Gas Turbine Operation, Control and Maintenance: Hot Gas Path Inspection and Outage Planning

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Introduction:

Gas turbines that drive generators, pipeline compressors and pumps lose output and availability when compressors foul, combustion hardware cracks, hot gas path coatings spall and trips go undiagnosed, while inspections are often scheduled by habit rather than by evidence. This Core Concept gas turbine course builds the expert skills to operate the machine inside its limits, read its control and protection behaviour, track degradation and scope combustion, hot gas path and major inspections. Participants produce a Gas Turbine Inspection and Outage Plan for a unit they are responsible for.

Course Objectives:

- Analyse gas turbine performance through the Brayton cycle, relating pressure ratio, firing temperature and ambient conditions to output and efficiency
- Operate start-up, loading, shutdown and cooldown sequences within the speed, temperature and vibration limits of industrial and aeroderivative machines
- Interpret governor, exhaust temperature and protection logic to diagnose trips, failed starts and control instability
- Diagnose compressor, combustor and hot gas path deterioration from performance trends, proximity probe data and borescope findings
- Determine combustion, hot gas path and major inspection scope and intervals from operating hours, starts, trips and parts condition
- Create a Gas Turbine Inspection and Outage Plan with schedule, spares, contractor roles and post-outage acceptance checks

Target Audience:

- Engineers responsible for the performance and reliability of gas turbine generator sets and mechanical drives
- Senior technicians responsible for gas turbine start-up, shutdown and routine operating checks
- Maintenance engineers responsible for combustion, hot gas path and overhaul work scopes
- Control and instrumentation staff responsible for turbine control, protection and fuel system devices
- Condition monitoring staff responsible for vibration, borescope and performance trend reviews on gas turbines

Course Outline:

Day 1: Gas Turbine Thermodynamics, Configurations and Duty

- Brayton Cycle Stations: Isentropic Compression, Constant-Pressure Heat Addition and Expansion
- Pressure Ratio and Turbine Inlet Temperature Effects on Specific Work and Thermal Efficiency
- Heavy-Duty Industrial Versus Aeroderivative Machines: Construction, Load Response and Duty
- Single-Shaft Generator Drives Versus Free Power Turbine Mechanical Drives
- Machine Baseline Datasheet: Rating Point, Firing Limits and Site Ambient Derate

Day 2: Compressor, Combustor and Turbine Sections

- Axial Compressor Staging, Variable Inlet Guide Vanes and Bleed Valve Scheduling
- Compressor Stall and Surge Margin on the Gas Turbine Operating Line
- Can, Can-Annular and Annular Combustor Layouts with Crossfire Tubes and Igniters
- Lean Premixed Low-Emission Combustion Modes, Flame Stability and Combustion Dynamics
- Turbine Nozzle and Blade Staging, Internal Cooling Passages and Tip Clearance Control

Day 3: Hot Gas Path Materials, Fuel Systems and Operating Envelope

- Nickel Superalloys, Directionally Solidified and Single-Crystal Blades and Creep Resistance
- Thermal Barrier Coating Stack: Bond Coat, Thermally Grown Oxide and Zirconia Top Coat
- Coating Failure Modes: Spallation, Oxidation and CMAS Attack from Ingested Sand
- Fuel Gas Conditioning: Superheat Margin, Filtration and Heating Value Variation Checks
- Liquid Fuel Systems: Flow Divider, Atomising Air, Purge and Dual-Fuel Transfer

Day 4: Start-Up, Governor Control, Protection and Auxiliaries

- Start Sequence Walkthrough: Starting Means, Purge, Ignition, Acceleration and Synchronisation
- Governor Control Loops: Droop, Isochronous, Load and Exhaust Temperature Control with Minimum Value Select
- Protection Functions: Overspeed, Flame Detection, Exhaust Temperature Spread and Trip Logic Testing
- Lube Oil, Hydraulic Oil and Emergency Pump Systems with Accumulator Checks
- Inlet Air Filtration Stages, Differential Pressure Monitoring and Enclosure Ventilation and Fire Protection

