PRG PAULIN Research Group

FEPipe v15.0 • NozzlePRO v15.0 • FEATools v15.0
Released: January 2021

**NEW FEATURES LIST**

## NEW FEATURES

**FEATools v15.0 is the first version of this program sold exclusively through PRG and its direct resellers. Hexagon no longer sells PRG software products, although the two companies are committed to cooperating on technology for the piping industry.**

**FEATools v15.0 will be included with FEPipe v15.0.**



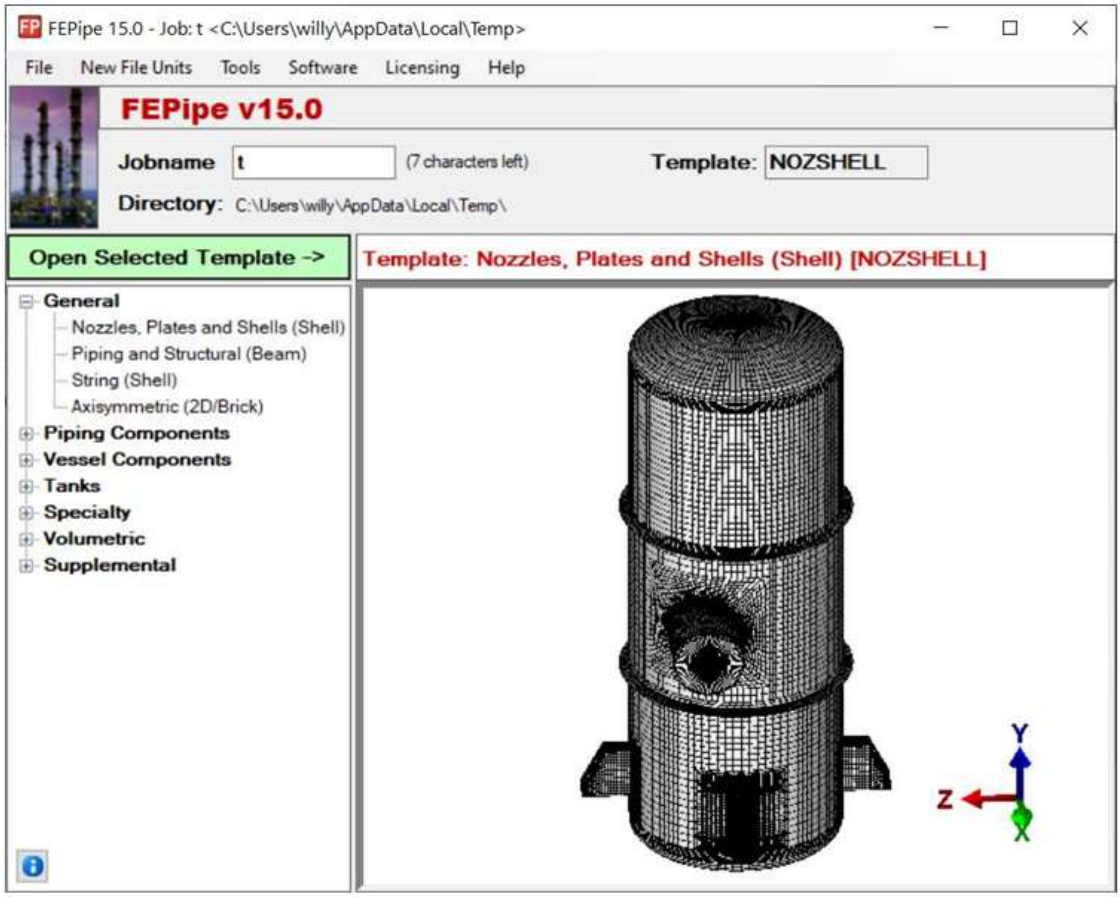
## NEW FEATURES PER PROGRAM



## FEPIPE, NOZZLEPRO and FEATOOLS INCLUDED MODEL SUMMARY

**New FEPipe Startup Interface**
*FEPipe*

The new FEPipe startup interface is more intuitive, easy-to-use and provides direct access to Code options and units settings. Models available appear in the displayed window and common control items such as licensing, setup and other software are available from the main menu.




**ASME 2019 Code Compliance**
*Added to All Programs*

The PRG software has been updated to include options for ASME VIII-2 Part 5 Rules and for B31.3 319.2.2 Overstrain Guidance. Please email support@paulin.com if there are any questions regarding either of these implementations.

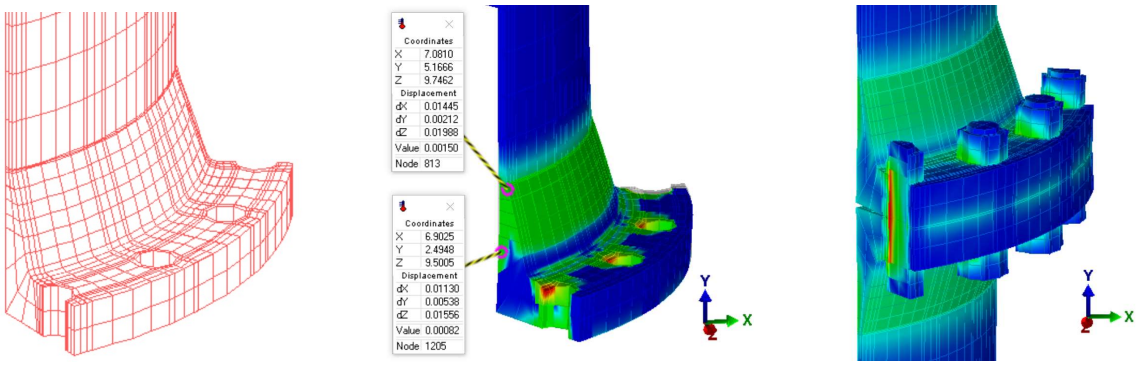
**Nonlinear Panel & Capability Expanded to All FEPipe Shell Templates**
*FEPipe*

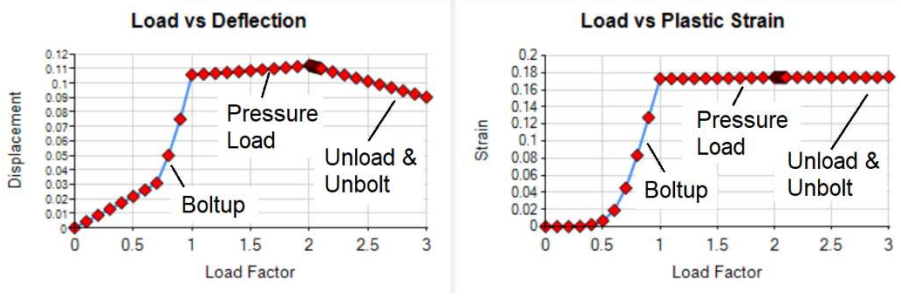
Nonlinear analysis capability was previously only available through the Nozzles/Plates/Shells template. This option has now been added to all FEPipe shell templates. (Not to be used with brick templates).

