Mastering Pipe Stress Analysis

Essential Techniques and Best Practices

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The Critical Role of Piping and Pipelines in Modern Infrastructure

Piping systems are essential to modern infrastructure, ensuring the efficient and safe transport of liquids and gases. **Pipelines** move oil, natural gas, and other fuels from production sites to consumers, reducing the risk of spills and lowering carbon footprints compared to other transportation methods like trucks or rail. They also distribute clean water and manage wastewater, providing communities with safe drinking water and effective sewage systems.

Piping systems ensure smooth operations within industries such as chemical manufacturing, power generation, food processing, and pharmaceuticals by transporting raw materials and process liquids and gases. These systems must be resilient and accurately designed to handle various loads and stresses over their lifetime and often involve high temperatures and pressures. A single component failure can lead to system shutdowns and loss of revenue, but more importantly safety issues causing a risk to life through toxic emissions, explosions, nuclear releases.

To mitigate these risks, **pipe stress engineers** must ensure the mechanical integrity and compliance to industry design codes of these systems as routed by the piping designer.

The Stress Engineer's Companion: Ensuring Integrity in Piping Systems

The impact of inaccurate pipe design carries significant costs and delays. To avoid these issues, many piping engineers around the world have chosen AutoPIPE®, a pipe stress analysis and design application, to create high quality and cost-effective pipe designs.

With AutoPIPE, design and analyze piping systems for a variety of projects, including:

- Nuclear and fossil power plants
- Chemical manufacturing and processing facilities
- Hydrogen production and transmission pipelines
- Thermosolar power plants
- Desalination plants
- Offshore FPSO and platform design
- Subsea manifolds, pipelines and risers
- Fire protection systems
- Oil refineries
- Cross-country oil and gas transmission pipelines
- Building services
- Water and wastewater treatment

Piping material can be metallic or non-metallic.

NUPIC, NIAC, and NRC Nuclear Users Audit AutoPIPE

Static loads

- Temperature
- Pressure
- Earthquake
- Wind
- Hydrotest
- Wave
- Snow
- Imposed displacements
- Buoyancy
- Fault crossing
- Soil liquefaction

Dynamic loads

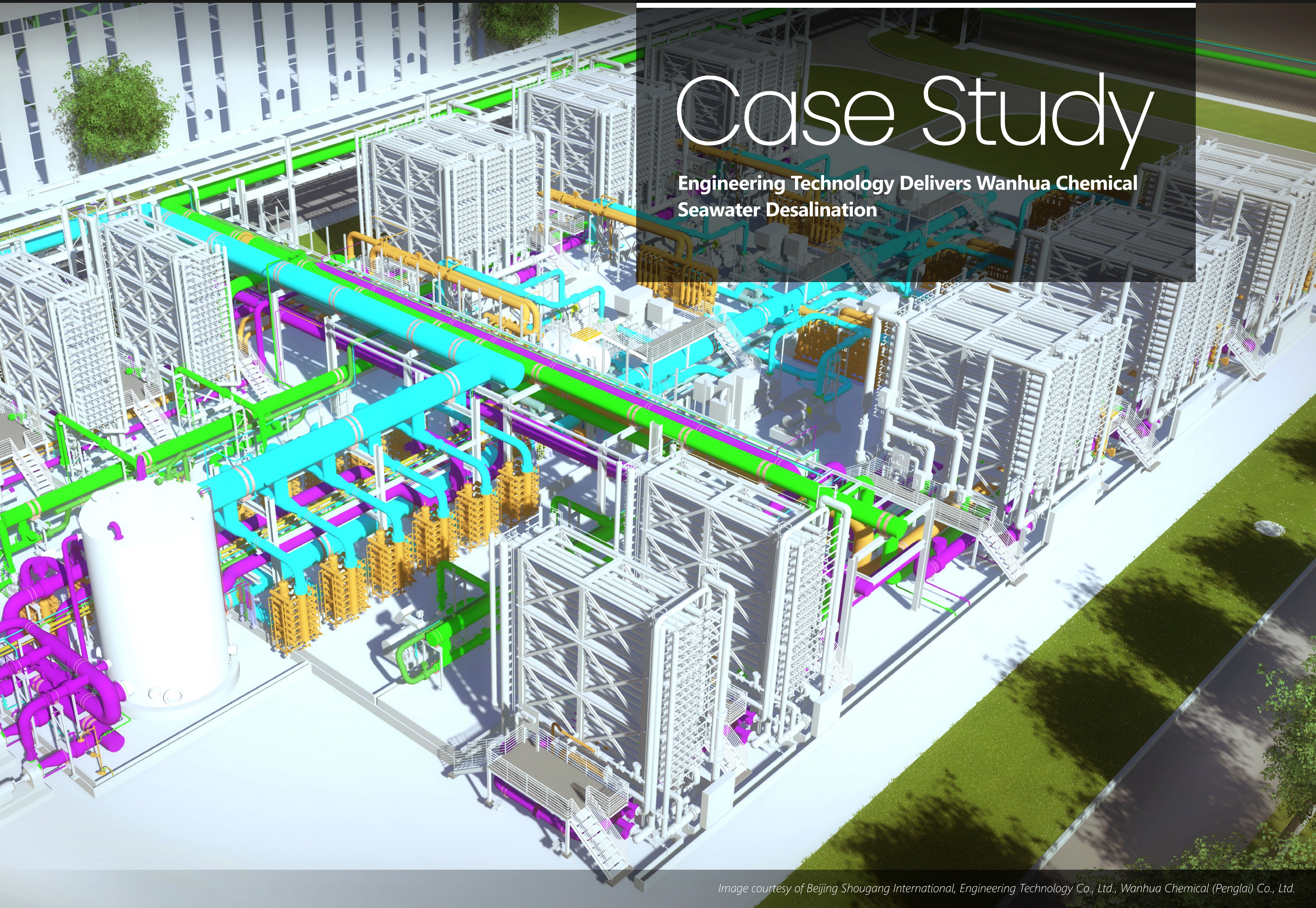
- Response spectrum
- Relief valve opening
- Seismic anchor movement
- Harmonics
- Water/steam hammer
- Time history loads
- Thermal transient
- Fatigue

