Advanced Rotordynamics and Machinery Dynamics Training Course

6 – 10 September 2027
Barcelona (Spain)



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Ref: 13_239111 **Date:** 6 – 10 September 2027 **Location:** Barcelona (Spain) **Fees:** 5900 GBP

Introduction:

Advanced rotordynamics and machinery dynamics is the engineering discipline that evaluates rotating shaft behaviour, gyroscopic effects, fluid-film bearing interactions, and structural resonance to prevent catastrophic turbomachinery failure. This one-week course equips rotating equipment engineers to evaluate lateral and torsional dynamic models, interpret non-stationary vibration phenomena, and produce a Rotordynamic Analysis and Vibration Diagnostics Verification Dossier. Taught at expert depth through a hands-on modelling build, delegates apply technical methodologies from API RP 684, a recommended practice governing rotordynamic tutorials, lateral critical speeds, and rotor balancing across process turbomachinery. Engineering specialists master advanced rotordynamics and machinery dynamics with Blackbird Training Centre to secure asset mechanical integrity.

Course Objectives:

- Distinguish between undamped critical speed maps and damped lateral unbalance responses to determine real rotor amplification factors and operational separation margins.
- Apply API 617 lateral stability criteria using logarithmic decrements to verify compressor rotor stability against destabilising aerodynamic cross-coupling forces.
- Interpret transient vibration data including Bode plots, polar Nyquist curves, and dynamic shaft centerline migration inside hydrodynamic bearings.
- Compare torsional natural frequencies against motor electrical excitation harmonics to prevent drivetrain fatigue failure during transient starts and variable-frequency operation.
- Select appropriate annular seal geometries, swirl brakes, and tilt-pad bearing preloads to suppress subsynchronous rotor instability in high-pressure rotating equipment.
- Justify rigid-rotor versus flexible-rotor balancing protocols using ISO 21940-11 to establish permissible residual unbalance limits across multi-stage machine trains.

Target Audience:

- Rotating equipment engineering teams responsible for turbomachinery asset integrity who must choose between tilt-pad bearing redesigns and annular seal modifications.
- Condition monitoring and diagnostic specialists responsible for vibration analysis who must judge whether high subharmonic vibration indicates oil whip or aerodynamic cross-coupling.
- Mechanical package design engineers responsible for capital project equipment procurement who must evaluate vendor lateral and torsional dynamic audit submissions.
- Plant reliability leaders responsible for critical turbomachinery availability who must decide on safe operational margins during unexpected critical speed shifts.



Course Outline:

Day 1: Lateral Rotordynamic Foundations and Critical Speed Behaviour

- Undamped Critical Speeds vs Damped Lateral Responses: Calculating Real Shaft Deflection Profiles and Amplification Factors
- Rotor Shaft Finite Element Modelling: Discretising Rotor Masses and Elastic Beam Elements Accurately
- Rigid-Body Modes vs Flexible Bending Modes: Determining Shaft Gyroscopic Stiffening Across High Speeds
- Hydrodynamic Bearing Dynamic Coefficients: Calculating Direct and Cross-Coupled Stiffness and Damping Parameters
- API 610 Critical Speed Margins: Evaluating Separation Margin Compliance on Multi-Stage Centrifugal Pumps

Day 2: Stability Assessments and Dynamic Standard Frameworks

- API 617 Level 1 vs Level 2 Stability Analyses: Calculating Aerodynamic Cross-Coupling and Alford Excitation Forces
- Logarithmic Decrement Evaluation: Establishing Rotor Damping Adequacy to Prevent Destabilising Lateral Oscillations
- Labyrinth Seals vs Honeycomb Annular Seals: Mitigating Destabilising Circumferential Flow Using Swirl Brakes
- Tilt-Pad Bearing Optimization: Evaluating Pad Preload, Pivot Configuration, and Load-Between-Pad Orientation Limits
- API RP 684 Standard Criteria: Standardising Lateral Stability Protocols Across Critical Turbomachinery Trains

Day 3: Advanced Transient and Multi-Channel Vibration Diagnostics

- Full Spectrum Orbits vs Cartesian FFT Spectra: Distinguishing Forward Precession from Reverse Precession Vectors
- Bode Plots vs Polar Nyquist Displays: Identifying Rotor Critical Speeds and Structural Phase Transitions
- Dynamic Shaft Centerline Tracking: Assessing Hydrodynamic Oil Film Thickness and Journal Elevation Trajectories
- API 670 Proximity Probe Instrumentation: Calibrating Radial Vibration Sensors and Keyphasor Phase Reference Pickups
- ISO 20816-3:2022 Severity Thresholds: Categorising Steady-State Industrial Vibration Amplitudes Across Rigid Foundation Zones