## Plasticity Solver Upgrades for Deformation of Flange Loading

*AxiPRO (included as a part of FEPipe)*

Any AxiPRO flange calculation can be evaluated for plasticity. The flange is bolted up; pressure and external loads are applied; and then the flange is unloaded and unbolted. All steps along the load path through unloading are available for review.

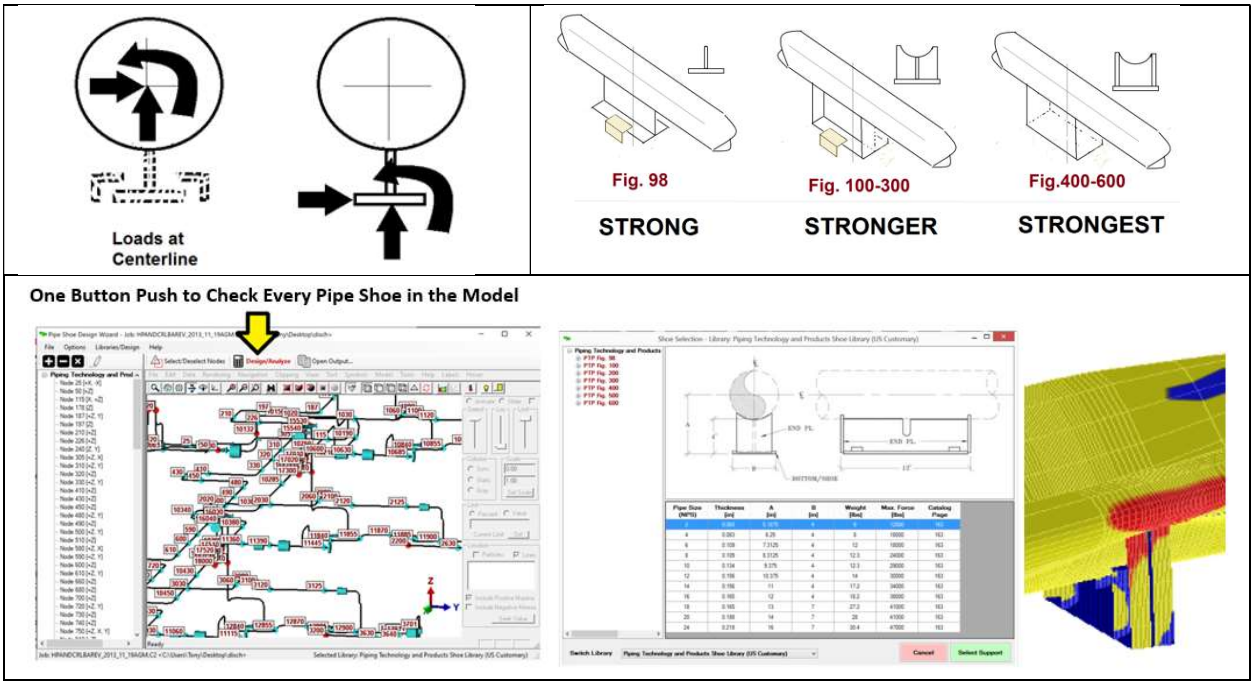



## Pipe Shoe Design Wizard

*FEPipe and FEATools*

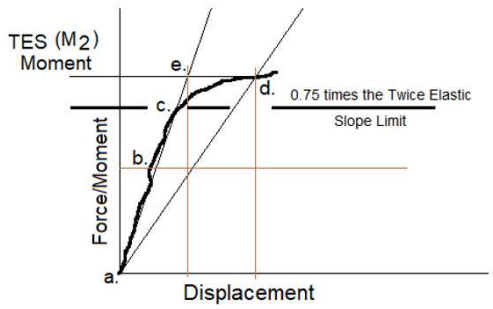
The Pipe Shoe Design Wizard automatically selects pipe shoe locations at restraints I the model and determines if loads at pipe shoe locations are too high. PIP shoe library has been added to the existing PTP library for easy reference. Pipe shoes can be clamped or welded.

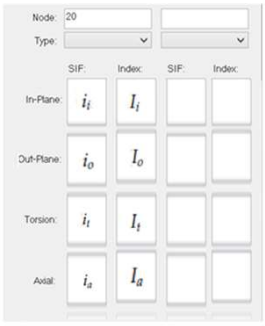


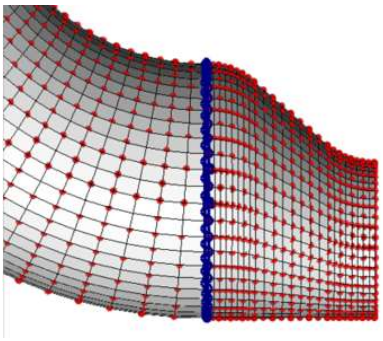
**Automated Nonlinear SSI and Collapse Calculations for Bends, Heads, Branches or Saddles**

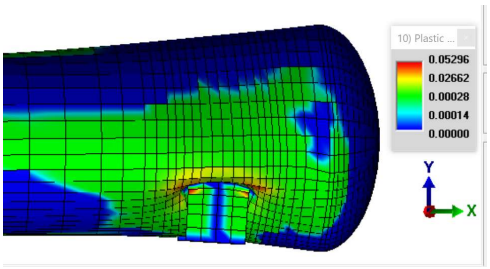
*FEBend, FETee, 661PRO and the Drawing Tools*

Generate Sustained Stress Indices (Allowable Primary Loads) Nonlinear Calculation following test procedure in B31J-2017 App.D and More Applicable Data for B31.3 CAESAR Index. Used in B31.3 319.2.2(b) Overload – Elastic Follow-up Calculation. Model building takes minutes for laterals, hillside, saddles, pipe shoes, vessel heads, bends with trunnions, 661 header box nozzles.

