



POWER PLANT ASSET INTEGRITY MANAGEMENT

- Thermal power
- Hydro power
- Geothermal power

QuestIntegrity.com

CHALLENGE CONVENTION

EFFECTIVE ASSET INTEGRITY MANAGEMENT IN POWER PLANTS

Effective asset integrity management in the thermal, hydro and geothermal power industries is critical to optimizing production performance, ensuring safety and compliance, reducing expenditure and obtaining maximum life value from critical assets.

Quest Integrity understands the significance and complexity of effective life management of critical assets. Our complete asset integrity management services include inspection planning, condition assessment, material testing, fitness-for-service assessment, life management, life assessment and life extension of assets. Our advanced technologies, industry expertise and extensive experience have been demonstrated to improve plant availability and reliability while maintaining safe operation.

OUTAGE SUPPORT SERVICES

Quest Integrity provides a comprehensive service to determine the condition of power industry assets. These include condition assessment and inspection services and we have proven that in many cases we can inspect assets that were previously considered uninspectable. In addition to performing inspections

we also provide inspection planning for both pressure and rotating equipment.

Services include:

- Remote Digital Video Inspection (RDVI™)
- Foreign object retrieval
- Eddy current inspection
- In-situ metallurgy evaluation
- Specialist turbine inspection
- End ring inspections
- Phased array ultrasonic testing
- Time of flight diffraction
- Boresonic inspection
- Ultrasonic (UT) in-line inspection of piping
- Inspection management and outage/turnaround support



ENGINEERING CONSULTING

Quest Integrity's engineering consultancy brings together a team of engineers, technical specialists and industry experts who possess the advanced technical skills and experience to increase asset life cycle and solve complex integrity issues. We conduct extensive in-house research into inspection techniques, high temperature materials, life assessment methods and procedures, and have been active in materials research for over 80 years.

Understanding component performance also allows us to determine remaining life, determine replacement intervals for specific components, assess suitability for repair or rejuvenation of components, and calculate risk associated with extended operation or deviation from normal practice.

Engineering Consulting Services

- Engineering critical assessments and fitness-for-service assessment
- Gas and steam turbine critical parts and rotor life management
- Steam side plant integrity and life management
- HRSG and boiler life management using risk-based methods
- Steam pipe welds life management
- Extension of operating intervals between planned outages
- Repair & refurbishment, specifications, tendering and procurement support
- Diesel and oil storage tank hydro test exemptions
- Corrosion life prediction modelling and water and steam chemistry issues
- Materials research and testing including mechanical and creep testing and fracture mechanics
- Training and technology transfer, both in-company and for international organizations
- Computational fluid dynamics (CFD analysis)
- Finite element analysis

Risk-Based Assessment

Plant maintenance and inspection resources should be used preferentially on high-risk assets. Quest Integrity's approach recognizes that a relatively small percentage of plant equipment accounts for a very

large percentage of disruption, shutdown and safety risk. Our plant assessment experience enables an operator to confidently extend inspection periods and improve operations that extend plant life.

Risk-based assessment (RBA) begins with identification of high-risk assets followed by assessment of equipment condition, evaluation of maintenance and inspection programs, study of operating protocols and estimation of life consumption of these priority assets. This process takes into account the likelihood and consequences of failure. The information is then used to modify and optimize inspection and maintenance programs, audit procedures, operating limits and safety information. RBA is an integral part of asset integrity management which effectively targets resources at the high risk items of plant to deliver best reliability outcomes.

Root Cause Failure Analysis

Failures can have catastrophic outcomes, including injury and loss of life, major economic costs and damage to business reputation. Understanding the cause of failure can help reduce the costs of future unplanned shutdown. Quest Integrity assists operators by diagnosis of root causes and by recommending immediate post failure requirements and advising ways to avoid repeated failures.

- On-site investigations upon short notice
- Advice on repair materials and procedures
- On-site metallurgical analysis
- Advice on materials selection and quality control
- Development of safe inspection periods including sister units to avoid failures
- Simulation of loading scenario by FEA
- Expert assistance for insurance claims
- Witnessing repair/refurbishment works on-site and at off-site locations





GEOTHERMAL POWER

Damage mechanisms such as corrosion, erosion, deposition and scaling are challenging issues that affect reliability and availability in geothermal plant. Our geothermal energy plant materials and assessment experience provide valuable information to enable operators to confidently extend inspection periods and improve operations to extend plant life. Comprehensive risk-based assessment allows inspection and monitoring to be targeted at critical equipment and critical locations improving reliability and preventing failures.

