Finite Element Analysis

Calculations for Flanges & Other Axisymmetric Models

Flange calculations have, for more than seventy years, been performed in accordance with ASME Secion VIII Division 1, Appendix 2 rules or some derivation thereof. New draft rules from the ASME BFJ (Bolted Flange Joint) committee, and from EN 13445 Annex G are attempting to augment, and in some cases replace, the methods of Appendix 2. The BFJ rules include new gasket constants which improve significantly on the "m" and "y" values used in Appendix 2 evaluations. EN 13445 Annex G includes a flange/bolt/gasket compliance model that removes the reliance on the rigid flange model still existing in both ASME approaches. ENG 13445 also incorporates a nonlinear gasket model and an iterative procedure to determine gasket load area based on flange rotation.

The FEA approach implemented in **Axi/PRO** includes all three of the methods described above, and ALSO uses BFJ rules for leakage prediction, extended by tests conducted at the Paulin Research GRoup Lab. Axi/PRO also uses nonlinear gasket properties based on additional tests at the PRG Lab.

Axi/PRO is a powerful, easy to use axisymmetric and brick finite element modeler, designed to analyze flanged joints and other axisymmetric geometries.

Bolts, nuts and holes may be included in the 3d brick models so that users can see the results of hole spacing on the stress distributions. Dimensionally accurate flange models including studs and nuts are generated automatically for six major flange standards.

Analysis results include graphical representations of ASME stress intensities, resultant bolt axial loads, gasket stress distribution, overall displacments and flange separation.

It allows automatic 3D models for the following code evaluations:

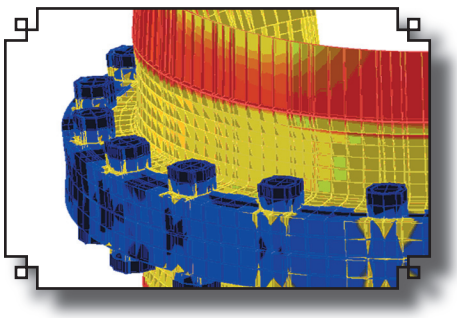
ASME Section VIII, Div. 1, App2

ASME BFJ

EN 13445

Axi/PRO Includes Procedures to Determine...

- Allowable external forces, moments or torsional loads on a flanged joint.
- Fugitive Emissions from a particular flanged joint to satisfy OSHA, DOT or the US Code of Federal Regulations requirements.
- The stress in the flange, bolt, hub and attached pipe, vessel or head. Calculations include the effect of the bolt holes, nonlinear gasket properties and gapped surfaces.
- Comparisons between European and American flange rules. EN 13445 Annex G, ASME BFJ, and ASME Appendix 2 flange rules are printed alongside FEA results.
- Stresses and rotations in DIN, API, ASME B16.5, B16.47 or user-defined flanges. (Flange Geometry Databases are included).
- Stresses in large heat exchanger models. Any number of bolts can be included in the FEA model.
- Liquid leak rates through flanged joints. (Based on tests conducted at the Paulin Research Group Lab in Houston, Texas).
- Effects of blind, matching, rigid or user-specified flange connections. The user can modify any automatic program generated geometry.



3-dimensional bolt/nut/flange interaction.

Gasket Factors & Parameters

Axi/PRO contains a database of gasket factors and parameters from ASME Appendix 2, EN-13445, and research performed at Paulin Research Group's testing facilities. In addition, a user can manually modify any of the parameters if default values are not already contained in AxiPRO's database.

Non-linear gasket properties from EN-13445 Annex G and PRG tests are used in the FEA models to better characterize the gasket behavior under load. You may review the gasket parameters used in Axi/PRO by simply selecting the various gaskets and reviewing the parameters that appear. If you do not already have a demo version of the program, we will be happy to provide one.

These gasket parameters are used in both the finite element calculation and the code rules output. AxiPRO calculates the results using three different design codes and automatically compares these to the finite element results. Stress results for ASME Appendix 2, En-13445 Annex G, and ASME Appendix BFJ are included.

Axi/PRO is a software program designed to analyze flanged joints and other axisymmetric geometries.