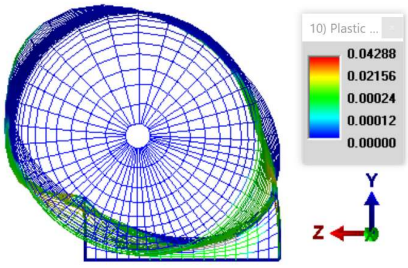


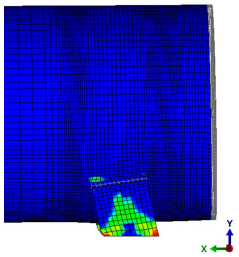





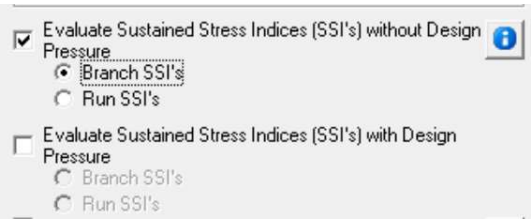

**Vertical Weight + Liquid**

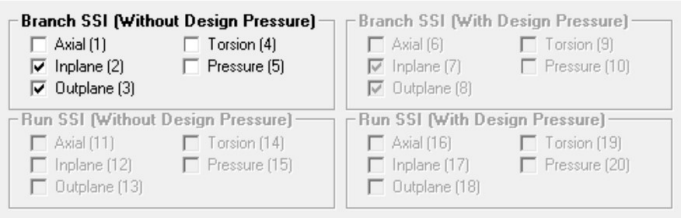



**Horizontal Weight + Liquid**




**Axial Load thru Shell**

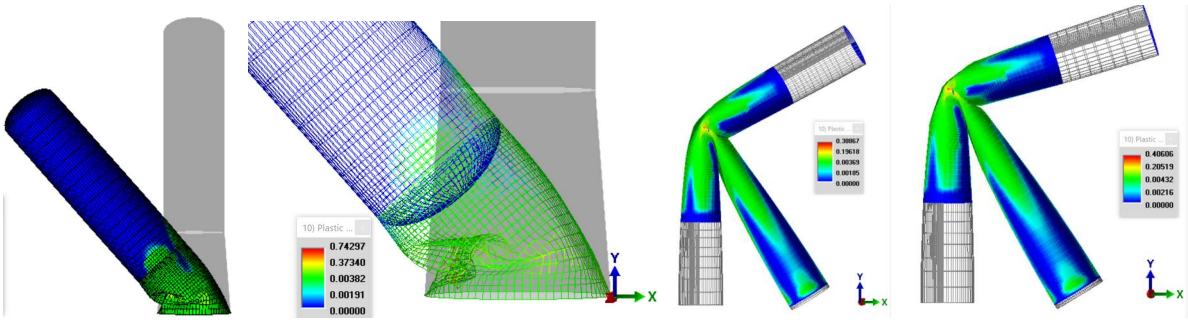


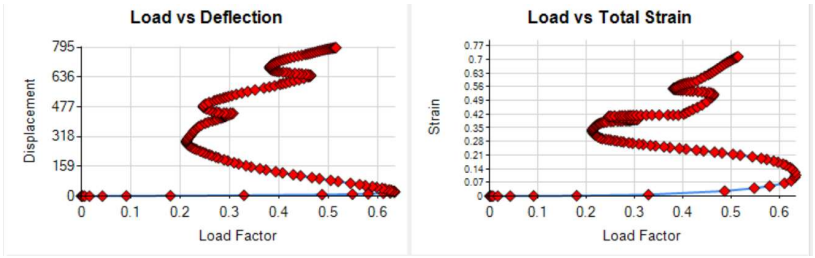



### Updated Nonlinear Material Large Rotation / Large Strain Solver

*FEPipe*

The new solver evaluates primary, sustained and occasional loads per ASME VIII-2 5.2.4, 5.3.3, and computes SSIs per guidelines in B31J Appendix D Test Simulations for direct input into CAESAR.

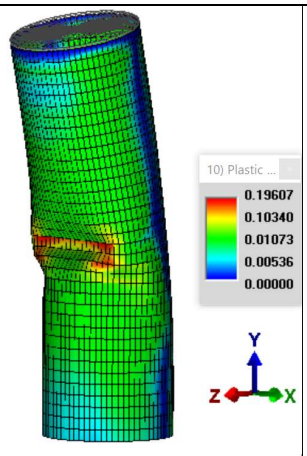
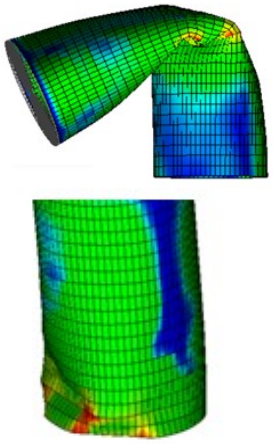
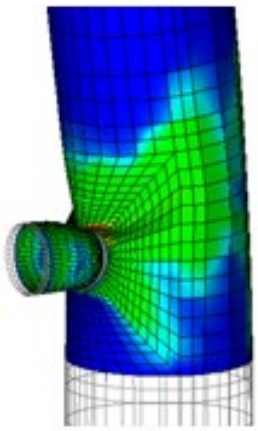
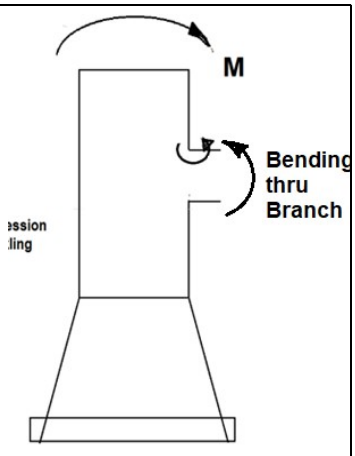



### Combination Loads Through the Run

*FEPipe and NozzlePRO*

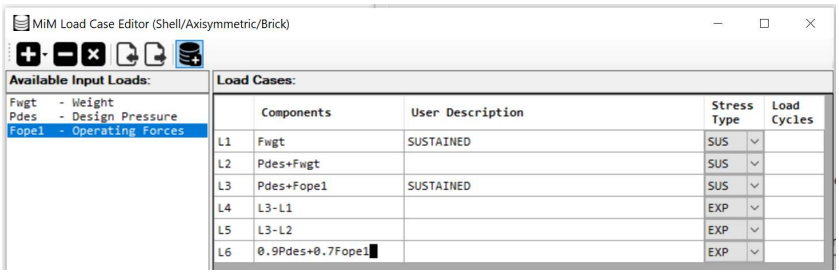
Overturning moments on the vessel can be applied with the nozzle load and external or internal pressure to determine the complete stresses in the nozzle. WRC 107/297/537 does not compute the nozzle discontinuity stresses due to loads in the vessel, therefore stresses due to bending moments can be significant for nozzles close to the bottom seam. FEPipe and NozzlePRO properly evaluate both sets of loads simultaneously for accurate stresses at the nozzle/shell junction.

| | | | |
|---|---|---|---|
|   |  |  |   |
| **Local Cylinder Buckle** | **To-scale buckled shapes of perturbed vessel** | **Nozzle Local Buckling due to Load thru Shell** | **Loads Thru Run and Branch** |

