PAULIN Research Group

FEPipe v7.0 ● **NozzlePRO** v9.0
Released: September 2014

New Features List

Paulin Research group is proud to announce its newest software release for FEPipe and NozzlePRO.

FEPipe version7.0

NozzlePRO version9.0

FEPipe v7.0 Program Description / Included Modules

FEPipe includes a comprehensive set of standard templates for finite element analysis of piping, pressure vessels and structural support systems. Sophisticated models are built using basic inputs; diameter, length, thickness, loads, etc. Interpretation of the results is simplified via comparison against ASME Section VIII, Div. 2 limits. Advanced analysis options include linear-elastic, plasticity, fitness-for-service, high temperature creep, buckling and harmonic convergence.

FEPipe v7.0 **Standard Shell Templates**:

- Unreinforced Fabricated Tee
- Reinforced Fabricated Tee
- Hillside Tee
- Welding Tee
- Y-Fitting Tee
- Bend with Staunchion (or Beam Supports)
- Tank Settlement
- Low Tank Nozzle
- Shell-To Head Nozzle
- Pipe Supports
- String Modeler (Advanced Template)
- Nozzles/Plates/Shells (Advanced Template)

FEPipe v7.0 **Standard Brick Templates**:

- Unreinforced Fabricated Tee
- Reinforced Fabricated Tee
- Olet Intersection
- Axi-Symmetric Flange Modeler

Additionally, PRG has developed specialized programs which address specific engineering analysis needs. This set of **Added Modules** is included with FEPipev7.0. The **Service Plan Modules** are only included with FEPipe if the client has an active support contract.

FEPipe v7.0 **Added Modules**:

- Standard Templates (shell, brick and axisymmetric)
- NozzlePRO
- MatPRO
- AxiPRO
- 661PRO
- StressPLOT
- PlasTEX

FEPipe v7.0 **Service Plan Modules:**

- FE107
- FESIF
- FETee
- FEBend
- PCL-Gold pipe stress module

NozzlePRO v9.0 Program Description / Included Modules

NozzlePRO offers component analysis capabilities of nozzles, supports or saddles on piping and pressure vessels.

NozzlePRO includes a set of specialized programs which address specific engineering analysis needs. This set of **Added Modules** is included with NozzlePRO v9.0. The **Service Plan Modules** are only included with NozzlePRO if the client has an active support contract.

NozzlePRO v9.0 **Added Modules**:

- NozzlePRO
- MatPRO
- Fitness for Service & NH Reporting

NozzlePRO v9.0 **Service Plan Modules**:

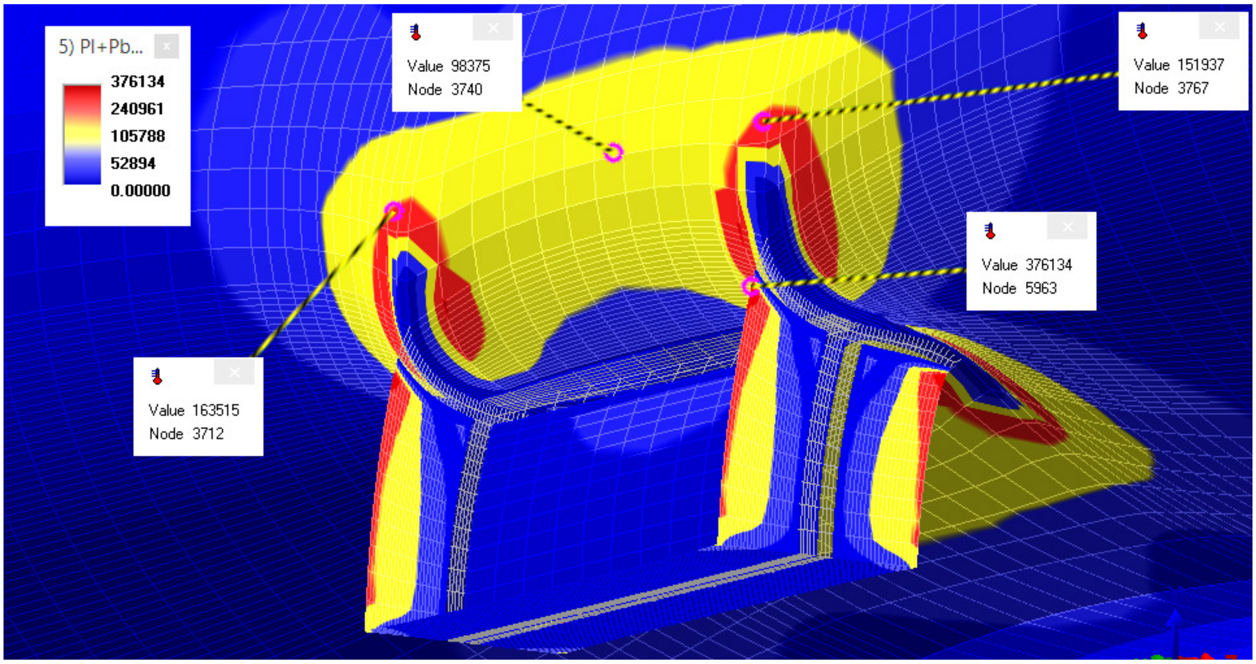
- FE107
- FESIF
- FETee

3D Viewer Tool Updates
FEPipe, NozzlePRO

The 3D Results Viewer has been improved to more easily examine the model.

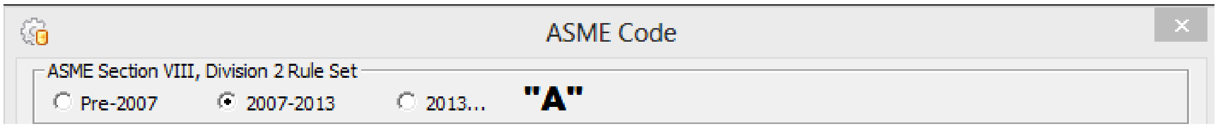
Multiple control panels were added and a striped line that moves to the point on the model where the cursor is located to measure geometric distances. You can select multiple locations and they are included in the display for reporting. Full copy-to-clipboard is supported for pasting into reports. You can inspect displacements, coordinates and contour values with the nearest node.

The sample below illustrates multiple measurement location points for primary plus secondary stresses:



ASME Section VIII, Division 2 – 2013 Edition
FEPipe, NozzlePRO

The 2013 Edition of ASME Section VIII, Division 2 introduced updates to the treatment of occasional loads and allowable stresses. You can select the code version that you want to compare your stress calculations as illustrated below. PRG software also now distinguishes between operating pressure and design pressure for ASME code compliance calculations.



Allowable Loads for Pressure Vessel Saddles

NozzlePRO

Pressure vessel supports must consider the external loads that are transferred in from attached piping. Yet, pressure vessel designers are not privy to the piping design and cannot account for loads that are transferred to the supports. Pipe stress codes offer no guidance for the stress intensification factors and allowable loads on supports. NozzlePRO automatically calculates allowable loads based on local stress analyses so that piping and pressure vessel engineers can more effectively and safely design supports that carry external loads through nozzle attachments. Pressure vessel engineers can calculate allowable loads and stress intensification factors and report to pipe stress engineers for subsequent pipe stress design.

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Allowable Forces and Moments on SHOE/SADDLE Support
       (See notes following the tables.)


*** Minimum Allowable Loads on Support ***

Minimum Allowable (Along Pipe) Axial Force =      44076.  lb.
Minimum Allowable Horizontal Force         =      13908.  lb.
Minimum Allowable Vertical Force           =       5691.  lb.

Minimum Allowable (Along Pipe) Torsion     =      18544.  ft.lb.
Minimum Allowable Vertical Moment          =      81246.  ft.lb.
Minimum Allowable Horizontal Moment        =      58767.  ft.lb.
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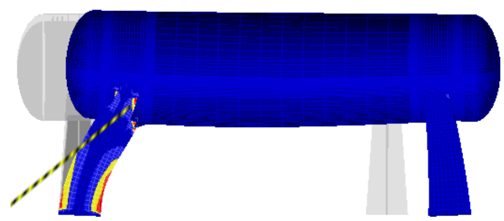
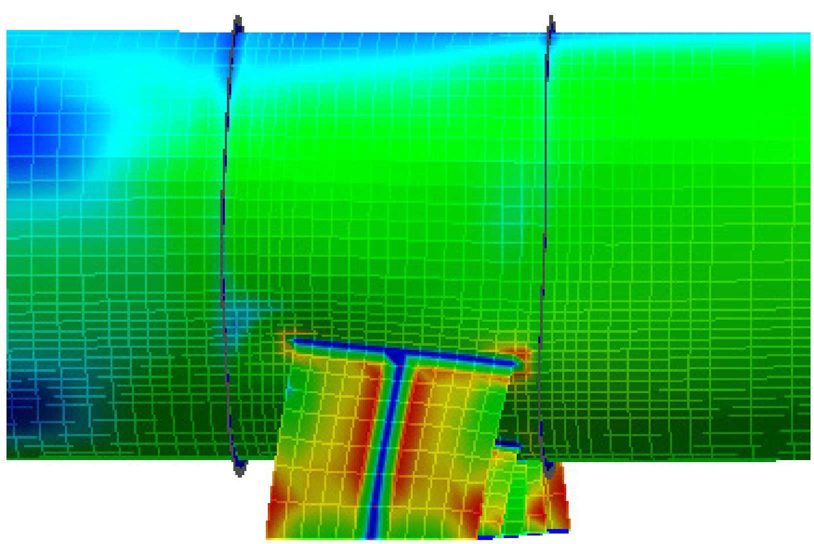