Quality assurance you can trust:

NQA-1

ASME SETTING THE STANDARD

10 CFR 50 APPENDIX B



Case Study

Engineering Technology Delivers Wanhua Chemical Seawater Desalination

Image courtesy of Beijing Shougang International, Engineering Technology Co., Ltd., Wanhua Chemical (Penglai) Co., Ltd.

Comply with Global Standards

AutoPIPE offers many global standards so you can ensure your pipe stress analysis complies with various guidelines.

Piping codes

- ASME B31.1, B31.3, B31.4, and B31.8
- ASME Sec III, NB, NC, and ND [NCD from 2021]
- ASME B31,12 IP / PL Hydrogen,
- ASME NM for non-metallic
- European Standards EN13480 metallic, EN14692 nonmetallic
- ASME B31.4 Ch IX, B31.8 Ch VIII, DNVGL-ST-F101, CSA-Z622 offshore
- ASME B31.J SIFs and Flexibilities
- CAN/CSA-Z662

Rotating equipment loads

- Centrifugal pumps: API 610
- Centrifugal compressors: API 617
- Steam turbines: NEMA SM 23

Vessel local stresses

- API 650, PD5500, WRC107, WRC297, KHK

Nozzle flexibility calculation

- ASME, API 650, WRC 297, and Biljaard methods, Spherical, User

Flange check

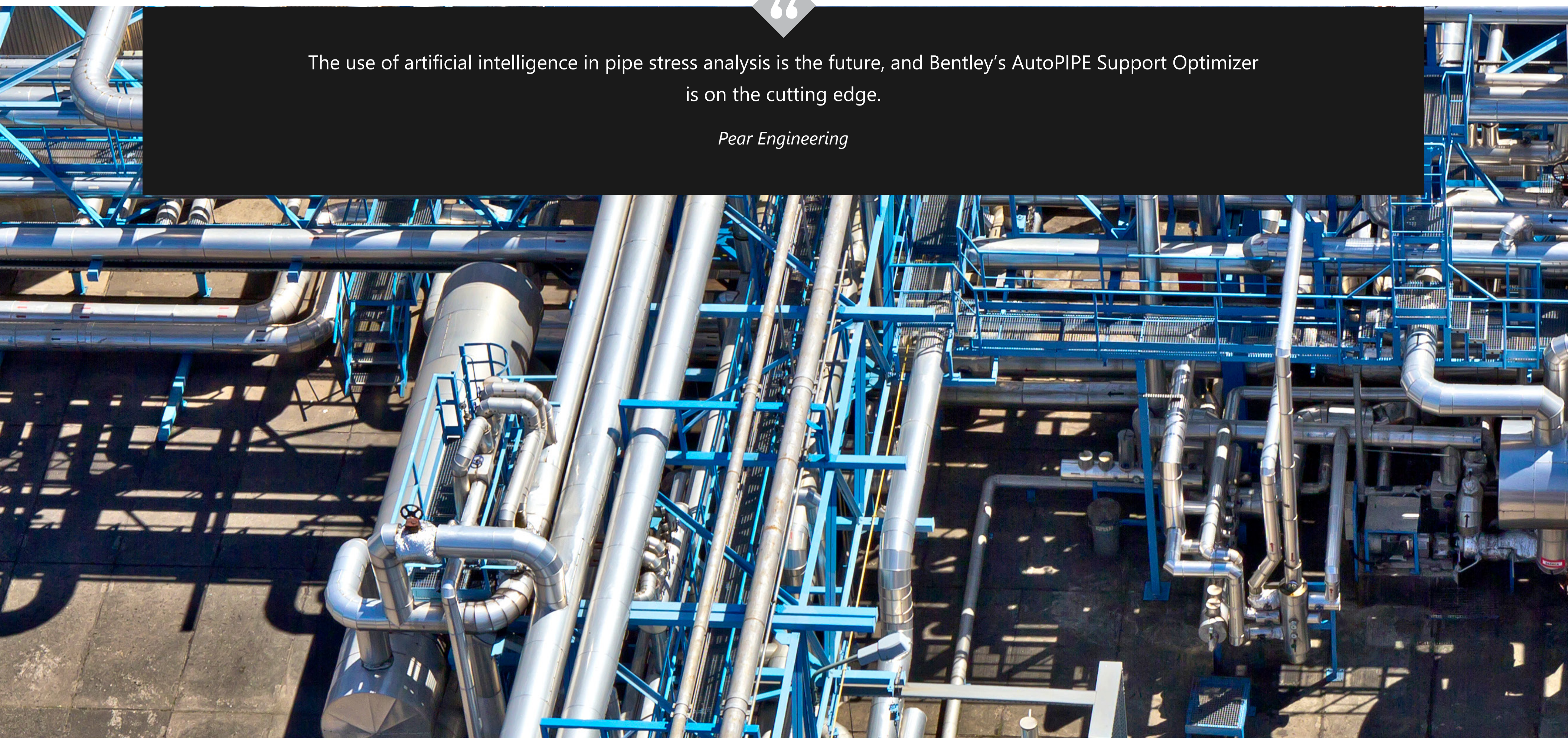
- ASME Section VIII, Division 1
- ASME Section VIII, Division 2
- ASME Section III, Appendix XI
- ANSI Check (Equivalent Pressure Method)
- European Flange EN 1591

AutoPIPE maintains legacy codes with most supporting codes years to the early 2000s ASME and all ASME III nuclear code years as far back as 1972. Further support for nuclear is provided with ASME B31.1 1967 and 1973 codes.

Optimize Your Support Configuration

Determining the optimal arrangement for pipe supports shouldn't take days or weeks for a pipe stress engineer. **AutoPIPE Advanced,** with its innovative **Support Optimizer,** leverages machine learning to swiftly evaluate multiple support options. This saves you time and money by ensuring the most efficient scenario.