**Multiple Load Cases in Load Case Editor**

*Added to NozzlePRO, Already Exists in FEPipe*

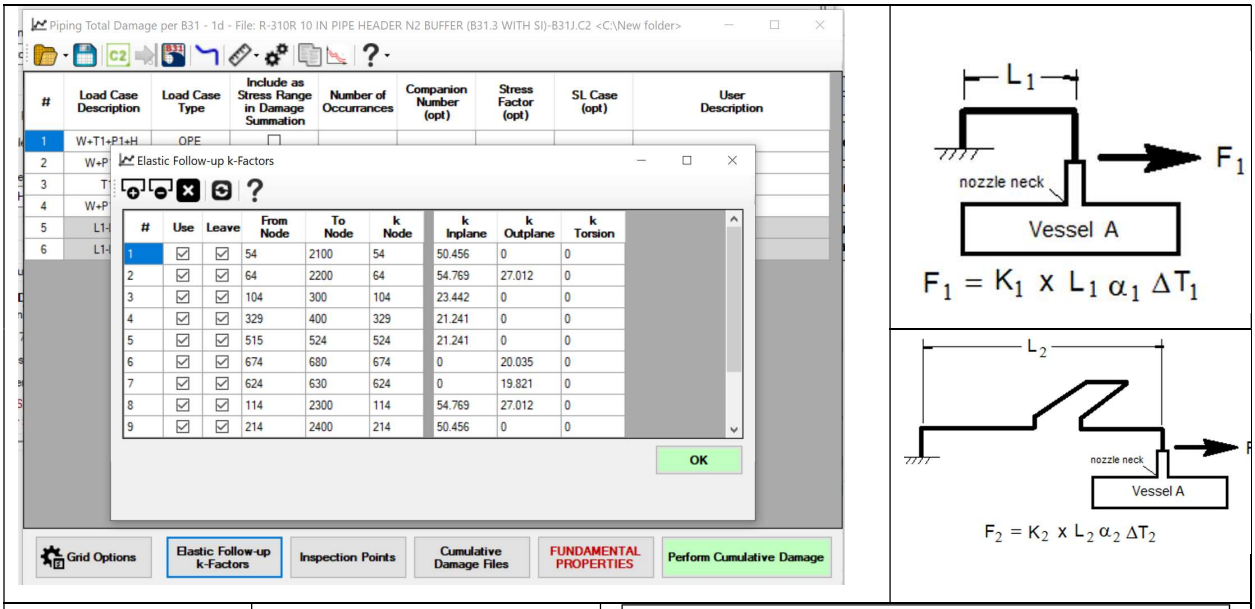
Users can enter load cases and can specify load component multipliers. Used for VIII-2 Part 5 Wind or Seismic Combinations.



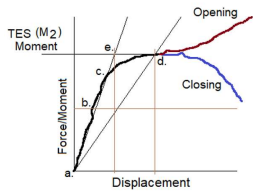

**B31.3 319.2.2 Overload Calculation**

*FEPipe*

Follow the guidance of ASME B31.3 paragraph 319.2.2 (b) to calculate elastic follow-up within the Cumulative Damage program. The k-factors from the piping model's advanced intersection and bends are automatically imported and used in the elastic follow-up calculation.




**Desired**




```
Paulin Research Group
Elements Susceptible to Overstrain/Elastic Follow-up
(See B31.3 319.2.2(b) (Version 1.2)

There are no HIGH PROBABILITY ELASTIC FOLLOWUP areas
in this model. Stress tending to plastically deform any
component is less than 0.75 times the twice elastic
slope limit.
```

**B31.3 319.2.2 Over-Loaded**

```
Paulin Research Group
Elements Susceptible to Overstrain/Elastic Follow-up
(See B31.3 319.2.2(b) (Version 1.2)

High Probability Elastic Followup Areas

                                  Reduction    Reduction     Approximate
 Node    Case    Type             in Life      in Force     Strain (percent)
 ----    ----    ----          ----------   -----------   ---------------
  2.1       1     OPE              5.           1.6            2.36
  2.1       4     OPE              5.           1.6            2.36
  2.1       6     OPE              5.           1.6            2.36
```

### ASME Code Classification Update

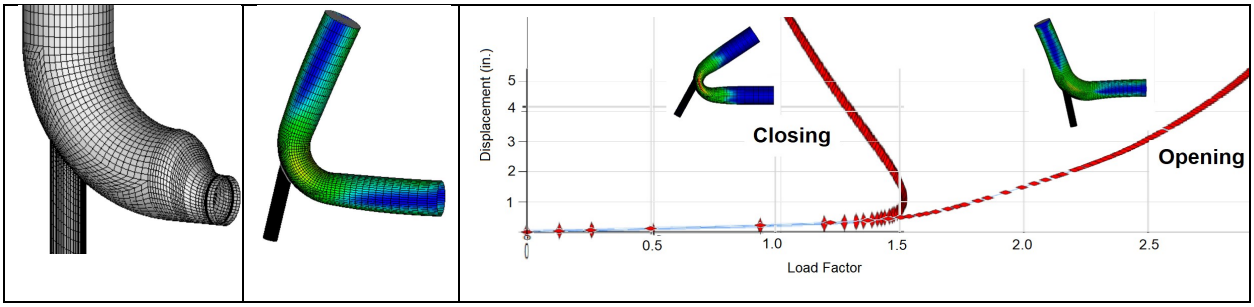
*FEPipe, NozzlePRO and FEATools*

The new ASME categorization options can be opened from FEPipe, NozzlePRO and FEATools using the buttons shown below. Settings can be stored locally (current model only) or globally (acts as a default for all new models generated by the user).


### Updated Bends with Trunnion Models

*FEPipe and FEBend in conjunction with the Drawing Tools (FEBend is included with FEATools)*

Users can add eccentric and concentric reducers; change boundary conditions; and determine SIFs, k-factors and nonlinear SSIs for bends with trunnions, reducers, and various other attachments. Primary, sustained and occasional loads are included per ASME VIII-2 5.2.4, 5.3.3, and SSIs are computed per guidelines in B31J Appendix




### Collapse Load Model Perturbation and Buckling for Heads, Cylinders, Bends and Branch Connections

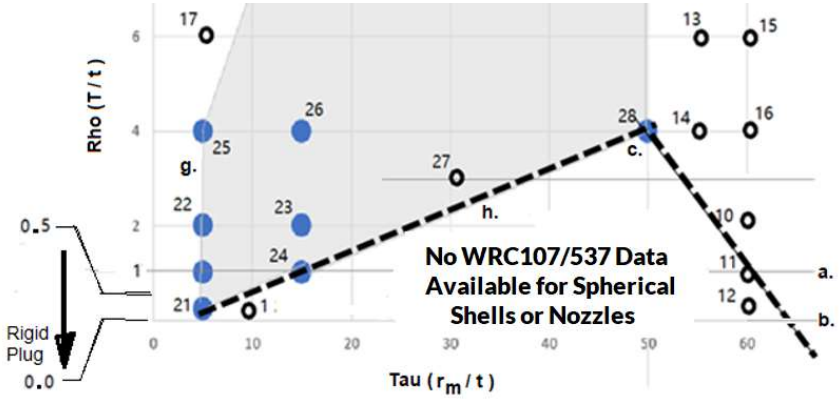
*All Programs except FE107, FESIF & AxiPRO**

All shell models can be perturbed from eigen buckling calculations, elastic analysis and unique load. Additionally, plastic analysis solutions may be used to perturb the solution to be sure that the minimum elastic-plastic collapse of the geometry is evaluated.

