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COURSE BROCHURE

Rotordynamics, Critical Speeds, and Dynamic Balancing Training

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Registered in the United Kingdom and Saudi Arabia

Rotordynamics, Critical Speeds, and Dynamic Balancing Training

Rotordynamics, Critical Speeds, and Dynamic Balancing Training is a 1-week training course for lead rotating equipment engineers, machinery reliability specialists, asset integrity managers, and vibration technical authorities, and each participant prepares a Rotordynamic Evaluation Dossier. Unscheduled turbomachinery trips and severe shaft vibration jeopardise plant continuity across process sectors. Jupiter Prime Training delivers this course to give technical leaders rigorous analytical methods for rotating shaft dynamics.

Why Rotordynamics, Critical Speeds, and Dynamic Balancing Matters Now

High-energy turbomachinery operating across continuous process plants and power generation facilities faces severe operational demands, where rotor instability or resonant amplification causes catastrophic component failure and production downtime. Capital asset operators must reconcile extended turnaround intervals with flexible operating profiles that push shaft trains close to resonant thresholds. Engineering integrity requires precise evaluation of fluid-film bearing stiffness, aerodynamic cross-coupling, and torsional excitations. Rooted in API RP 684 guidelines for lateral critical speeds, stability, and torsional response, alongside ISO 20816-3:2022 vibration evaluation zones and ISO 21940-11:2016 balance tolerances, structured rotordynamic governance ensures asset health and unbalance mitigation across lifecycle stages.

Who Gains Most from Rotordynamics, Critical Speeds, and Dynamic Balancing

- Rotating equipment specialists responsible for auditing vendor lateral response predictions, stability analyses, and machinery protection boundaries
- Plant reliability leaders tasked with diagnosing complex sub-synchronous instability, shaft deflection anomalies, and bearing wear patterns
- Condition monitoring technical authorities managing relative shaft vibration instrumentation, phase reference tracking, and spectral diagnostics
- Asset integrity managers establishing risk-based overhaul scopes and dynamic balance tolerances for high-speed compressor and turbine trains

A cross-functional machinery management group comprising rotating equipment specialists, condition monitoring analysts, and mechanical turnaround leads gains most, as unified attendance aligns technical criteria for resonance margins, bearing retrofits, and multi-plane balancing decisions.

Rotordynamics, Critical Speeds, and Dynamic Balancing Capabilities

Participants acquire precise diagnostic methods, analytical modelling practices, and dynamic correction techniques necessary to protect critical rotating assets across harsh operating regimes.

- Assess lateral critical speed maps and undamped mode shapes — separation margin verification against continuous operational speeds
- Weigh aerodynamic cross-coupling against bearing damping coefficients — stability threshold validation and subsynchronous whirl mitigation
- Calculate multi-plane influence coefficients using trial weight vectors — residual unbalance reduction to international balance quality grades
- Design lumped-parameter mass-elastic models for coupled drive trains — torsional natural frequency clearance from harmonic electrical excitations
- Specify probe locations and threshold boundaries under API Standard 670 — continuous shaft relative displacement and casing monitoring integrity
- Evaluate broadband casing and relative shaft vibration amplitudes — zone compliance classification during commissioning and transient runs

Key Rotordynamics, Critical Speeds, and Dynamic Balancing Terms

- Campbell Diagram — A plot tracking rotor natural frequencies against rotational speed to identify critical speed interference points and required separation margins.
- Logarithmic Decrement — A dimensionless parameter quantifying decay rate of free oscillations, used to evaluate rotordynamic stability against subsynchronous aerodynamic or fluid whirl.
- Cross-Coupled Stiffness — Asymmetric fluid-film or aerodynamic forces acting perpendicular to rotor displacement that promote self-excited forward subsynchronous whirl and instability.
- Influence Coefficient — A complex mathematical vector defining the vibration response change at a measurement plane caused by a unit unbalance weight.
- Tilting-Pad Journal Bearing — A hydrodynamic fluid-film bearing configuration providing asymmetric stiffness and damping characteristics to suppress oil whirl phenomena in high-speed rotors.
- Torsional Natural Frequency — An angular natural oscillation frequency of a shaft train driven by rotational mass moments of inertia and torsional stiffness.

Rotordynamics, Critical Speeds, and Dynamic Balancing Day by Day

Day 1: Lateral Rotordynamic Fundamentals and Critical Speed Mapping

- Timoshenko Beam Finite Element Modelling — Discretising Shaft Geometry For Lateral Dynamic Response Evaluation
- Undamped Critical Speed Maps — Evaluating Support Stiffness Influence On Rotor Natural Frequencies
- Campbell Interference Diagrams — Identifying Resonant Intersections Across Operating Speed Envelopes
- Separation Margin Criteria Under API RP 684 — Verifying Clearance Margins For Variable Speed Turbomachinery
- Shaft Mode Shape Visualisation — Determining Node Locations And Optimal Probe Placement Planes

