

# ***AUTOMATICALLY*** add the Accuracy of a Finite Element Calculation to your Pipe Stress Analysis.

## **PCL-Gold**

### **The B31.3 Piping Checklist Premiere Edition**

Pipe stress analysis capabilities including 18+ degree of freedom beam elements. **PCL-Gold is the first pipe stress program to run a finite element analysis for the components that require it.**

- Microsoft® Excel Piping Interface
- Nonlinear Refractory Models (up to 10 layers)
- Automatic Import and Modeling of FEA SIFs and Stiffnesses for Nozzles in Cylinders and Flat, Conical, Spherical, Elliptical and Dished Heads
- FEA SIFs include axial **and** torsional directions
- Models for Stiffening Rings and Bimetallic Welds
- Non-conservative, path dependent friction and gaps (computes true stress ranges)
- B31.1 / B31.3 Code Compliance Reports
- Spring Hanger Design
- Automatic Development of Hot Sustained Code Cases (B31.3 Appendix S)
- Point loads and supports on pipe surface - **not on pipe centerline**
- Rain and Radiation models for horizontal, vertical or skewed pipe
- Solution option to toggle between 6 and 18+ degree of freedom beam models
- Expansion Joint and Cold Spring Element Types
- Operating and Occasional Cycling for Path Dependant Static and Kinetic Friction
- Asynchronous FEA Batch Option. All FEA models not already in the FEA databank can be queued to run asynchronously at a convenient time. The FEA analysis of these intersections is never performed again. Needed data is retrieved from the local or global databank.
- Large Rotation and Stress Stiffening / Softening P - Δ
- Includes All the Features of PCL-Free

## **PCL-Free**

### **The B31.3 Piping Checklist Shareware Edition**

The PRG B31.3 Piping Checklist uses basic process and geometry information to develop a checklist and guidance tips for the engineer to follow to ensure compliance with the ASME B31.3 piping code.

Several reports are written to assist the analyst in developing comprehensive pipe stress evaluations without unnecessary calculations.

- Simple, basic input
- Area replacement calculations
- External load and buckling analysis for straight pipe sections.
- Analysis checklist for specific system characteristics
- Code compliance assurance and code references
- Corrosion Fatigue Life Estimate
- Definition of system complexity
- Effects of components such as expansion joints, reinforcing pads and rotating equipment
- Effects of uncertainty in flexibilities and stress intensification factors (SIFs)
- Environment effects including rain
- Consideration of dynamic loads such as slug loads and waterhammer
- Expert system that cross references ASME B31.3 for your specific system
- Improved safety in piping system designs
- Rich text format reports
- Risk analysis summary
- Pipe wall thickness calculations

### **Paulin Research Group**

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Sales: 281-920-9775 Ext. 3  
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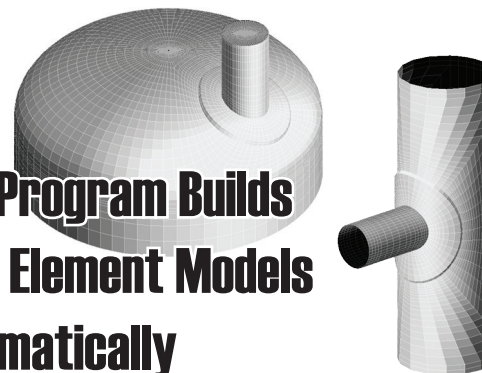
## **Why Use Finite Element Results in a Piping Analysis?**

- Accurate SIFs and Flexibilities for non-Code geometries or for geometries outside of the Code limits
- Validation of Pressure Designs in large d/D Intersections
- Collapse of thin-walled piping geometries
- Thermal or Pressure Cycles > 5000
- Large Hillside or Lateral Nozzles
- $D/T > 100$
- Piping attached to the nozzle is long, flexible and somewhat unrestrained AND  $D/T > 50$
- Area replacement rules for pressure are only barely satisfied and  $D/T > 50$



Typical FEA geometries analyzed by **PCL-Gold** are shown below. The results from these finite element runs are used in automatic SIF and Flexibility models in the piping analysis.

**Our Piping Program Builds  
These Finite Element Models  
Automatically**





## Finite Element Databank

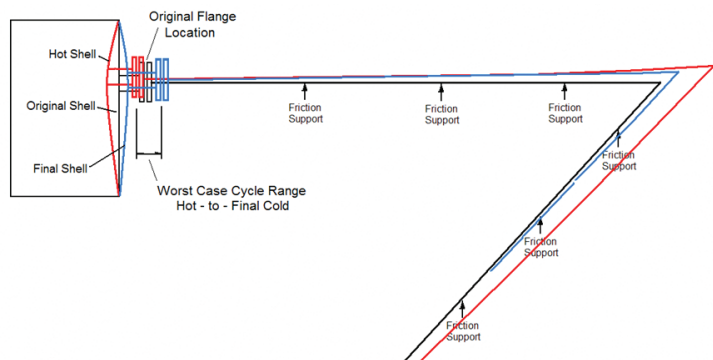
PCL-Gold has access to a databank of previously run FEA models. The user can generate and access these results from up to three different sources:

- PRG's Internet Databank (use of these results requires user to contribute)
- Results Stored on a Local Drive (user generates and accesses these values)
- Results Stored on a Company Drive (available to PCL-Gold users at the company)

Access to thousands of previously run geometries makes the inclusion of finite element technology for piping analysis fast, thorough, and accurate.