Allowable Loads & SIFs for Pipe Shoes, In-Line Anchors, Guides & Limit Stops

NozzlePRO

NozzlePRO can now be used to calculate SIFs for pipe supports. This offers significant improvement in pipe stress analyses. You can run one set of calculations using shell elements to determine accurate discontinuity stresses and then use the SIFs in your pipe stress calculations to include multiple load cases and nonlinearities.

A sample finite element analysis of a saddle subject to axial loads is illustrated below:



Automated Averaged / Not Averaged Comparison Plots for Shell Solutions

FEPipe, NozzlePRO

The quality of a solution that is based on the finite element method is dependent on the mesh distribution, particularly in critical regions where local discontinuity stresses are highest. A useful validation technique to test for a sufficient mesh is to compare stresses averaged across adjacent nodes against non-averaged stresses. FEPipe and NozzlePRO automatically compare averaged and non-averaged stresses in tabular form that offer a global view of the mesh quality. Further, the discrepancies can be inspected graphically on a nodal basis in case you need to determine where you need to increase the mesh density to improve the convergence.

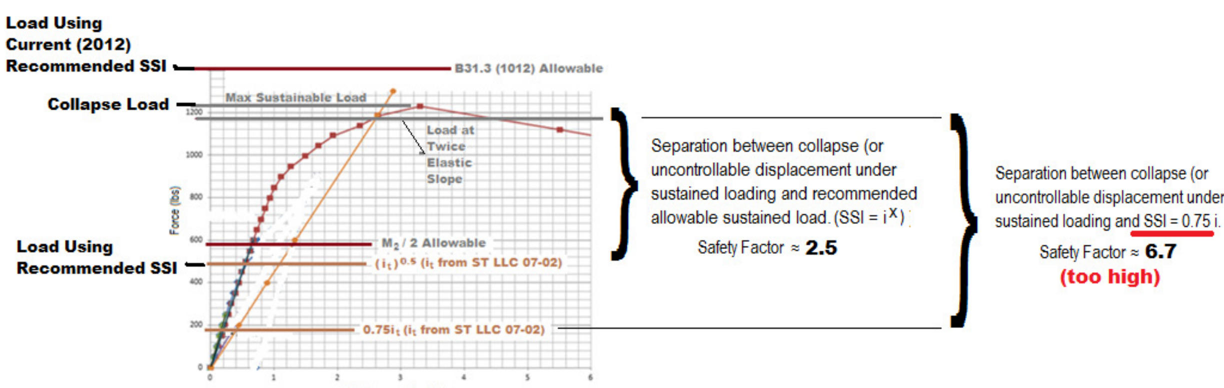
B31.3 Sustained Stress Indices (SSI) for 2010 & 2012 Code

FEPipe, NozzlePRO

Paulin Research Group is actively involved in the research of sustained stress indices (SSI) for ASME B31 code. The research effort is incorporated into FEPipe and NozzlePRO in the SIF reports for intersections.

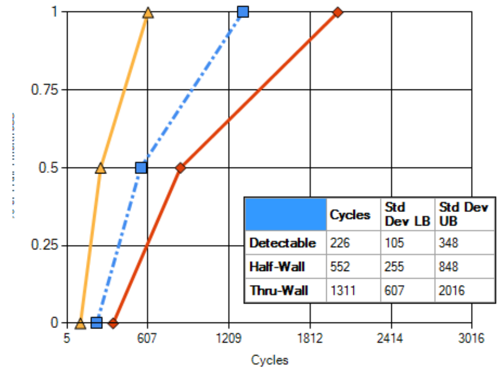
The image to the left shows a thin walled pipe intersection that collapsed below the ASME B31.3 allowable load and the test data for load and displacement.

The image below shows the test data for loads and displacements.