> The use of artificial intelligence in pipe stress analysis is the future, and Bentley's AutoPIPE Support Optimizer is on the cutting edge.
>
> *Pear Engineering*



The **AutoPIPE Support Optimizer** operates in the background, testing thousands of possibilities, promoting the most effective solutions, and learning from failures to offer the optimal support configuration. It presents the most cost-effective options that comply with your specifications, allowing you to modify or enhance the solution based on your expertise.

> We successfully used the optimizer to rule out two other possible pipe layouts, and the client is very happy to have optimized the available choices.
>
> *Scano Safety & Integrity*

Increase Accuracy with ASME B31J

The beam theory idealization of a piping system often fails to capture the local stresses in bends, intersections, and joints. This issue is addressed through the introduction of **Flexibility & Stress Intensification Factors (SIF).**

Piping codes traditionally provide simple formulas to calculate these stress intensification factors for standard components first established by Markl in the 1950s. In their 2020 edition, B31.1 and B31.3 codes adopted the modern and more accurate approach of ASME B31J that had been first released in 2017 and updated in 2023.

ASME B31J aims to provide a standardized method for developing stress intensification factors and determining flexibility factors for metallic piping components. It also establishes sustained stress factors used in B31 piping analysis, enhancing the accuracy and reliability of stress evaluations.