Day 4: Torsional Train Dynamics and Rotor Instability Mechanisms

- Hydrodynamic Oil Whirl vs Destabilising Oil Whip: Diagnosing Fluid-Film Bearing Instability and Journal Trapping
- Torsional Drivetrain Modelling: Converting Multi-Body Rotating Equipment Trains into Lumped-Inertia-Spring Networks Accurately
- Variable Frequency Drive Harmonics vs Line-Frequency Excitations: Evaluating Inter-Harmonic Dynamic Torque Pulsations on Couplings
- Transient Motor Start-Up Torque Spikes: Calculating Drivetrain Shaft Fatigue Accumulation During Across-the-Line Starting
- Flexible Rotor Balancing Protocols: Applying ISO 21940-11 Balance Grades Across High-Speed Multi-Plane Assemblies

Day 5: Modelling Build of the Rotordynamic Verification Dossier

- Campbell Diagram Predictions vs Measured Coast-Down Responses: Reconciling Analytical Natural Frequencies with Physical Test Data
- Lateral Unbalance Response Simulation: Modelling Unbalance Mass Distributions to Verify Dynamic Clearance Safety Margins
- Compressor Subsynchronous Stability Verification: Evaluating Cross-Coupled Bearing Coefficients Under Full Operating Density and Pressure
- Drivetrain Torsional Resonance Audit: Verifying Coupling Stiffness Selections to Eliminate Operating Speed Interference Clashes
- Final Dossier Consolidation: Completing the Rotordynamic Analysis and Vibration Diagnostics Verification Dossier

Skills You Will Gain:

- Lateral Critical Speed Calculation
- Campbell Diagram Evaluation
- Logarithmic Decrement Assessment
- Dynamic Orbit Vector Interpretation
- Transient Bode Plot Analysis
- Torsional Natural Frequency Modelling
- Multi-Plane Rotor Balancing
- Annular Seal Stability Optimization



Why Attend This Course:

- From relying on basic steady-state overall vibration amplitudes to diagnosing complex non-stationary rotor dynamics using orbit vectors, Bode plots, and full spectrum analysis.
- From treating critical speed calculation as vendor proprietary data to independently auditing lateral unbalance responses and stability margins against API RP 684 standards.
- From reacting to unexplained high subsynchronous vibrations in high-pressure compressors to designing out aerodynamic cross-coupling instability using tilt-pad bearings and swirl brakes.
- From managing fragmented diagnostic spreadsheets to completing an audit-ready Rotordynamic Analysis and Vibration Diagnostics Verification Dossier.

Conclusion:

Advanced rotordynamics and machinery dynamics gives engineers the analytical framework required to model, evaluate, and control dynamic vibration behaviours across high-performance rotating machinery trains. The course provides clear technical distinctions between undamped natural frequencies and damped response peaks, internal bearing oil whirl versus structural oil whip, and steady-state lateral bending modes versus transient drivetrain torsional oscillations. Structured for operational rotating equipment specialists and asset integrity engineers operating at expert depth, this curriculum delivers the engineering rigor required to safeguard critical process turbomachinery against operational instability and resonance failures.

Frequently Asked Questions FAQ:

What is advanced rotordynamics and machinery dynamics?

Advanced rotordynamics and machinery dynamics is the specialised discipline that models the dynamic behaviour of rotating shafts, fluid-film bearings, seals, and supporting structures. It identifies critical speeds, torsional vibrations, and destabilising aerodynamic forces to ensure reliable machinery operation without destructive mechanical resonance.

What is the difference between oil whirl and oil whip in advanced rotordynamics and machinery dynamics?

Oil whirl is a fluid-film instability where the journal precesses at roughly 0.42 to 0.48 times running speed, shifting with rotor speed, whereas oil whip occurs when whirl frequency locks onto the rotor first flexible critical speed, causing uncontrollable subsynchronous vibrations.

Which standards govern advanced rotordynamics and machinery dynamics?

The course applies API RP 684 for rotordynamic design tutorials, API 617 for compressor stability screening and aerodynamic cross-coupling, API 610 for centrifugal pump vibration and separation margins, API 670 for vibration protection systems, and ISO 20816-3:2022 and ISO 21940-11:2016 for evaluation thresholds.



Is this advanced rotordynamics and machinery dynamics course appropriate for condition monitoring engineers?

Yes, this course is tailored for condition monitoring engineers and rotating equipment specialists who manage critical turbomachinery. It equips participants at expert depth to diagnose complex transient events, evaluate Campbell diagrams, calculate damping logarithmic decrements, and verify rotordynamic models against empirical field vibration spectra.

