CONCEPT

Rotordynamics and Machinery Dynamics: Critical Speeds, Rotor Stability and Balancing

22 – 26 November 2026
Dammam - Eastern Province five-star



Rotordynamics and Machinery Dynamics: Critical Speeds, Rotor Stability and Balancing

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Introduction:

Rotordynamics and machinery dynamics decide whether a high-speed compressor, turbine or pump train can run through its speed range without resonance, rubs or self-excited whirl, yet many design audits accept vendor critical speed and stability reports without challenge, and field teams chase recurring high vibration without a rotor-bearing model. This Core Concept course trains engineers to model rotor-bearing systems, read Campbell diagrams and unbalance response plots, judge separation margins and logarithmic decrement, check torsional trains and plan multi-plane balancing. Participants produce a Rotordynamic Design Review Report for a case compressor train.

Course Objectives:

- Build and validate a lateral rotor-bearing model from shaft geometry, mass-elastic data, bearing coefficients and support stiffness
- Interpret undamped critical speed maps, Campbell diagrams and unbalance response plots to confirm amplification factors and separation margins
- Assess rotor stability using logarithmic decrement, cross-coupled stiffness and fluid-film bearing and seal coefficients
- Review torsional natural frequencies, interference diagrams and coupling selection for motor-, turbine- and gear-driven trains
- Plan shop and field balancing using influence coefficient and modal methods for rigid and flexible rotors
- Diagnose high-speed rotor problems from orbit, Bode, polar and shaft centreline data and recommend design or operating corrections

Target Audience:

- Rotating equipment engineers who approve vendor rotordynamic reports for compressors, turbines and high-speed pumps
- Machinery reliability engineers who investigate recurring high vibration, rubs and bearing failures on critical trains
- Machine design and project engineers who specify bearings, seals, couplings and rotor geometry for new trains
- Turbomachinery field service engineers who carry out run-up tests and field balancing on flexible rotors
- Technical authority and asset integrity engineers who sign off rerates, overspeed changes and driver replacements

Course Outline:

Day 1: Rotor-Bearing System Modelling and Natural Frequencies

- Rotordynamic Vocabulary: Rigid and Flexible Rotors, Forward and Backward Whirl, Mode Shapes
- Jeffcott Rotor Model for Resonance, Phase Shift and Amplification Factor
- Rayleigh-Ritz and Dunkerley Estimates of First Lateral Natural Frequency
- Finite Element Beam Model Build: Stations, Shaft Sections, Impellers and Added Mass
- Gyroscopic Stiffening, Support Stiffness and Pedestal Flexibility Effects on Mode Frequencies

Day 2: Critical Speed Maps, Campbell Diagrams and API 684 Analysis Principles

- Undamped Critical Speed Map Versus Bearing Stiffness Range
- Campbell Diagram Construction with Excitation Orders and Interference Checks
- Unbalance Response Analysis: Unbalance Placement, Probe Locations and Bode Plots
- Separation Margin and Amplification Factor Criteria per API 684 Tutorial Principles
- Seal Clearance Check Against Predicted Rotor Deflection at Maximum Continuous Speed

Day 3: Fluid-Film Bearings, Seal Forces and Rotor Stability

- Plain, Lemon-Bore, Pressure-Dam and Tilting-Pad Journal Bearing Characteristics
- Eight Dynamic Coefficients: Direct and Cross-Coupled Stiffness and Damping Versus Sommerfeld Number
- Oil Whirl and Oil Whip Mechanisms with Subsynchronous Frequency Signatures
- Aerodynamic Cross-Coupling, Labyrinth and Damper Seal Coefficients and Swirl Brakes
- Logarithmic Decrement, Level I Screening and Level II Stability Analysis Workflow

Day 4: Torsional Train Analysis, Rotor Balancing and Troubleshooting Cases

- Torsional Mass-Elastic Model: Inertias, Shaft Stiffness, Couplings and Gear Ratios
- Torsional Interference Diagram, Motor Start-Up Transients and Variable Speed Drive Excitation
- Influence Coefficient Method for Single-Plane and Multi-Plane Field Balancing
- Modal Balancing of Flexible Rotors and High-Speed Shop Balancing Acceptance
- Orbit, Polar, Bode and Shaft Centreline Plot Reading for Rub, Thermal Bow and Instability Cases

Day 5: Case Compressor Train Rotordynamic Review

- Case Compressor Train Data Pack: Rotor Drawings, Bearing Data and Vendor Analysis Report
- Lateral Critical Speed and Unbalance Response Review Worksheet with Margin Findings
- Stability and Torsional Results Challenge Using Logarithmic Decrement and Interference Checks
- Run-Up and Coast-Down Test Data Comparison Against Predicted Response
- Rotordynamic Design Review Report Assembly and Peer Challenge

Skills You Will Gain:

- Rotor-Bearing Modelling
- Critical Speed Analysis
- Campbell Diagram Interpretation
- Bearing Coefficient Evaluation
- Rotor Stability Assessment
- Torsional Train Analysis
- Flexible Rotor Balancing
- Transient Vibration Data Interpretation

Why Attend This Course:

- Return with a Rotordynamic Design Review Report built on a case compressor train
- Challenge vendor rotordynamic reports with clear questions on margins, stability and model assumptions
- Resolve subsynchronous vibration, rubs and repeat balancing problems on high-speed machines with a model-based approach
- Compare design review and troubleshooting practice with peers from oil and gas, petrochemicals, power generation and process industries

Conclusion:

High-speed machine trains run reliably when their rotor-bearing systems are modelled correctly, their critical speeds are kept clear of the operating range, their bearings and seals leave enough damping and their torsional and balancing behaviour is checked. The course moves from rotor models and natural frequencies, through critical speed maps and Campbell diagrams, to bearing and seal coefficients, stability, torsional analysis and balancing. The final day applies these methods to a case compressor train and produces a Rotordynamic Design Review Report.