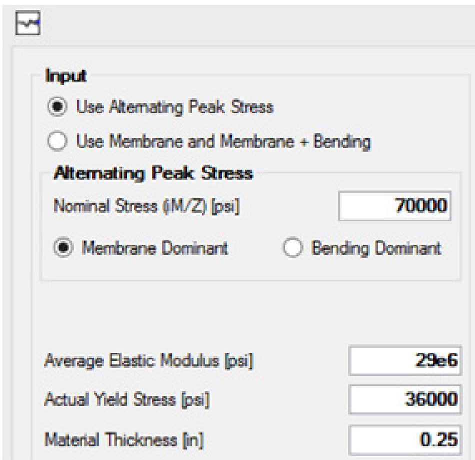
Crack Prediction – Measureable First Crack Calculator

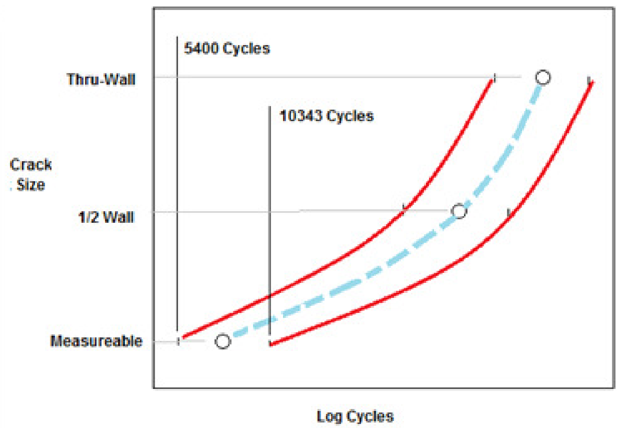
FEPipe, NozzlePRO



Paulin Research Group has recorded the appearance of cracks during cyclical loading tests of piping and pressure vessel components. Crack appearance has been detected through the use of single channel shear wave and phased array flaw detection techniques. A correlation equation has been developed from the test data which predicts thru-wall and first crack appearance cycle counts. The method improves over far field stress methods that tend to be significantly conservative.

Examples input and results are illustrated in the plots given below.

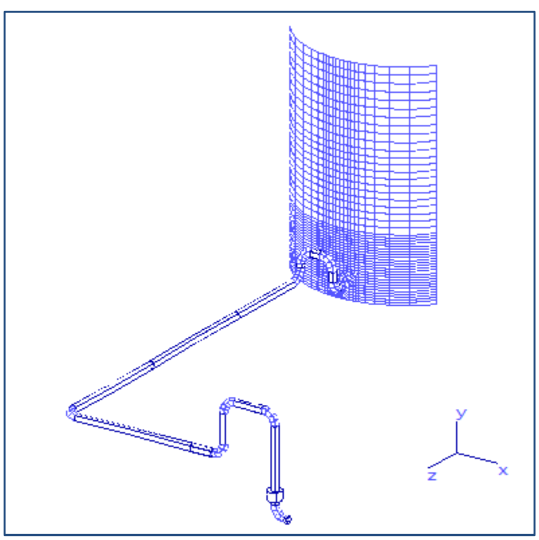




Hillside Nozzle on Tanks

FEPipe

The ***Low Tank Nozzle*** template in FEPipe was updated to include the ability to offset the nozzle in a hillside arrangement.



The template applies a linear tank wall pressure profile as a function of the liquid height.

In the exaggerated displacement plot to the left, you can see the tank wall rotating against the rigid tank floor. The maximum bending is at the tank wall intersection with the floor.

These high bending stresses combine with the discontinuity stresses at the nozzle discontinuity so that finite element analysis offers the most realistic method for calculating the critical stress.