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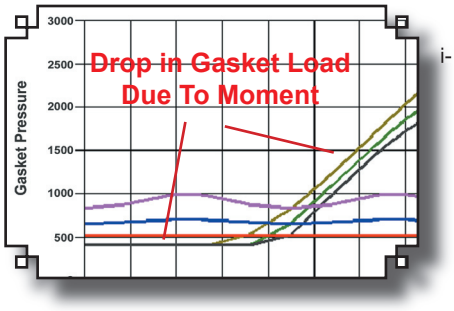
Flange Leakage Predictions

Leakage prediction is provided on two levels. First, leakage prediction in accordance with ASME BFJ is provided. However, ASME BFJ is limited to Helium leakage prediction. To supplement this, PRG has developed correlations to allow leakage prediction for other fluids and gases. The user may either choose from a provided list of gases and fluids, or enter their own physical properties.

Dimension of standard flanges in accordance with ASME B16.5, ASME B16.47, API 605, and DIN 2600 are provided. All the user needs to do is specify the nominal flange size. However, if a custom flange is required the user can specify their own unique dimensions.



Loads through the gasket surface used to determine leakage.

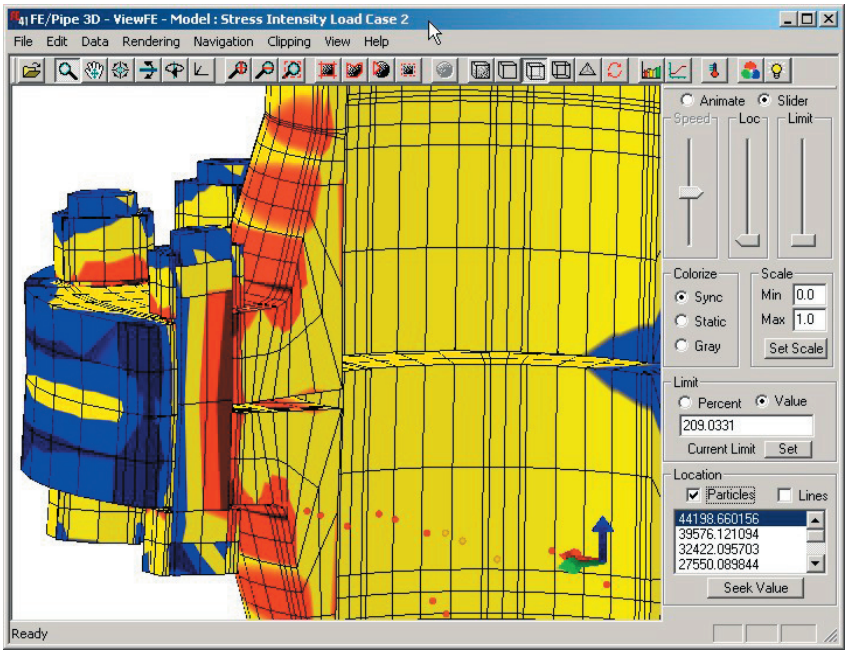
Quality Control for Axi/PRO

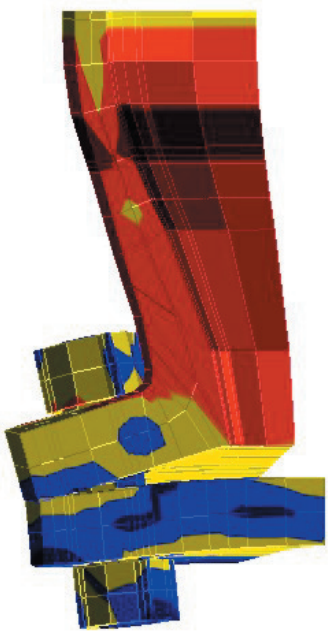
PRG contracted two third party consultants to check Axi/PRO calculations. The German consultant was engaged specifically to check the EN 13445 Annex G calculations We have also performed our own Appendix 2 calculation checks against Compress and Appendix 2 Calculations by hand. BFJ has been checked using the applicable examples in the back of the BFJ standard.

The table look-up values are solved using Waters original equations (so that the tables are not required). This method was introduced in Singh and Soler's text on Pressure Vessel and Heat Exchanger design.

On-site testing has included hydrogen and liquid leak testing. We have also performed gasket load studies to determine any non-linear behavior and creep in composition gaskets.

DirectX 3-D Viewer





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