### WRC 107/537 Update Guidance for Spheres, Elliptical and Dished Heads

*FEPipe and NozzlePRO*

WRC 107/537 updated calculations are now included on the QuikCalc/Buckling Instability button in FEPipe and the Stability button in NozzlePRO. Although WRC107/537 is a good calculation when in recognized parameter ranges, results can be either overtly conservative or non-conservative when falling outside of these ranges.




**WRC MODEL 1 – Spherical Head with Non-Conservative WRC 107/537 Results**

*T/t = 2; Do=144, T=1, do=15.5, t=0.5, F=20,000 lb.*
*rm = (15.5-0.5)/2 = 7.5; rm/t = 15.; ro=15.5/2 = 7.75, Rm=(144-1)/2 = 71.5*

| | *WRC 107/537* | *Shell* | *Brick* | *Brick(1)* |
|---|---|---|---|---|
| *M+B Max* | *5882* | *10154* | *11239* | *10199* |

*Brick(1) – Alternate Integration Scheme*
*High stress in nozzle. Nozzle stress not calculated in WRC 107/537.*
*WRC107/537 does not evaluate elastic instability, but this is for very high D/T heads*

**WRC MODEL 2 – Spherical Head with Conservative WRC107 Results**

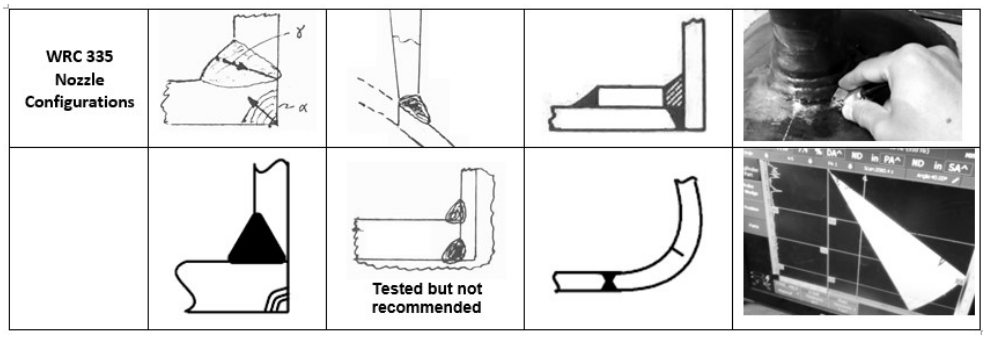
*T/t=1; rm/t=35; Do=144, T=1, Axial Force = 285,000 lb.*

| | *WRC 107* | *Shell* | *Brick* | *Brick(1)* |
|---|---|---|---|---|
| *M+B Max* | *28573* | *11207* | *12504* | *12192* |

### Recommended SCF for Pressure Stress on Welds

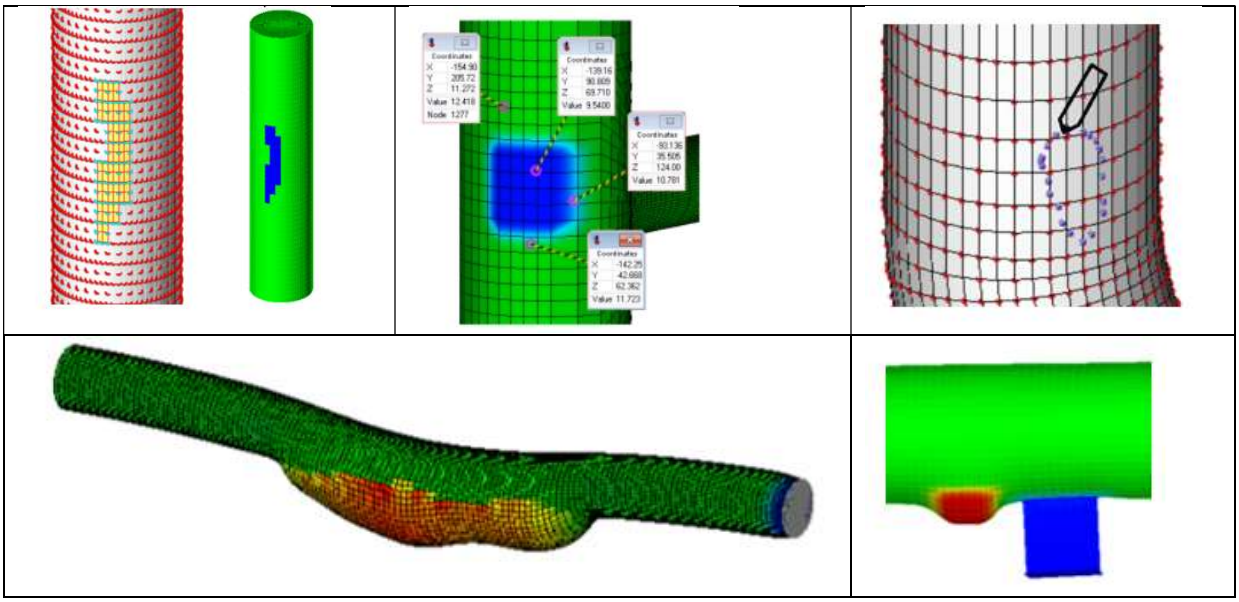
*Pressure Cycling and ASME Part 5 Smooth Bar or Welded Fatigue Curve Evaluation*
*FEPipe & NozzlePRO*

A shell model is created for a variety of WRC355 pressure cycled nozzle configurations. This permits users to apply cyclic external loads and pressure and to predict cycles-to-failure or satisfy Code requirements. ASME VIII-2 Part 5 Fatigue Analysis for Cyclic Loads are performed. Guidance for phased array (PA) inspection in small thick nozzles is provided.

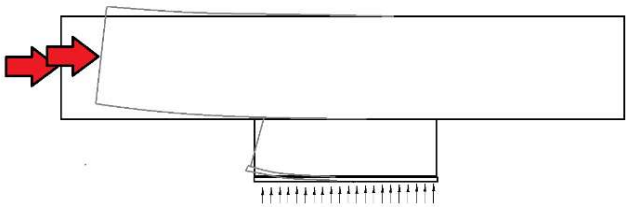


**Interactive Local Thin Area Drawing & Analysis**
*FEPipe and NozzlePRO*

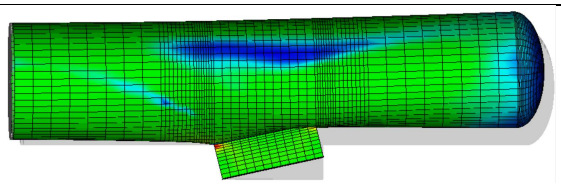
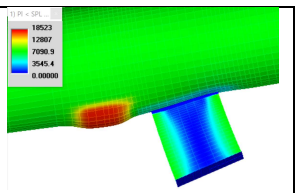
Local thinned areas can be outlined using the NEW Model Marker Tool. Elements or Node Thicknesses can be specified graphically. RSF can be user controlled for elastic or plastic (VIII-2 5.3.4) analysis.