Hot Formed Default Tee Cross Sections

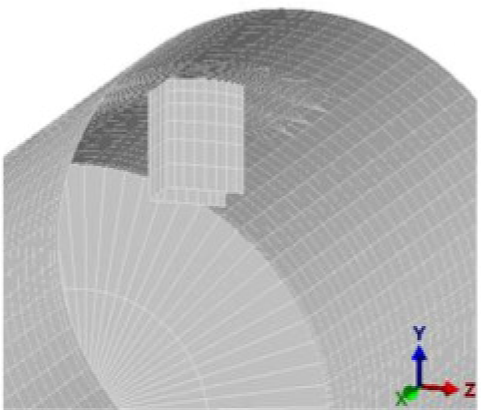
FEPipe

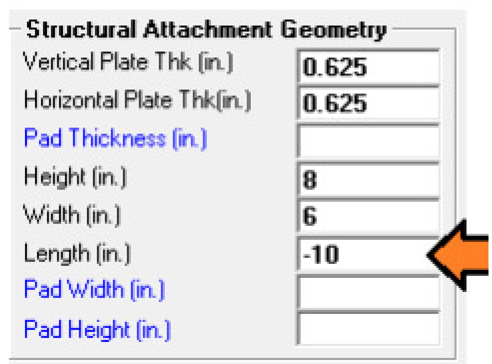
PCL-Gold intersection library was expanded to include hot formed welding tee forged fittings. Hot forming is used for construction materials that are susceptible to cracking during the forming process. The geometries in the library are typical of those that result from manufacturers that form the tees from oversized pipe and then compressed to the appropriate diameters prior to extruding the branch outlet fittings.

Internal Support Clips and Lugs

NozzlePRO

Structural supports can now project into heads and cylindrical shells as illustrated below. Previously, only external projections were supported. These attachments can be used to model supports for reactor beds and internal equipment.

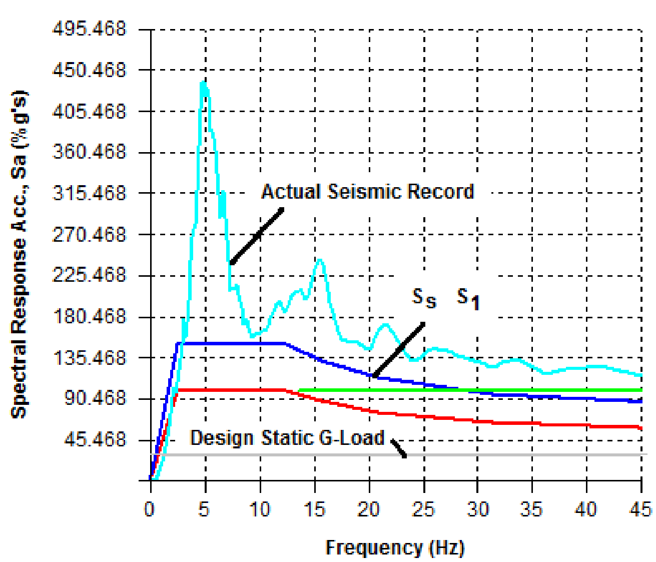




Modal Participation Factors for Seismic Stresses

FEPipe

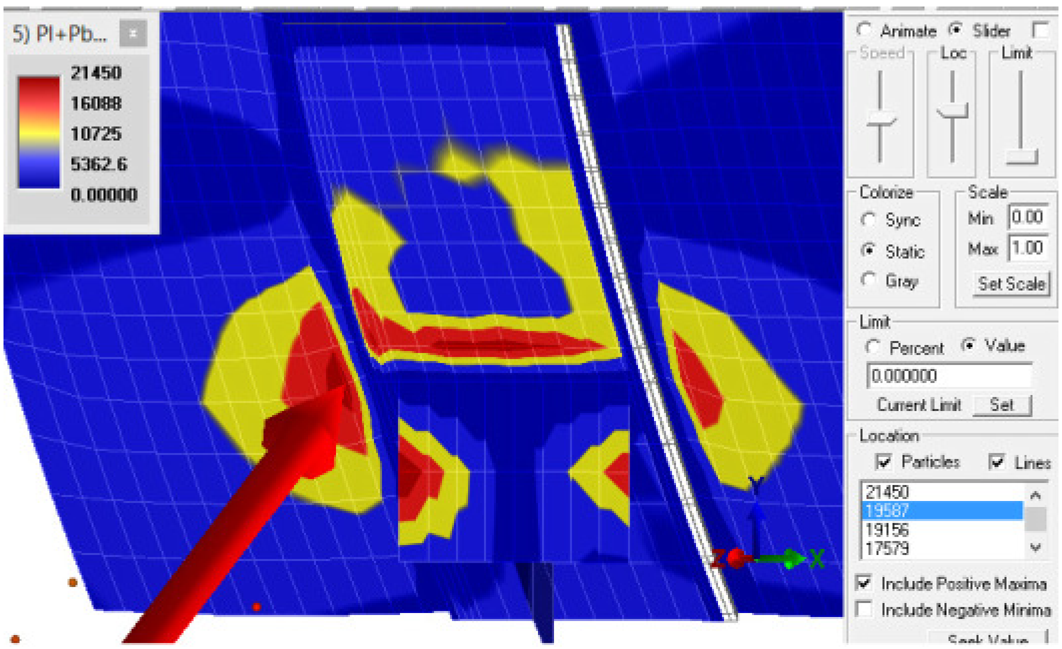
The plot below illustrates the comparison of ASCE design g-load basis and an actual seismic record for the same location. It shows how much the actual records can be higher than the design g load. This underscores the basis for seismic design.