## Path Dependent Friction

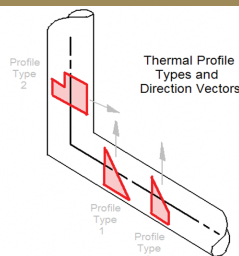
During startup, as the pipe heats it moves away from the nozzle. The friction supports located downstream react to the outward sliding and push back on the vessel nozzle putting the nozzle in compression axially. When the pipe returns to ambient during a shutdown, the direction of the friction force changes (since friction acts against the direction of motion), and the friction load puts the nozzle in tension, pulling outward on the vessel.



If the path dependent nature of the friction loads was not properly considered, the range of stress would be non-conservative.

## Thermal Bowing

Thermal bowing may be used to consider the effects of liquid layers developed inside the pipe, such as those which occur due to furnace radiation, rain, or sun or when filling with LNG. Any of these effects can produce a circumferential varying temperature gradient along the axial length of the pipe. Depending on the source of these gradients, they may be found in horizontal or vertical pipe.



## Quick, Easy Input via Excel®

	Plot	Run	Hide/Show	Go To	Find Page	Find Node	Insert Page	Delete	Results	E
1										
2	Pages	Pipe	Vectors	Element Properties						
3	Pages	Nodes (Start, Middle, End)	Bend Tangent Nodes(s)	dx,dy,dz (in.) Start -> Middle	dx,dy,dz (in.) Middle -> End	Pipe OD (in.), Wind OD(in.)	Thickness (Pipe, Insul, Cor, Ref,m)	Radius (Bends only) (in.)	Rigid Element Weight (lb.)	
4	1									
5	2									
6	3									
7	4									
8	5									
9	6									

## Hot Sustained Cases

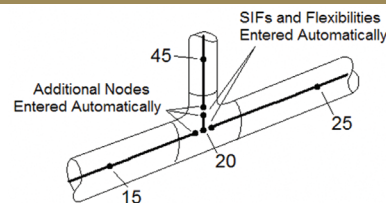
Per B31.3 includes the following:

321.1.1 (g) addresses **unintentional** disengagement of piping. B31.3 Appendix S Paragraph S302 addresses the potential **intentional** disengagement of piping. S302.6.2 states, "All anticipated sustained conditions utilizing all possible support scenarios should be considered and either evaluated or "Approved By Inspection."

The hot sustained load case is always the last load case analyzed. Note that if the highest SL is found in the hot sustained case, then this SL will be used to reduce the expansion case stress allowable.

## Automated Intersection Models

One of the greatest difficulty in preparing a beam-type piping model for a finite element analysis is the conversion of the nodes at the intersection. PCL-Gold automatically inserts the additional nodes.



## P-Δ Effects , Large Rotation, Stress Stiffening & Softening

For pipe overhangs, considerable sag may occur if designers do not properly account for the increased flexibility along with the weight. Condensate can collect, further increasing the sag, ultimately resulting in a situation where unexpected slugging occurs in the line.

When vertical risers are permitted to move laterally, compressive axial loads can reduce the lateral strength of the line, permitting additional lateral displacement and greater offset, producing greater bending moments at the base of the riser.

When axial loads develop in long lines due to friction, the lateral load bearing capacity is reduced and large displacement can occur in the lateral direction as the pipe "conforms" to the axial load. Small axial displacements (thermal strains), can produce very large lateral displacements and binding or failure of supports.

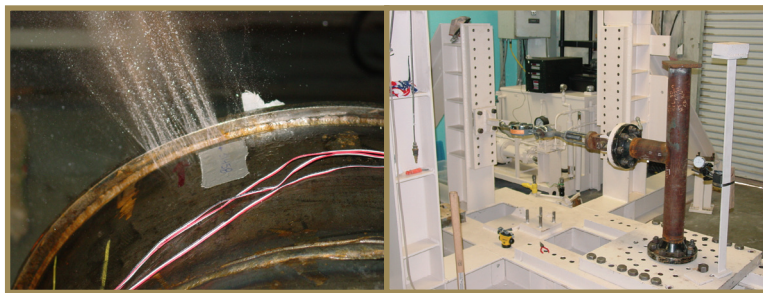
GRE piping is particularly susceptible to the development of axial compressive stresses and so can be particularly likely to stress soften.

When piping systems are subject to tensile loads, they may experience a lateral stiffening effect and so deflect less when subject to lateral loads such as wind, weight or developed loads due to attached piping. This is the well known "guitar-string" effect.

These stiffening effects also may also alter natural frequencies and mode shapes.

## Physical Testing to Verify Results

Paulin Research Group uses real-world tests to verify the accuracy of our software results. We regularly perform burst, fatigue, acoustic, and soil tests.



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