CONCEPT

Piping Stress Analysis and Flexibility Design: Supports, Nozzle Loads and Expansion Joints

4 – 15 October 2027
London - Central London four-star



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Introduction:

Piping stress analysis decides whether hot lines crack at elbows, overload pump nozzles, lift off supports or leak at flanges once a plant heats up. Many projects still release stress-critical lines with incomplete input data, unchecked spring hangers and nozzle loads nobody compared with vendor limits. This Core Concept course trains piping and mechanical engineers to calculate flexibility, design restraint schemes, check equipment nozzles and expansion joints, and run a software stress model from load cases to a signed report. Participants produce a Pump Suction and Discharge Piping Stress Analysis Report.

Course Objectives:

- Select stress-critical lines and the right analysis method, and assemble the input data a stress model needs
- Evaluate sustained, displacement and occasional stresses against ASME B31.3 allowables using stress intensification factors
- Design flexibility and restraint schemes with loops, guides, line stops, anchors and spring hangers
- Check pump, compressor, turbine, vessel and tank nozzle loads against the applicable equipment standards and vendor limits
- Specify occasional load cases and select bellows expansion joints for lines where layout flexibility is not enough
- Build, run and troubleshoot a pipe stress software model and issue a stress report with support loads and hold points

Target Audience:

- Engineers who perform flexibility and code stress calculations on process and utility piping
- Piping layout designers who route lines and locate supports around equipment and pipe racks
- Rotating equipment engineers who accept or reject piping loads on pumps, compressors and turbines
- Static equipment engineers who review nozzle loads and local stresses on vessels, exchangers and tanks
- Pipe support and civil interface engineers who size supports from reported restraint loads
- Engineering checkers who review stress models and reports before line release

Course Outline:

Day 1: Stress Analysis Purpose, Scope and Stress-Critical Line Selection

- Piping Stress Analysis Objectives: Code Stress, Equipment Loads and Support Loads
- ASME B31.3 and ASME B31.1 Flexibility Analysis Requirements Compared
- Stress-Critical Line List Criteria: Temperature, Pipe Size and Connected Equipment
- Analysis Method Selection: Visual Review, Simplified Chart Methods and Computer Analysis
- Stress Input Data Register: Isometrics, Line List, Equipment Drawings and Design Conditions

Day 2: Code Stress Categories and Allowable Stress Basis

- Sustained Longitudinal Stress From Pressure, Weight and Insulation
- Displacement Stress Range and the Cyclic Reduction Factor
- Occasional Stress Evaluation and the Allowable Stress Increase Principle
- Stress Intensification and Flexibility Factors for Elbows, Tees and Branch Fittings
- Hot and Cold Allowable Stress Values From the Code Material Tables

Day 3: Thermal Growth, Layout Flexibility and Restraint Design

- Thermal Growth Calculation From Mean Expansion Coefficient Tables and Anchor Movements
- Expansion Loops, Offsets and Directional Changes as Flexibility Devices
- Restraint Functions: Resting Supports, Guides, Line Stops and Directional Anchors
- Variable and Constant Spring Hanger Selection and Load Variation Checks
- Friction, Gaps and Lift-Off Effects at Shoes, Trunnions and Dummy Legs

Day 4: Equipment Nozzle Load Limits for Rotating and Static Equipment

- API-610 Allowable Nozzle Loads for Centrifugal Pump Suction and Discharge
- API-617 Nozzle Force and Moment Checks for Compressors
- NEMA-SM23 Steam Turbine Nozzle Load Evaluation at Overview
- Vessel and Tank Nozzle Local Stresses With WRC 107/297 Concepts and API-650
- Air Cooler and Exchanger Nozzle Allowables Under API-661 and HEI at Overview

Day 5: Week-One Case Study: Hot Line Flexibility Hand Check

- Case Brief: Hot Hydrocarbon Line From Heater Outlet to Column Inlet
- Guided Cantilever Hand Calculation for a Candidate Expansion Loop
- Support Scheme Mark-Up on the Isometric: Guides, Stops and Spring Locations
- Nozzle Load Screening Against Vendor Allowable Tables
- Week-One Findings Review and Stress Input Data Gaps Log

Day 6: Occasional Loads and Dynamic Effects on Piping

- Wind Load Application on Elevated and Pipe Rack Lines
- Seismic Static Coefficient and Response Spectrum Methods at Overview
- Relief Valve Discharge Thrust in Open and Closed Systems
- Slug Flow and Water Hammer Force Estimation for Restraint Sizing
- Modal and Harmonic Analysis for Vibrating Lines at Overview

Day 7: Expansion Joints, Flange Leakage and Design Risk Controls

- Untied, Tied, Hinged and Gimbal Bellows Configurations and Pressure Thrust
- Bellows Selection Under EJMA Standards: Cycle Life, Spring Rate and Squirm
- Flange Leakage Checks at Overview: Equivalent Pressure and EN 1591 Methods
- Stress Model Design Review Checklist and Independent Checking
- Change Control for Rerouted Lines, Added Supports and Revised Design Conditions

Day 8: Software Modelling Workflow and Interdisciplinary Interfaces

- CAESAR II-Type Model Build: Nodes, Elements, Material and Section Properties
- Restraint, Hanger and Nozzle Flexibility Modelling in Pipe Stress Software
- Load Case Set-Up: Operating, Sustained, Expansion and Occasional Combinations
- Restraint Load Transfer to Civil and Structural Teams at Pipe Racks
- Nozzle Load Resolution Meetings With Rotating Equipment Vendors

Day 9: Results Review, Iteration and Stress Deliverable Metrics

- Code Compliance Output: Stress Ratios and Highest Stressed Nodes
- Displacement, Restraint Load and Spring Hanger Table Review
- Overstress Troubleshooting: Rerouting, Added Flexibility or Restraint Changes
- Stress Report Structure: Basis, Assumptions, Load Cases, Results and Hold Points
- Stress Deliverable Tracking: Line Coverage, Rework Rate and Checker Findings

Day 10: Capstone: Pump Suction and Discharge Stress Analysis

- Capstone Data Pack: Pump Datasheet, Isometrics and Operating Scenarios
- Model Build of Parallel Pump Lines With Running and Standby Cases
- Pump Nozzle Compliance and Support Scheme Optimisation
- Pump Suction and Discharge Piping Stress Analysis Report Drafting
- Capstone Presentation and Peer Challenge of Model Assumptions

Skills You Will Gain:

- Pipe Flexibility Calculation
- Code Stress Evaluation
- Restraint Scheme Design
- Spring Hanger Sizing
- Equipment Nozzle Load Assessment
- Bellows Expansion Joint Selection
- Pipe Stress Software Modelling
- Stress Report Preparation

Why Attend This Course:

- Return with a Pump Suction and Discharge Piping Stress Analysis Report built from a working software model
- Resolve nozzle overloads and support conflicts before they turn into site rework or equipment misalignment
- Defend a stress-critical line list and load case set to checkers, vendors and project managers
- Compare stress practice with engineers from refining, petrochemicals, gas processing, power and utilities

Conclusion:

Piping stress analysis protects equipment and supports only when inputs, load cases and restraint assumptions match how the line will operate. The first week moves from stress-critical line selection and code stress categories through thermal growth, restraint design and equipment nozzle limits to a hand-check case study. The second week adds occasional and dynamic loads, bellows expansion joints, flange leakage, software modelling, results review and reporting, and ends with a Pump Suction and Discharge Piping Stress Analysis Report ready for checking and line release.