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Steam Turbine Generator
Failure Modes, Troubleshooting and Industry Proven Repair Methods

Course Description

This 2 ½ day-course is designed for plant maintenance and operations personnel, consultants, loss control engineers, equipment OEMs and central staff responsible for fossil/aero-derivative, nuclear, simple cycle and combined cycle plant reliability. Our instructors will focus on risk informed repair and life extension strategies which have a significant bottom line impact. The course will also offer best practices and maintenance considerations for flexible operation which typically includes more cycling, lower minimum loads, and greater capacity ratings. All modules are supplemented with current case studies demonstrating the applied techniques.

Course Training Modules

MODULE 1 – Steam Turbine Design, Failure Modes, and Advanced Troubleshooting

- *Industry failure statistics*-locating the areas of highest risk
- *Steam turbine design features* – key features for your unit and technology advancements
- *Common failure modes for steam turbines* –explained, impacted components, how to manage and impact of flexible operations on each failure mode
    - ✓ High Cycle Fatigue
    - ✓ Low Cycle Fatigue
    - ✓ Stress Corrosion Cracking
    - ✓ Solid Particle Erosion
    - ✓ Water Droplet Erosion
    - ✓ Creep and Embrittlement
    - ✓ Foreign Object Damage
- *Advanced Troubleshooting* – detecting and mitigating before manifesting into a forced outage
- *Turbine vibration* – unlocking the secrets of rotor lateral and torsional vibration
- *Nondestructive testing* – most effective nondestructive inspections to detect known failure modes
- *OEM Technical Advisories/Service Bulletins* – management and integration into outage scopes

MODULE 2 – Generator Reliability Improvements, Failure Modes, and Troubleshooting

- *Key components and design features* – overview and purpose of each components
    - ✓ Winding Insulation Types
    - ✓ Retaining Rings – 18-5 vs. 18-18
    - ✓ Hydrogen vs. Air Cooled
    - ✓ Auxiliary Equipment (exciter, grounding brushes, high voltage bushings, coolers, heaters, etc.)
- *Failure modes* – stator vs. rotor/field: visual and electrical signs, root causes, and mitigating actions
- *Electrical testing* – overview of standard electrical testing and information proved by each and acceptance criteria
- *NDE techniques* – Recommended techniques for retaining rings, fan blades, etc.

- *Outage type* – robot vs. rotor out, pros and cons of each
- *Generator capability curve* – how to read and importance
- *Economical repair options* – looseness, girth cracking, oil ingress
- *Operations* – operational data trending, flux probes and partial discharge monitoring

MODULE 3 – Impact of Flexible Operations on Steam turbine and Economical Repair Options

- *Turbine operational audits* – how to identify and avoid common operational pitfalls
- *Impact of renewable energy and gas prices on steam turbine assets*
  - ✓ Ultra-Minimum Load
  - ✓ Two-Shift Cycling
- *Steam turbine rotor retrofits* – key considerations, performance benefits, technology enhancements
- *"No-brainers" to regain lost capacity* – upgraded sealing technologies, blade path repairs and smoothing
- *Emergent issues on combined-cycle steam turbines* – unplanned findings early in unit life on both rotor and casings
- *Strategies to safely reduce cold start times* – benefits of steam seal preheat and modified hold speeds/times
- *Material sampling and life extension assessments* – fix only what is broken
- *Targeted outage repairs* – how to get back online with as little spend, time and risk as possible
- *Repair options and considerations* – casing cracking, stress corrosion cracking, rotor bow, solid particle erosion and water droplet erosion, foreign object damage
- *Outage planning and risk assessments for key turbine hardware* – how to optimize outage intervals based on current hardware condition

Gas Turbine
Failure Modes, Troubleshooting and Condition Based Maintenance

MODULE 4 – Gas Turbine Design Fundamentals, Technology Enhancements and Failure Modes

Compressor:

- *Blade design* – materials, blade root and airfoil design, coatings
- *Inlet guide vanes* – function, mechanical design, inspections

Combustion:

- *Technologies* – overview of different combustion designs and key attributes
- *Design of combustion components* – introduction, materials, coatings, and function
- *Emissions control* – enhancements to reduce emissions

Hot Gas Path:

- *Blade design* – inlet vs. aft stage blades, blade casting and internal cooling design
- *Stationary blade design* – singlet vs. doublet/triplet design, heat transfer and cooling
- *Design life and failure modes* – base loaded vs. cycling, limiting failure mode vs. location in hot gas path
- *Material upgrades* – grain structure, alloys

- *Coating systems* – oxidation protection vs. thermal barrier coatings, application processes, evaluation of remaining life
- *Cooling systems* – overview of cooling techniques, types of cooling holes
- *Upgrade/retrofit opportunities* – overview of new offerings and benefits

Rotor Design

- *Construction* – disc, spacers, through bolts, aero derivative vs. frame machine
- *Materials* – materials vs. location in engine

Failure Modes

- *Creep* – overview of mechanism, detection, life of parts and which parts are limited
- *Oxidation* – overview of mechanism, coatings to protect against, repair limitations
- *Thermal mechanical fatigue* – overview of mechanism, detection, life of parts and which parts are limited
- *High cycle fatigue* – overview of mechanism and impacted components
- *Foreign and domestic object damage* – sources of material, ways to protect against

MODULE 5 – Gas Turbine Operations, Maintenance, and Repair Technology

Operating Parameters and Impact on Life

- *Fuel type* – impact of fuel type of intervals and part life
- *Firing temperatures* – reduction/extension in life based on actual firing temperature vs. design
- *Inlet temperatures* – impact on part life and power output
- *Inlet chilling/wet compression* – overview of power augmentation techniques, impact on maintenance intervals
- *Fast starts* – reduction of life based on starting time

Maintenance Intervals & Repair

- *Equivalent operating hours approach (EOH)* – pluses and minuses of using an EOH vs. an hour or start based criteria for maintenance intervals
- *Condition based maintenance approaches* – which parts are applicable, how to avoid unnecessary spend
- *Borescope inspections* – how to interpret results, what to look for and frequency of inspection
- *Combustion inspections* – included items, rotatable parts
- *Hot gas path inspections* – included items, rotatable parts
- *Major inspections* – included items, scope of inspection/repair
- *Water washes, online and offline* – pros/cons of online vs. offline water washes, performance benefits
- *Inspection techniques* – NDE techniques, detectable limits, repair limits
- *Keys to successful part overhaul* – coating quality, crack repair, blade restoration