Day 2: Rotor Stability, Bearing Dynamics, and Fluid-Film Mechanics

- Tilting-Pad Journal Bearing Dynamic Coefficients — Calculating Directional Stiffness And Damping Matrix Parameters
- Aerodynamic Cross-Coupled Stiffness Evaluation — Assessing Destabilising Forces In High-Pressure Centrifugal Impellers
- Logarithmic Decrement Stability Thresholds — Establishing Damped Eigenvalue Margins Under Varying Gas Densities
- Subsynchronous Oil Whirl and Whip Diagnostics — Differentiating Boundary Lubrication Instabilities From Structural Resonances
- Annular Gas and Liquid Damper Seals — Enhancing Rotordynamic Stability In High-Differential Pressure Applications

Day 3: Torsional Dynamics and Drive Train Resonance Analysis

- Lumped-Parameter Mass-Elastic Modelling — Formulating Inertia And Torsional Stiffness Branch Matrices
- Torsional Natural Frequency Calculations — Mapping Shaft Line Angular Resonances Against Drive Harmonics
- Campbell Diagrams for Torsional Excitations — Assessing Grid Harmonics And Reciprocating Machine Interferences
- Transient Start-Up Torque Simulation — Evaluating Peak Stress Accumulation In Couplings During Motor Acceleration
- Torsional Vibration Damper Selection — Mitigating Angular Resonance Stresses In Mechanically Coupled Driver Packages

Day 4: Vibration Diagnostics and Signal Processing Methods

- Radial Shaft Relative Transducer Arrangements Under API Standard 670 — Setting Standardised Orthogonal Probe Orientations
- Orbit and Shaft Centerline Trajectory Analysis — Identifying Precession Patterns And Journal Equilibrium Offsets
- Bode and Polar Nyquist Response Diagrams — Measuring Critical Speed Amplification Factors During Deceleration
- Full-Spectrum Cascade Plot Evaluation — Tracking Subsynchronous And Superharmonic Trends Across Operational Speeds
- Broadband Evaluation Criteria Under ISO 20816-3:2022 — Classifying Operating Vibration Severity Zones Across Machinery Types

Day 5: Dynamic Balancing Practice and Machinery Acceptance

- Static-Couple Resolution Methods — Separating Dynamic Unbalance Into Independent Static And Couple Vectors
- Multi-Plane Influence Coefficient Balancing — Calculating Correction Masses For Flexible Rotors Operating Above First Critical
- Residual Unbalance Verification Under ISO 21940-11:2016 — Determining Admissible Residual Unbalance For Balance Quality Grades
- Vendor Factory Acceptance Test Auditing — Validating Unbalance Response Sensitivity Against Dynamic Design Calculations
- Rotordynamic Evaluation Dossier — Consolidating Lateral Stability Findings, Balancing Calculations, And Diagnostic Checklists

Applying Rotordynamics, Critical Speeds, and Dynamic Balancing After the Course

- Audit original equipment manufacturer rotordynamic design reports for upcoming capital compressor trains against API RP 684 separation margins and logarithmic decrement thresholds before mechanical run testing.
- Implement structured multi-plane influence coefficient balancing protocols during major plant turnarounds, verifying that residual unbalance levels conform strictly to ISO 21940-11:2016 balance quality grades.

Rotordynamics, Critical Speeds, and Dynamic Balancing Questions FAQ

What is Rotordynamics, Critical Speeds, and Dynamic Balancing and why does it matter now?

Rotordynamics, Critical Speeds, and Dynamic Balancing evaluates the dynamic behaviour of rotating shafts, fluid bearings, and balancing states. It matters now because modern industrial plants push rotating equipment to higher operating speeds and extended intervals, where uncontrolled critical speed resonance or fluid instability causes destructive asset failure.

Which roles gain most from Rotordynamics, Critical Speeds, and Dynamic Balancing?

Rotating equipment engineers, machinery reliability specialists, asset integrity managers, and vibration technical authorities gain most. The material provides the mathematical foundations and diagnostic methods necessary to audit vendor rotordynamic designs, resolve stubborn unbalance, and prevent severe subsynchronous vibration across critical plant turbomachinery.

How does this course differ from general vibration analysis courses?

General vibration analysis courses focus primarily on basic route data collection and spectral fault detection for common plant machinery. This course delves into lateral critical speed modelling, bearing dynamic coefficients, torsional mass-elastic systems, and multi-plane balancing for high-speed flexible rotors governed by API and ISO standards.

What practical artefact do participants bring back to their organisation?

Participants return with a completed Rotordynamic Evaluation Dossier. This documented technical framework provides step-by-step methodologies for validating vendor rotordynamic reports, verifying logarithmic decrement stability margins, executing field multi-plane balancing calculations, and establishing baseline vibration acceptance criteria under ISO 20816-3:2022.

Rotordynamics, Critical Speeds, and Dynamic Balancing: The Way Forward

The Rotordynamic Evaluation Dossier equips technical teams to audit turbomachinery design reports and guide complex field balancing interventions. Machinery reliability authorities and rotating asset leaders use it to validate equipment design changes and overhaul criteria. Engineering groups should revisit the dossier after its first operational turnaround, updating site empirical damping values and baseline vibration profiles against continuous operating telemetry.