WRC 107 comparisons to FE/Pipe results are excellent when thin shells are analyzed and when the model is within the accepted parameters of WRC 107. Nozzles in the centers of heads are evaluated most accurately. Most WRC 107 programs give the stress intensity at four points around the nozzle on both the inside and outside of the geometry. This stress is usually compared to 3Sm (Sm is the average of the hot and cold allowable stress) and is caused by all operating loads on the nozzle. The resulting stresses from a WRC 107 run of this type should be compared to the Pl+Pb+Q stresses from the finite element calculation. Note that Pl stresses evaluated in accordance with ASME Section VIII Division 2 are membrane stresses. These are the average stresses through the thickness and do not include the bending stress component at the junction. (See ASME Section VIII Division 2 Appendix 4 Table 4-120.1.)

WRC 297 comparisons in the vessel or header tend to be good but become overly conservative when the high stress moves into the branch when the t/T ratio becomes less than 1.0. This result is certainly demonstrated in the finite element calculation.

WRC 107 tends to be somewhat less conservative than finite element results, but that WRC 107 results parallel FE calculations through d/D ranges of 0.1 to 0.8, where the WRC and Finite element curves cross, the WRC 107 results becoming much more conservative beyond this range. (When the approach used outside of WRC curve parameters is “last curve value.”)

The following list summarizes areas where WRC 107 and WRC 297 are considered weak, or where there is cause for concern.

- d/D > 0.5
- t/T > 1.0
- Pad reinforced nozzles
- Hillsides or laterals
- Area replacement rules for pressure are barely satisfied and large diameter divided by thickness ration (D/T).
- Temperatures are approaching the creep regime.
- Cycles are greater than 5000.
- Design and operating conditions are approximately the same.
- The load consists of high-pressure stresses and high loads.
- The Piping attached to the nozzle is long, flexible, and somewhat unrestrained.

MatPRO Integration

FE107 offers tight integration with MatPRO to provide the convenience and reliability of material properties lookup. The PRG database that contains a full set of the 2000, 2002 and 2004 ASME Section II Part D material databases.

FE Viewer

FE107 includes the FE-Viewer utility that allows you to interrogate the finite element analysis calculation so that you better understand the results of the finite element calculations.