QUEST
Professional Center

PROFESSIONAL TRAINING COURSE

Course No. 1661

Materials Engineering & Failure Analysis

MATERIALS, WELDING & FABRICATION ENGINEERING
INDUSTRIAL ENGINEERING, MAINTENANCE & OPERATIONS

DURATION
5 Days

DELIVERY
Classroom

Course Overview

The Materials Engineering & Failure Analysis Training Course provides a comprehensive and practical framework for understanding engineering materials, their behavior under service conditions, and the systematic investigation of material and component failures. The course is designed to help engineers, technical specialists, inspectors, maintenance professionals, and decision makers improve material selection, assess degradation mechanisms, identify failure causes, and strengthen equipment reliability.

Materials performance is directly connected to the safety, reliability, efficiency, and service life of industrial assets. In sectors such as oil and gas, petrochemicals, power generation, manufacturing, construction, and heavy industry, inappropriate material selection, manufacturing defects, corrosion, fatigue, overheating, mechanical overload, or unsuitable operating conditions can contribute to premature equipment failure. Understanding these mechanisms enables organizations to make better engineering decisions and reduce avoidable operational risks.

The program covers the fundamental principles of materials engineering, including metals and alloys, polymers, ceramics, composites, mechanical properties, metallurgical characteristics, heat treatment, material selection, and degradation mechanisms. It also introduces systematic failure analysis methodologies covering visual examination, evidence collection, fracture characteristics, metallurgical assessment, non-destructive testing, laboratory investigation, and root-cause analysis.

A major focus is placed on identifying the relationship between material properties, design conditions, manufacturing processes, operating environments, and failure mechanisms. Participants will examine common forms of failure such as corrosion, erosion, fatigue, brittle fracture, ductile fracture, creep, stress corrosion cracking, hydrogen-related damage, wear, thermal degradation, and manufacturing-related defects.

Through practical case studies and failure investigation exercises, participants will learn how to structure a failure analysis, interpret technical evidence, distinguish between immediate and underlying causes, evaluate corrective actions, and develop recommendations for preventing recurrence. The course supports organizations in strengthening asset integrity, maintenance strategies, engineering decision-making, and long-term equipment reliability.

Objectives

- Analyze the fundamental principles of materials engineering and relate material properties to industrial applications during the course.
- Evaluate the mechanical, thermal, chemical, and metallurgical properties of engineering materials for specific service conditions.
- Apply structured material selection principles based on operating environment, design requirements, performance expectations, and lifecycle considerations.
- Analyze common material degradation mechanisms and evaluate their potential effects on equipment integrity and service life.
- Identify characteristic failure modes including fatigue, fracture, corrosion, erosion, creep, wear, and environmentally assisted cracking.
- Apply systematic failure investigation methodologies to collect, organize, and evaluate technical evidence.
- Evaluate visual, mechanical, metallurgical, and non-destructive examination findings when investigating failed components.
- Analyze the relationship between design conditions, manufacturing processes, material characteristics, operating conditions, and component failure.
- Apply root-cause analysis techniques to distinguish immediate failure mechanisms from contributing and systemic causes.
- Evaluate corrective and preventive actions and determine their suitability for reducing the likelihood of failure recurrence.
- Improve material selection, inspection, maintenance, and asset integrity decisions using failure analysis findings.
- Develop a practical materials and failure analysis improvement plan addressing identified technical and operational risks by the end of the course.

Who Should Attend

This training course is designed for materials engineers, metallurgical engineers, mechanical engineers, corrosion engineers, inspection engineers, reliability engineers, maintenance engineers, quality engineers, welding engineers, and technical specialists involved in the selection, inspection, operation, maintenance, and integrity management of industrial equipment.

It is particularly relevant to professionals working with pressure equipment, pipelines, storage tanks, rotating equipment, heat exchangers, boilers, structural components, valves, welding systems, and other critical assets. The course is suitable for engineers and specialists working in oil and gas, petrochemical, power generation, manufacturing, marine, construction, mining, utilities, and heavy industrial organizations.