Our expertise covers assets such as geothermal wells and steam-filled equipment, steam turbines, hot well pumps, condensing plant and cooling towers, binary plant/geothermal heat exchangers and high pressure steam piping.

THERMAL POWER

Achieving reliability and availability is a key focus in thermal power plants. Our range of asset integrity management services combine expertise in creep life management, fatigue life management and corrosion. We have extensive experience in gas turbines, steam turbines and pressure equipment with tried and tested cost effective life management

procedures for boilers, heat recovery steam generators (HRSGs), high temperature piping and balance of plant. This is combined with planning, supervision and execution of world-class condition assessment and inspection techniques to provide a holistic service.

HYDRO POWER

We have extensive experience in assisting the hydro power industry in achieving reliability and availability targets and preventing unplanned downtime. Our asset integrity experience and expertise has allowed operators to obtain maximum life value from their operations through effective life management combined with optimized inspection planning.

We specialize in integrity management of the following critical assets:

- Francis, Kaplan and Pelton turbines and runners
- Penstocks, draft tubes, spillway gates
- Valves, nozzles and manways
- Scroll casings, stay vanes and wicket gates
- Generators (rotors and stators)
- Generator and turbine shafts
- Support structures
- Headcovers

CASE STUDIES

RISK-BASED ASSESSMENT AT GEOTHERMAL PLANT

Quest Integrity has performed Risk-Based Assessment (RBA) for inspection optimization at eight geothermal power stations. RBA has been used to control the risk of premature or unexpected failure and for targeting maintenance. The ability to predict the corrosion chemistry in key parts of the plant so that material-environment combinations can be modelled allows the prediction of damage mechanisms and identifies the most likely location for that damage to occur. Operators were provided with a targeted approach and thus the ability to focus their time and resources more efficiently. RBA provided a basis for an Overall Inspection and Test Plan describing what and when to inspect and results in a living inspection document that identifies where and how to inspect. RBA and inspection activities are part of an operations philosophy that aims to deliver 96% availability with no forced outages.

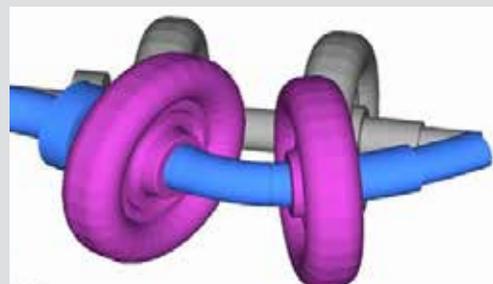
CRITICAL SPARE MANAGEMENT FOR THERMAL POWER PLANT

Recovering quickly from an unplanned outage is an essential part of business continuity planning. Quest Integrity assisted three gas fired power stations by determining their critical spare requirements, identifying all single point failure locations, determining the failure modes for each critical component, special tooling needs and staff competency. Detailed monitoring, maintenance and inspection test plans specific to each component were produced and the reliability and availability of critical items of plant assessed. This not only resulted in improved availability but minimized their essential spares holding and maximized their ability to recover quickly in the event of failure.

ENGINEERING CRITICAL ASSESSMENT FOR HYDRO-TURBINE ROTORS

Six horizontal shaft hydro-turbine generators, each with two Pelton wheel runners installed, were discovered to contain cracks during overhauls. These were removed by grinding, leaving circumferential machined grooves on the shafts. Quest Integrity performed a 3D finite element analysis (FEA) including the worst of the identified grooves. The model included the loading due to the shrink fit, centrifugal load applied by the spinning runners, the torque applied on the shaft due to the runners, and the total assembly self-weight. Finite element stress analysis, critical crack size computation and fatigue life calculations were performed to provide guidance regarding the future safe operating of the units.

The fracture mechanics assessment showed that the shaft assembly could withstand a significant crack depth around the shaft before failure would occur. A conservative estimate of six years remaining life was obtained. The stress analysis also included a natural frequency evaluation to ensure that the rotation of the assembly would not interfere with the shafts the natural frequency. The 40.69Hz natural frequency of the structure, much higher than the 13.92Hz maximum rotational speed, implied that there should be limited excitation at the natural frequency under normal operation.



QUEST INTEGRITY

Quest Integrity, a Team Industrial Services company, is a global leader in the development and delivery of asset integrity and reliability management services. The company's integrated solutions consist of technology-enabled, advanced inspection and engineering assessment services and products that help organizations improve operational planning, increase profitability, and reduce operational and safety risks. Quest Integrity is built on a foundation of leading edge science and technology that has innovated and influenced industry best practices since 1971.

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