Day 5: Week-One Integration: Guided Operating Case Study

- Case Study: Hot Day Output Loss and Rising Exhaust Temperature on a Generator Unit
- Case Study: Failed Start and Flame-Out on a Pipeline Compressor Driver
- Operating Limit Map Build: Speed, Load, Exhaust Temperature and Vibration Alarm Settings
- Shutdown and Cooldown Procedure: Turning Gear, Rotor Bow and Hot Restart Risk
- Week-One Operating Envelope Summary Sheet Review

Day 6: Performance Degradation, Compressor Washing and Condition Monitoring

- Recoverable Versus Non-Recoverable Degradation: Fouling, Erosion, Seal Wear and Clearance Growth
- Online and Offline Compressor Wash Procedures, Detergent Selection and Effectiveness Checks
- Corrected Parameter Trending: Compressor Efficiency, Exhaust Temperature and Fuel Flow
- Proximity Probe Signatures: Orbit, Shaft Centreline and Bode Plots During Run-Up
- Borescope Access Ports, Defect Classification and Image Reporting Practice

Day 7: Inspection Types, Intervals and Parts Life Risk

- Combustion Inspection Scope: Fuel Nozzles, Liners, Transition Pieces and Crossfire Tubes
- Hot Gas Path Inspection Scope: First-Stage Nozzles, Blades, Shrouds and Coating Condition
- Major Overhaul Scope: Compressor Blading, Rotor Inspection and Casing Alignment
- Equivalent Operating Hours and Start-Based Interval Counting with Trip Factors
- Repair, Refurbish or Replace Decisions with Quality Hold Points for Returned Parts

Day 8: Outage Organisation, Contractors and Communication

- Outage Work Breakdown Structure and Critical Path Schedule
- Manufacturer, Service Contractor and Repair Shop Responsibility Matrix
- Capital Spares Pool and Rotable Parts Logistics Plan
- Permit to Work, Energy Isolation and Confined Space Controls Inside the Turbine Enclosure
- Outage Readiness Review and Daily Progress Reporting to Plant Management

Day 9: Post-Outage Verification, KPIs and Continuous Improvement

- Post-Outage Commissioning Checks: Crank, Purge, Firing, Overspeed and Load Tests
- Before and After Performance Comparison with Corrected Output and Efficiency
- Gas Turbine Reliability KPIs: Starting Reliability, Forced Outage Rate and Mean Time Between Trips
- Repeat Trip Root Cause Analysis Using Fishbone and Five Whys on Event Logs
- Fixed Interval Versus Condition-Based Inspection Scheduling Benchmark

Day 10: Capstone: Gas Turbine Inspection and Outage Plan

- Unit Condition Assessment from Participant Trend and Borescope Data
- Inspection Scope Selection and Interval Justification Worksheet
- Outage Schedule, Resource Loading and Spares Plan Drafting
- Gas Turbine Inspection and Outage Plan Presentation
- Peer Challenge Panel and Action Register Finalisation

Skills You Will Gain:

- Gas Turbine Performance Analysis
- Turbine Control Logic Interpretation
- Trip and Failed Start Diagnosis
- Hot Gas Path Condition Assessment
- Borescope Findings Evaluation
- Compressor Wash Planning
- Inspection Interval Calculation
- Outage Scheduling and Spares Planning

Why Attend This Course:

- Return with a Gas Turbine Inspection and Outage Plan built on trend and inspection data from your own unit
- Justify each combustion, hot gas path or major inspection to management with hours, starts and parts condition evidence
- Cut repeat trips and failed starts by reading what the control and protection system is actually telling you
- Compare operating and maintenance practice with peers running generator sets and mechanical drives in power, oil and gas and industrial plants

Conclusion:

Gas turbine availability depends on operating the machine inside its limits, understanding what its controls do and inspecting the right parts at the right time. Week one moves from Brayton cycle performance and machine sections through hot gas path materials, fuel systems, start-up, governor control, protection and auxiliaries to a guided case study. Week two adds degradation and condition monitoring, inspection scopes and intervals, outage organisation and post-outage KPIs, and closes with a Gas Turbine Inspection and Outage Plan ready for plant review.