**+Y Simple Nonlinear Supports for Saddles, Pipe Shoes and Similar Geometries**
*Available with any shell model that has supports.*
*FEPipe, NozzlePRO, FEATools & their associated shell templates.*



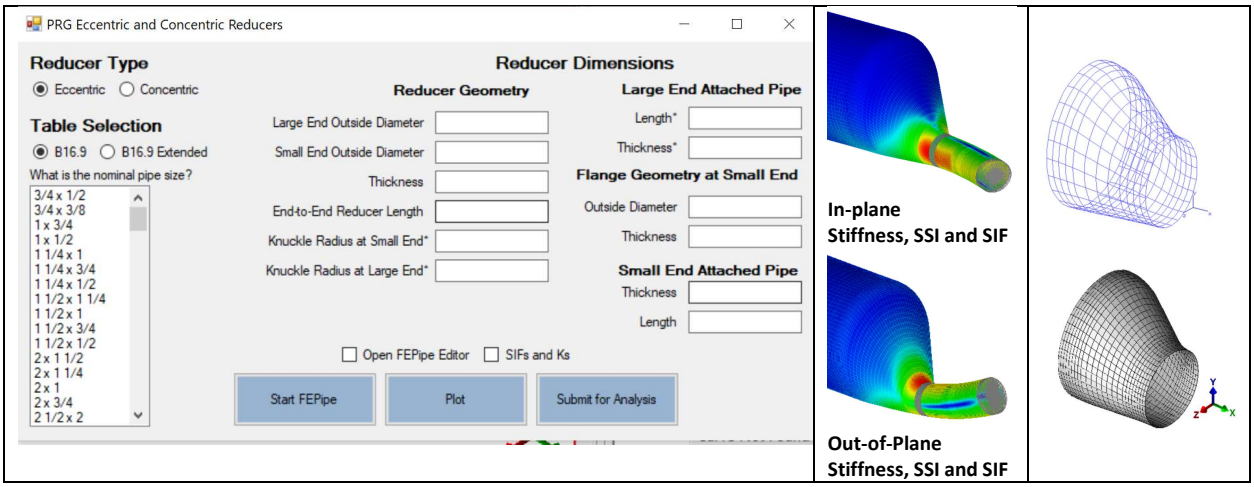
**Local liftoff** of supports can be simulated and the effect on local stresses estimated.

| | | |
|---|---|---|
| **Support Liftoff Under Axial Load** |  |  |

## Eccentric and Concentric Reducer Model

*FEPipe*

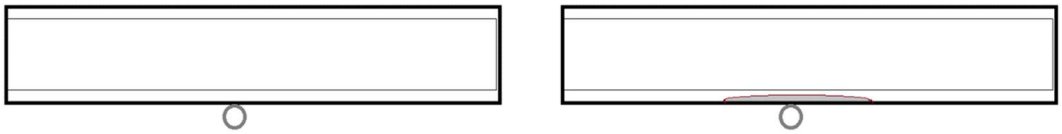
Automated concentric or eccentric reducer models can be generated in standard and extended sizes - up to 48x40 or down to the extended size 48x4. SIFs, SSIs, k-factors and stiffnesses can be calculated.




## Bar Supports & Local Thin Areas

*FEPipe and NozzlePRO*

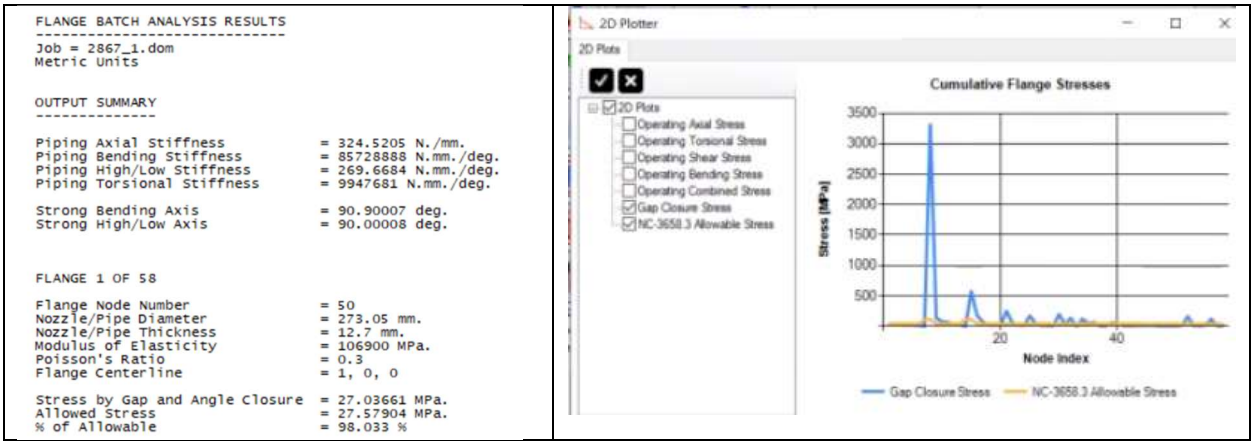
Evaluation of CAESAR II and PCL-Gold local loads on bar supports and corroded pipe on bar supports:



## Flange Automated Evaluation Wizard (Condense)

*FEPipe and FEATools*

CAESAR II or PCL-Gold models are read in and users can then either specify flange locations or allow the program to pick all possible flange locations for evaluation. In the results below – flange locations in between axial support points are showing high stresses when bolt up tolerances are evaluated. The program simulates the load on the flange due to bolt up with default or specified tolerances. For maintenance or initial installation, (depending on the system configuration and type of anchor) flanges should not be bolted up when anchors are in place. Tabular reports show the stiffness of the surrounding condensed system.