The program also benefits engineering managers, maintenance managers, inspection managers, asset integrity professionals, quality assurance and quality control specialists, technical authorities, project engineers, and decision makers responsible for equipment reliability, material specifications, failure prevention, lifecycle management, and technical risk reduction.

Learning Outcomes

- Explain the relationship between material composition, microstructure, mechanical properties, and industrial performance.
- Evaluate engineering materials according to mechanical, thermal, chemical, environmental, and service requirements.
- Select suitable materials for industrial applications based on operating conditions and expected degradation mechanisms.
- Identify common material failure modes and recognize their characteristic features.
- Distinguish between corrosion, fatigue, fracture, creep, erosion, wear, and environmentally assisted degradation.
- Develop a structured approach for investigating material and component failures.
- Collect and evaluate physical evidence while maintaining the integrity of failure investigation activities.
- Interpret findings from visual inspection, non-destructive testing, mechanical testing, and metallurgical examination.
- Apply root-cause analysis to determine immediate, contributing, and underlying causes of material failures.
- Evaluate the influence of design, fabrication, welding, heat treatment, installation, operation, and maintenance on failure occurrence.
- Recommend appropriate corrective and preventive actions to reduce failure recurrence and improve equipment reliability.
- Prepare a professional failure analysis report containing evidence, technical conclusions, root

causes, recommendations, and follow-up actions.

Course Outline

DAY 01

Materials Engineering Fundamentals & Industrial Material Selection

- Principles of materials engineering and the relationship between material structure and performance
- Classification and characteristics of metals, alloys, polymers, ceramics, and composite materials
- Mechanical properties including strength, hardness, toughness, ductility, fatigue resistance, and wear resistance
- Material selection based on temperature, pressure, chemical environment, loading conditions, and service requirements

PRACTICAL APPLICATION

Evaluate an industrial component and select suitable material options based on operating conditions and performance requirements

DAY 02

Material Degradation & Common Failure Mechanisms

- Corrosion mechanisms and environmental degradation of engineering materials
- Fatigue, fracture, creep, erosion, wear, and mechanical damage
- Stress corrosion cracking, hydrogen-related damage, and environmentally assisted cracking
- Effects of temperature, pressure, cyclic loading, chemicals, moisture, and operating conditions on material performance

PRACTICAL APPLICATION

Analyze industrial failure cases and identify the most probable degradation mechanisms and contributing conditions

DAY 03

Failure Investigation & Diagnostic Techniques

- Principles and stages of systematic failure analysis
- Failure evidence collection, documentation, preservation, and investigation planning
- Visual examination, fracture surface assessment, dimensional examination, and material verification
- Non-destructive testing and laboratory examination in failure investigations

> **PRACTICAL APPLICATION**
>
> Conduct a structured investigation of a failed component and develop an evidence-based failure hypothesis

DAY 04

Metallurgical Analysis, Root Causes & Failure Prevention

- Metallurgical examination, microstructure evaluation, hardness testing, and material verification
- Fracture characteristics and interpretation of failure surfaces
- Root-cause analysis and identification of immediate, contributing, and systemic causes
- Influence of design, fabrication, welding, heat treatment, installation, operation, and maintenance on failure

> **PRACTICAL APPLICATION**
>
> Perform a root-cause analysis for a complex equipment failure and develop technically justified corrective and preventive actions

DAY 05

Failure Analysis Reporting, Asset Integrity & Continuous Improvement

- Preparing professional materials engineering and failure analysis reports
- Evaluating corrective actions, material changes, inspection strategies, and maintenance recommendations

DAY 05 — CONTINUED

- Integrating failure analysis with asset integrity, reliability, maintenance, and lifecycle management
- Developing lessons learned and mechanisms for preventing recurring failures

FINAL WORKSHOP

Complete a comprehensive failure analysis case covering evidence evaluation, failure mechanism identification, root-cause analysis, corrective actions, and an asset integrity improvement plan

Register or Request More Information

Course page: https://quest-training.com/courses/materials-engineering-failure-analysis
Website: https://quest-training.com
Email: info@quest-training.com
Phone: +905016771440