Non-Integral Clips & Lugs

NozzlePRO (already exists in FEPipe)

Previous versions of NozzlePRO assumed an integral model where the shell and reinforcing pad were modeled with a single layer of elements. This is sufficient for smaller geometries but wider reinforcing pads under sufficient edge loading cause the reinforcement to separate from the parent geometry. In practice, there can be varying amounts of separation between the reinforcement and the shell. NozzlePRO includes various options that you can investigate to determine the worst case scenario during design or you can select the most appropriate if you are evaluating a field case.   The image below illustrates the primary plus secondary stress on a non-integral wear plate on a saddle supported pressure vessel.



Pipe Shoe Wizard

NozzlePRO

Building pipe shoe models in NozzlePRO is now simplified through the use of the new pipe shoe wizard, which allows the user to step through design for reliable models.

Print Control Updates

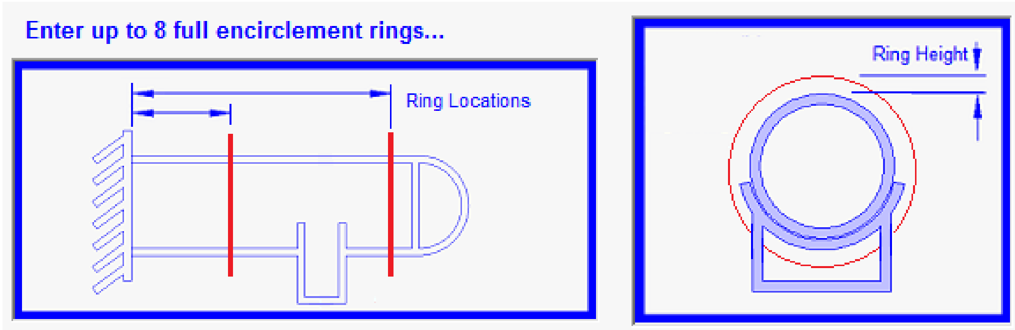
NozzlePRO

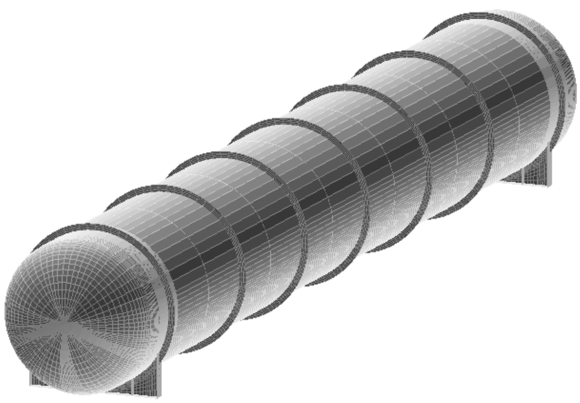
The NozzlePRO print function has been updated to afford you better control over the HTML results reports generated during the analysis. You can print reports individually or comprehensively including tabular reports and graphical. The generated HTML reports are suited across multiple browsers including Microsoft® Internet Explorer®, and Mozilla Firefox®.

Rings on Pipe Shoes and Saddle Supported Pressure Vessels

FEPipe, NozzlePRO

Stiffening rings are common in thin wall pressure vessels. FEPipe and NozzlePRO now allow you to easily place stiffening rings in the geometry that offer reinforcement against ovalization.