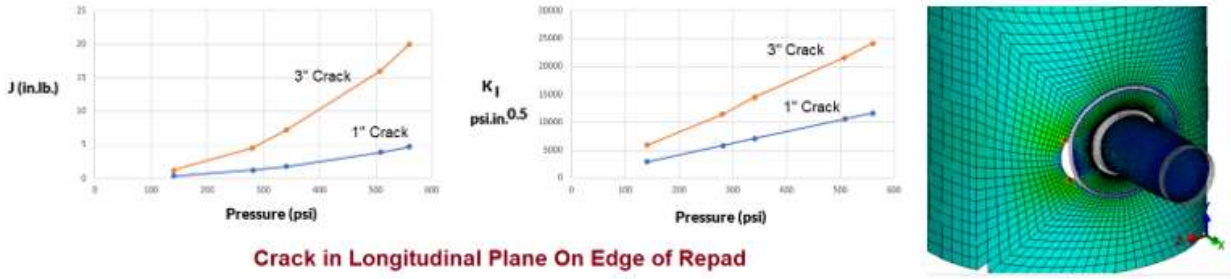


```
FLANGE BATCH ANALYSIS RESULTS
-----------------------------
Job = 2867_1.dom
Metric Units


OUTPUT SUMMARY
--------------

Piping Axial Stiffness          = 324.5205 N./mm.
Piping Bending Stiffness        = 85728888 N.mm./deg.
Piping High/Low Stiffness       = 269.6684 N.mm./deg.
Piping Torsional Stiffness      = 9947681 N.mm./deg.

Strong Bending Axis             = 90.90007 deg.
Strong High/Low Axis            = 90.00008 deg.


FLANGE 1 OF 58

Flange Node Number              = 50
Nozzle/Pipe Diameter            = 273.05 mm.
Nozzle/Pipe Thickness           = 12.7 mm.
Modulus of Elasticity           = 106900 MPa.
Poisson's Ratio                 = 0.3
Flange Centerline               = 1, 0, 0

Stress by Gap and Angle Closure = 27.03661 MPa.
Allowed Stress                  = 27.57904 MPa.
% of Allowable                  = 98.033 %
```

**Leak-Before-Break Linear and Nonlinear Pressure Fatigue of Thick Nozzles & Olets**

*FEPipe and NozzlePRO*

Nonlinear J-Integral Calculations are used to determine if cracks growing to leaks will result in leaking (mists/drops) or a fishmouth break.

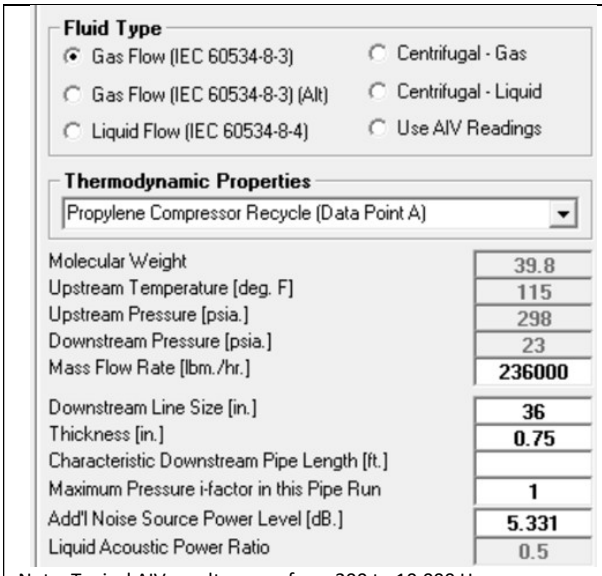



Crack in Longitudinal Plane On Edge of Repad

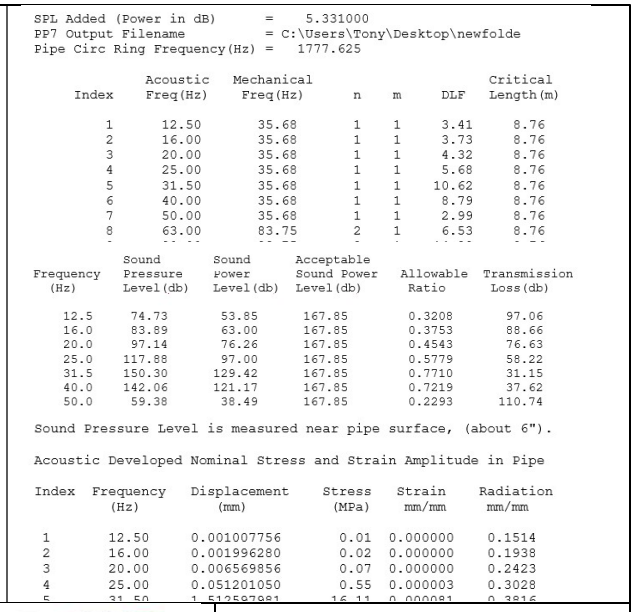
**Acoustic Induced Vibration (AIV) Update**

*FEPipe and NozzlePRO*

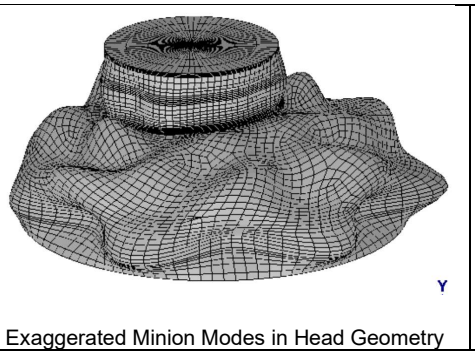
Sound Pressure Levels (SPL) are calculated at six microphone positions and printed for both the model and for a geometrically similar cylinder. Maximum displacements are computed for minion modes using IEC 60534-8-3 and the same displacements are used for the branch, head or bend with trunnion finite element model to predict stresses. If the IEC 60534-8-3 predicted stress for the cylinder is within acceptable limits and the stress in the studied geometry is less, then it is expected that the stress in the modeled geometry will be less. Local integral thickening is recommended if possible, or circumferential clamps or bolted precision cut rings can be used.



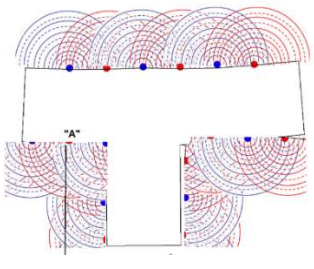

Note: Typical AIV results range from 200 to 10,000 Hz.