AutoPIPE has implemented B31J as an internal module—just activate it with a simple click!

Simulate Real Behaviors

Load path-dependent analysis

In real-world scenarios, gravity loads are applied first, followed by temperature, pressure, or other loads. While the sequencing of these loads doesn't matter in a linear analysis, it becomes crucial in nonlinear analysis, which accounts for gaps, friction, or soil interactions.

Each load is applied considering the initial state of the supports from the previous load step, making the sequencing essential.

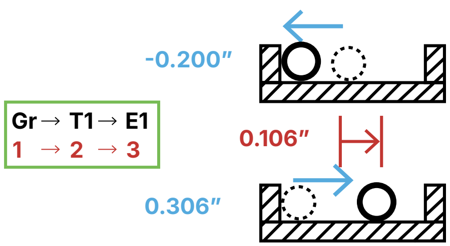
Peng recommends this load sequencing (operational) approach to accurately capture the real behavior of piping under operating conditions.

Friction case

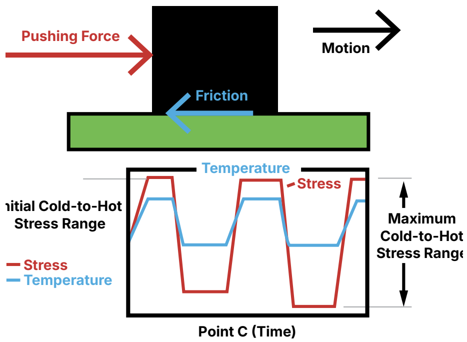
When a piping system returns to ambient conditions after an operating cycle, friction forces reverse their direction but maintain their magnitude. This can potentially double the stress and load ranges during cooldown. By simulating real behaviors with AutoPIPE, you can achieve more precise and reliable pipe stress analyses, ensuring the safety and integrity of piping systems.

AutoPIPE's load sequencing feature can simulate the entire load cycle, allowing for an accurate evaluation of the true stress range.

Result of load sequencing



Incremental analysis approach



Evaluate Multiple Scenarios

In plant design, performing pipe stress analyses to examine various loading conditions is crucial.

AutoPIPE enables engineers to define multiple analysis sets and reference these results from separate analyses during post-processing.

Certain piping codes, such as nuclear class NB, require different hot moduli to be applied to various thermal analysis sets.

A hot modulus static analysis allows you to calculate hot stresses corrected to an ambient or cold modulus condition, while support and equipment loads are calculated with a hot modulus reflecting a hot operating condition.

This means that you can simultaneously examine linear vs. nonlinear scenarios, hot vs. cold modulus, pressure vs. no-pressure stiffening, and a wide range of soil properties.

Ensuring Flange Integrity in Piping Systems

Flanges are crucial connection points between pipes and components like pumps and tanks, designed to handle the stresses and forces they encounter. For instance, a heat exchanger with a specific type of flange can be fabricated well in advance, even before knowing the loads from the piping assembly on that flanged joint. This can result in excessive loads on the flanged joint, potentially causing it to fail.

To prevent such failures, flange checks must be performed to ensure structural integrity, prevent damage, adhere to industry standards, avoid leaks, and optimize the overall performance and longevity of the piping system.

The AutoPIPE flange check module is fully integrated in the pipe stress workflow. The checks are updated with any change in the system.

AutoPIPE supports various methods for flange design:

- ASME Section VIII, Division 1
- ASME Section VIII, Division 2
- ASME Section III, Appendix XI
- ANSI Check (Equivalent Pressure Method)
- European Flange EN 1591

Rotating Equipment Checks

Rotating equipment involves sensitive elements. Excessive loads imposed by the piping on the equipment can deform machine parts and impact its operability. The stress engineer must ensure that the piping loads never exceed the allowable values.

AutoPIPE automatically takes forces and moments from all selected loads and user combinations to perform a rotating equipment analysis. This eliminates the need to manually enter loads for each operating condition.

Users can define custom rotating equipment using vendor-supplied allowable loads for different terminal anchor points. This flexibility allows for the analysis of specialized equipment.

Alternatively, AutoPIPE can check the equipment loads to relevant standards:

- **API 610** for centrifugal pumps
- **API 617** for centrifugal compressors
- **NEMA SM 23** for steam turbines

A detailed report provides all intermediate calculations and a summary to indicate whether the loads on the equipment are acceptable or not.

The AutoPIPE rotating equipment module is fully integrated in the pipe stress workflow. The checks are updated with any change in the system.