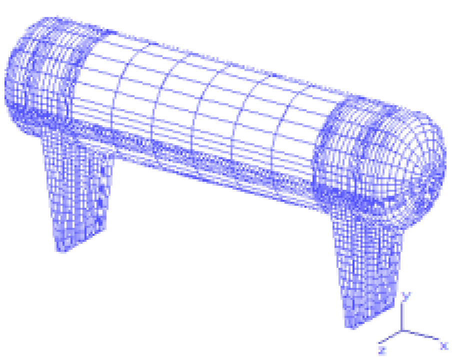


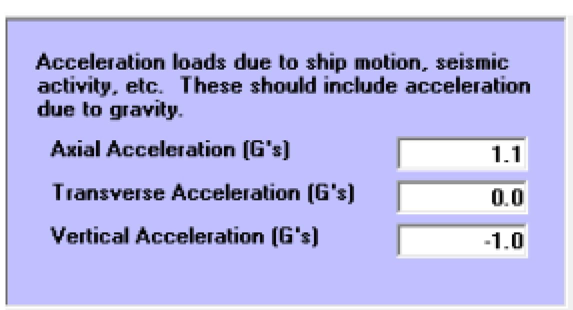


Seismic Load vs. Time Record Comparisons

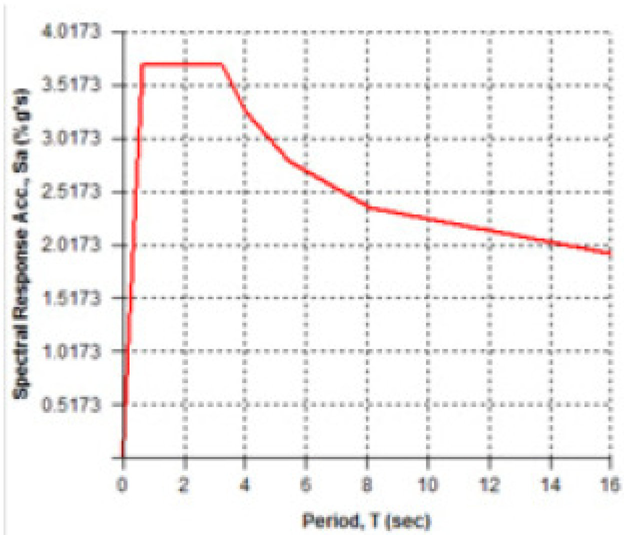
NozzlePRO

The seismic load calculator offers an estimate of the g loads developed from the ASCE 7 design rules. The acceleration loads can be used directly in the saddle wizard when a full sized pressure vessel or exchanger model is constructed.





The seismic load case tool contains a library of time histories that can be scaled as needed to produce response spectra. Ground response spectra can be turned into vessel stresses by using the participation factors from the seismic analysis. Examples that exemplify typical applications are included. One example of a response spectrum is illustrated below for Oakland, California USA.

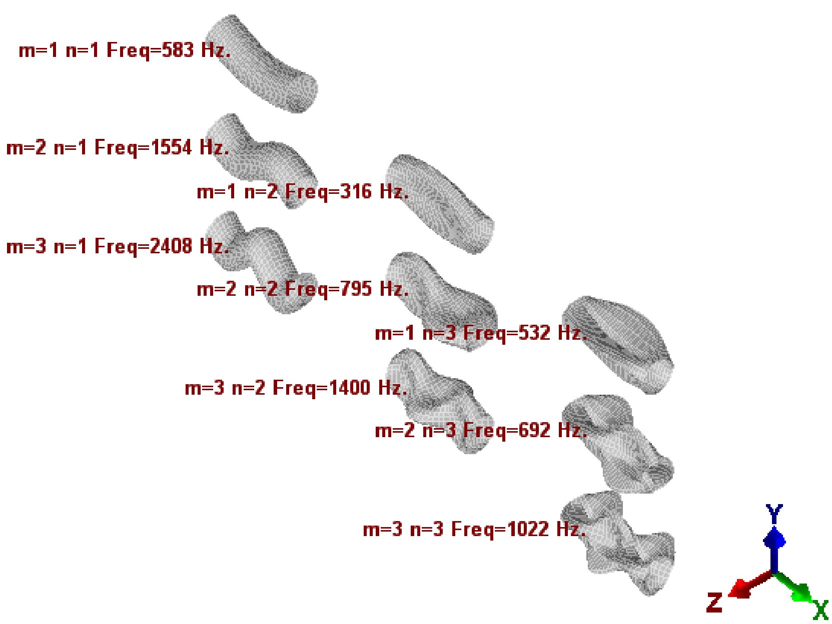


Shell Dynamic Mode Calculator

FEPipe, NozzlePRO

The shell mode calculator produces natural frequencies and mode shape plots of panel ended cylinders. The output of the calculator indicate mode shapes associated with dynamic natural frequencies. Commonly, analyses only consider beam natural frequencies and cylindrical modes can have lower natural frequencies for large diameter, thin-walled geometries. When shell natural frequencies are lower than beam natural frequencies, shell deflections during a seismic or other dynamic event may cause more stress than a corresponding beam mode. Also, you can identify when shell modes may interact with pulsation or blade pass frequencies in adjoining rotating equipment.