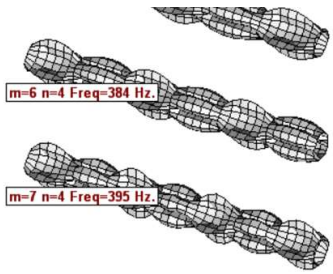
```
SPL Added (Power in dB)       =    5.331000
PP7 Output Filename           = C:\Users\Tony\Desktop\newfolde
Pipe Circ Ring Frequency(Hz) =   1777.625

                Acoustic   Mechanical                          Critical
      Index     Freq(Hz)    Freq(Hz)       n     m      DLF    Length(m)

          1        12.50       35.68       1     1     3.41       8.76
          2        16.00       35.68       1     1     3.73       8.76
          3        20.00       35.68       1     1     4.32       8.76
          4        25.00       35.68       1     1     5.68       8.76
          5        31.50       35.68       1     1    10.62       8.76
          6        40.00       35.68       1     1     8.79       8.76
          7        50.00       35.68       1     1     2.99       8.76
          8        63.00       83.75       2     1     6.53       8.76

              Sound       Sound       Acceptable
Frequency     Pressure    Power       Sound Power   Allowable   Transmission
  (Hz)        Level(db)   Level(db)   Level(db)      Ratio       Loss(db)

    12.5        74.73       53.85       167.85        0.3208       97.06
    16.0        83.89       63.00       167.85        0.3753       88.66
    20.0        97.14       76.26       167.85        0.4543       76.63
    25.0       117.88       97.00       167.85        0.5779       58.22
    31.5       150.30      129.42       167.85        0.7710       31.15
    40.0       142.06      121.17       167.85        0.7219       37.62
    50.0        59.38       38.49       167.85        0.2293      110.74

Sound Pressure Level is measured near pipe surface, (about 6").

Acoustic Developed Nominal Stress and Strain Amplitude in Pipe

Index  Frequency    Displacement     Stress    Strain     Radiation
          (Hz)          (mm)          (MPa)    mm/mm      mm/mm

 1        12.50    0.001007756        0.01   0.000000    0.1514
 2        16.00    0.001996280        0.02   0.000000    0.1938
 3        20.00    0.006569856        0.07   0.000000    0.2423
 4        25.00    0.051201050        0.55   0.000003    0.3028
```



Exaggerated Minion Modes in Head Geometry




Discretized sound pressure emanating from shell surface




Exaggerated Minion Modes in straight cylinder

# New Features Per Program

## FEPipe version15.0

- New Module - FEATools v15.0 is now included with FEPipe v15.0.
- ASME 2019 Code Compliance
- Nonlinear Panel & Capability Expanded to All FEPipe Shell Templates
- AxiPRO Plasticity Solver Upgrades for Deformation of Flange Loading
- Pipe Shoe Design Wizard – PIP Shoe Library Added
- Automated Nonlinear SSI and Collapse Calculations for Bends, Heads, Branches or Saddles (FEBend, FETee, 661PRO and the Drawing Tools)
- Updated Nonlinear Material Large Rotation / Large Strain Solver
- Combination Loads Through the Run
- B31.3 319.2.2 Overload Calculation
- ASME Code Classification Update
- Updated Bends with Trunnion Models (FEPipe Shell Template & FEBend with Drawing Tools)
- Collapse Load Model Perturbation and Buckling for Heads, Cylinders, Bends and Branch Connections
- WRC 107/537 Update Guidance for Spheres, Elliptical and Dished Heads
- Recommended SCF for Pressure Stress on Welds
- Interactive Local Thin Area Drawing & Analysis
- +Y Simple Nonlinear Supports for Saddles, Pipe Shoes and Similar Geometries
- Eccentric and Concentric Reducer Model
- Bar Supports & Local Thin Areas
- Flange Automated Evaluation Wizard (Condense)
- Leak-Before-Break Linear and Nonlinear Pressure Fatigue of Thick Nozzles & Olets
- Acoustic Induced Vibration (AIV) Update

## NozzlePRO version15.0

- ASME 2019 Code Compliance
- Automated Nonlinear SSI and Collapse Calculations for Heads, Branches or Saddles (FETee and the Drawing Tools)
- Combination Loads Through the Run
- Multiple Load Cases in Load Case Editor
- ASME Code Classification Update
- Collapse Load Model Perturbation and Buckling for Heads, Cylinders and Branch Connections
- WRC 107/537 Update Guidance for Spheres, Elliptical and Dished Heads
- Recommended SCF for Pressure Stress on Welds
- Interactive Local Thin Area Drawing & Analysis
- +Y Simple Nonlinear Supports for Saddles, Pipe Shoes and Similar Geometries
- Bar Supports & Local Thin Areas
- Leak-Before-Break Linear and Nonlinear Pressure Fatigue of Thick Nozzles & Olets
- Acoustic Induced Vibration (AIV) Update

## FEATools version15.0

- ASME 2019 Code Compliance
- Pipe Shoe Design Wizard – PIP Shoe Library Added
- Automated Nonlinear SSI and Collapse Calculations for Bends or Branches (FEBend, FETee and the Drawing Tools)
- ASME Code Classification Update
- Updated Bends with Trunnion Models (as a part of FEBend with Drawing Tools)
- Collapse Load Model Perturbation and Buckling for Heads, Cylinders, Bends and Branch Connections
- +Y Simple Nonlinear Supports for Pipe Shoes and Similar Geometries
- Flange Automated Evaluation Wizard (Condense)

## **FEPipe** v15.0 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 v15.0 **Standard Shell Templates**:

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

FEPipe v15.0 **Standard Brick Templates**:

- Unreinforced Fabricated Tee
- Pad Reinforced Fabricated Tee
- Olet Intersection
- Axisymmetric Flange Modeler

Beginning with FEPipe v15.0, PRG will no longer distinguish between permanent modules and SMS-dependent modules.

FEPipe v15.0 Included Modules

- NozzlePRO
- MatPRO
- AxiPRO
- 661PRO
- FE107
- FESIF
- FETee
- FEBend
- PCL-Gold Pipe Stress Module
- Pipe Shoe Design Wizard
- High Frequency
- Cumulative Damage
- BOS B31
- Flange Automated Evaluation Wizard (Condense)
- SIF/SSI/k (PRGik)
- Flaw Detection
- MimOut Point Clouds
- Drawing Tools
- Nonlinear Analysis
- Fitness for Service
- **FEATools v15.0 – New with FEPipe v15.0**

## **NozzlePRO** v15.0 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 v15.0.

Beginning with NozzlePRO v15.0, PRG will no longer distinguish between permanent modules and SMS-dependent modules.

- MatPRO
- SIF/SSI/k
- High Frequency
- Flaw Detection
- Nonlinear Analysis
- Drawing Tools
- FE107
- FESIF
- FETee

## **FEATools** v15.0 Program Description / Included Modules

FEATools v15.0 transforms your piping model (CAESAR II and PCL-Gold) by including upgraded branch connections (with the addition of rigid elements and restraints) to better simulate real-world displacement and forces. The FEA-based calculations provide the necessary k-factors, SSIs and SIFs that will be added to every branch connection.

FEATools v15.0 is the first version of the program sold exclusively through PRG and its direct resellers. Hexagon no longer sells PRG software products. If you have any questions regarding licenses purchased through Hexagon, please contact our sales group at sales@paulin.com.

- Piping FEA Translator
- Pipe Shoe Design Wizard
- Criticality Evaluator
- SIF / SSI / k (PRGik)
- Flaw Detection
- Drawing Tools (via FETee & FEBEnd)
- Flange Automated Evaluation Wizard (Condense)
- Cumulative Damage
- FESIF
- FETee
- FEBend