Close the Collaboration Gap

Many projects involve interdependent disciplines. Accurate and up-to-date information reduces the risk of errors and helps you make better decisions.

AutoPIPE provides tools to optimize project workflows and enhance collaboration:

Standard Data Exchange Formats
Easily import data using industry standards exchange formats like PCF from third-party CAD systems.

Bidirectional Links
Integrate with STAAD®/SACS™ models to transfer pipe loads and account for structural flexibility.

CAESAR II Compatibility
Import and export CAESAR II input files for seamless data transfer.

3D Export
Include the stress model in the CAD model for comprehensive visualization.

Spreadsheet Import
Import pipe routing coordinates using a spreadsheet format for efficient data handling.

Pressure Surge Analysis
Exchange data with PIPENET or AFT IMPULSE for accurate pressure surge transient analysis.

Nozzle Load Export
Export nozzle loads to AutoPIPE Vessel for the design of pressure vessels and heat exchangers.

Close the Collaboration Gap

Standard formats:

Import

- CAESAR II
- PCF
- PXF
- PDS neutral file
- ADLPipe

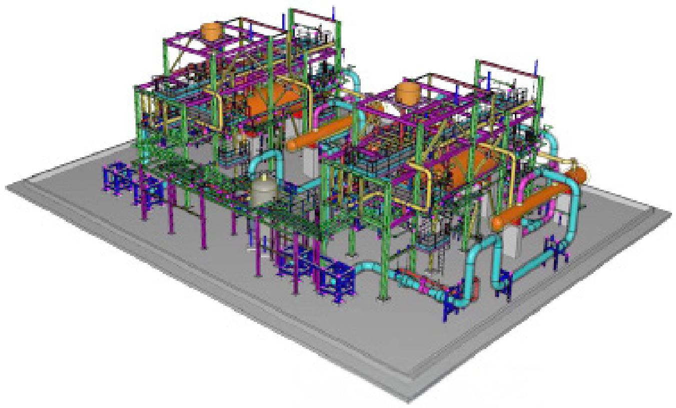
Export

- CAESAR II
- DXF
- PDMS XML
- DGN for hot clash detection
- SQLite

Specific applications

- STAAD and SACS
- PipeNet, AFT Impulse
- CAESAR II
- MicroStation®
- OpenPlant® and AutoPLANT®
- AutoPIPE Vessel
- AutoCAD
- Revit
- PDMS/E3D
- PDS
- SmartPlant 3D
- Inventor
- SolidWorks
- LICAD

A stress model referenced in the global CAD model to update the piping and easily locate supports.



AutoPIPE Data API is the most recent option to close the collaboration gap. Perfect for automations and customizations, the application programming interface (API) is a library of exposed functions allowing engineers access to AutoPIPE's internal functions and routines as well as its graphical commands. This API allows engineers and other users to link in-house or third-party applications with AutoPIPE. As an example, users could export automatically their results to a spreadsheet or read in pipe specs from another spreadsheet, generate automatically load combinations, and more!

The Pipeline to a Greener Future

As the world transitions towards more sustainable energy sources, the role of piping and pipe systems becomes increasingly critical. These systems are the backbone of energy infrastructure, ensuring the efficient and safe transport of various fluids and gases essential for energy production and distribution.

- **Efficient energy transport**
  Piping systems are designed to transport energy resources such oil, natural gas, and hydrogen over long distances withminimal loss
- **Integration with renewable**
  The future of energy lies in renewables like solar, wind, and geothermal power. Piping systems play a vital role in integrating these sources into the existing energy grid
- **Support for carbon capture and storage**
  Carbon capture and storage (CSS) is a key technology for reducing greenhouse gas emissions. Piping systems support CSS by transporting captured CO_2 from industrial sites to storage locations
- **Water management**
  Piping systems are used in desalination plants, wastewater treatment, and the distribution of clean water, all of which are essential for supporting sustainable communities and industries

Piping and pipe systems are indispensable to the future of energy and sustainability. As we move towards a more sustainable future, the importance of these systems will only continue to grow.

Better Pipe Stress Analysis Starts Here

Choose AutoPIPE to increase the accuracy of your pipe design projects. Save time and manage costs with easy-to-use software that helps you perform advanced analysis and design, leading to a more resilient and sustainable future.

By adopting new thinking and leveraging advanced technology, you can revolutionize your approach to piping engineering to stay ahead in a competitive industry.

Learn More   Chat with an Expert