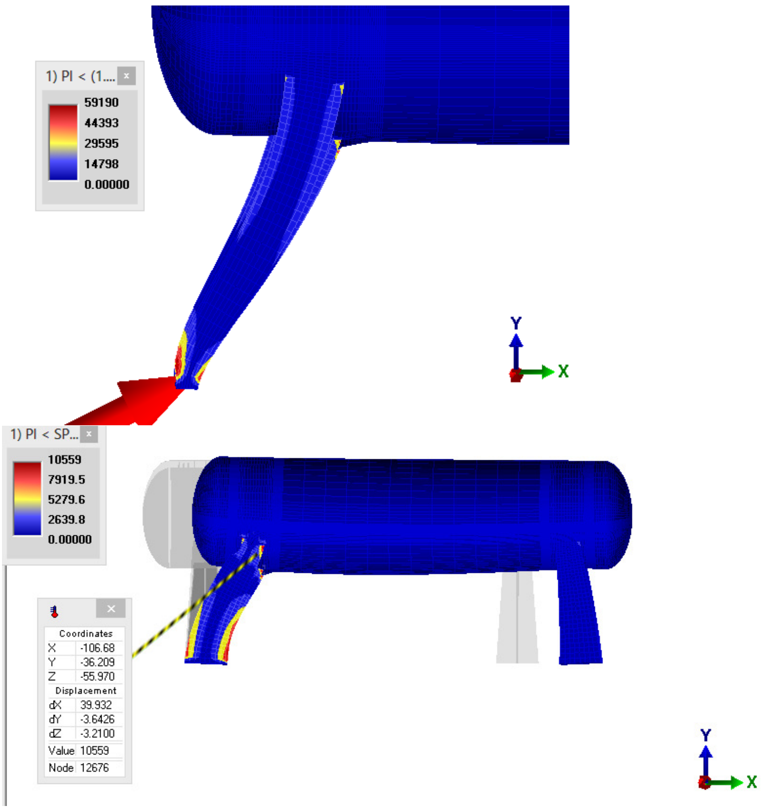
Sample Output:



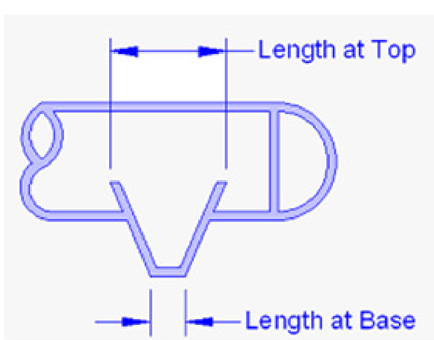
Tapered Saddle Supports

NozzlePRO

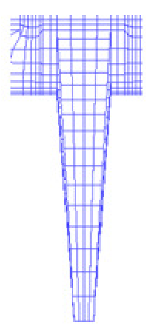
Saddles subject to axial loads are outside the scope of Zick analytical methods. Yet, axial loads can be significant in offshore applications and in high seismic zones. Tapered saddles with thickness gradients can now be modeled in NozzlePRO. The two images shown below illustrate the design effects of thickening the saddles.



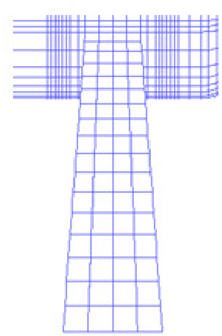
The design on the right remediates the overstressed design on the left by thickening the saddle at grade where the moment is highest. This is easily implemented as shown in the input below.



Saddle Wizard Input



Tapered Saddle



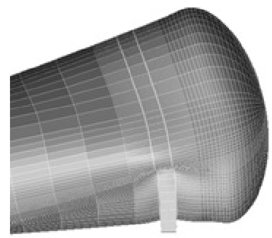
Reverse Tapered Saddle

Zick Calculations of Saddle Supported Vessels with Pressure Stiffening of the Shell

NozzlePRO

Internal pressure stiffening can decrease the stress in a horizontally supported vessel. Pressure will tend to remove ovalization relieving some of the bending of the shell around the horn of the saddle and increase the stiffness of the shell due to the tensile membrane load in the shell. Comparison of the maximum displacement using NozzlePRO with pressure stiffening and analytical method in Brownell and Young are shown below.

Brownell and Young Vessel Displacement Summary

Load	Vert Disp (in.)	Vert Disp (in.) Stiffened	Stiffened Shape	%Dif
W	-0.07746	-0.04534		52.3

The finite element analysis displacement plots shown below illustrate the vessel bending over the saddle support.