



FE063: Metallurgical Failure Analysis & Prevention

Training Description:

Metallurgical Failure Analysis & Prevention is a comprehensive training program designed to provide engineers and technical professionals with the knowledge and practical skills required to investigate material failures, determine their root causes and implement preventive measures. The training course covers the principles of metallurgy, material behavior under service conditions, failure mechanisms, laboratory investigation techniques, fracture analysis, corrosion, fatigue, creep, wear and failure prevention strategies.

Participants will learn internationally recognized failure investigation methodologies using real industrial case studies from oil & gas, petrochemical, power generation, manufacturing, marine, mining, aerospace, and infrastructure sectors. The training course emphasizes systematic root cause analysis, material selection, quality control, and engineering solutions that improve equipment reliability and reduce maintenance costs.

Training Objectives:

By the end of the training, participants will be able to:

- ✓ Understand the fundamentals of physical and mechanical metallurgy
- ✓ Recognize common metallurgical failure mechanisms
- ✓ Perform systematic metallurgical failure investigations
- ✓ Interpret fracture surfaces and identify fracture modes
- ✓ Understand the influence of manufacturing defects on failures
- ✓ Evaluate corrosion, erosion, fatigue, creep and wear failures
- ✓ Apply laboratory testing methods used in failure analysis
- ✓ Interpret metallographic and microscopic examination results
- ✓ Conduct root cause analysis using engineering methodologies
- ✓ Recommend corrective and preventive actions
- ✓ Improve material selection for specific operating environments
- ✓ Reduce equipment failures and maintenance costs
- ✓ Develop failure prevention and reliability improvement strategies

Training Designed for:

This training course is intended for Mechanical Engineers, Metallurgical Engineers, Materials Engineers, Maintenance Engineers, Reliability Engineers, Inspection Engineers, Corrosion Engineers, Welding Engineers, Plant Engineers, Manufacturing Engineers, QA/QC Engineers, Asset Integrity Engineers, Failure Investigation Specialists, Technical Consultants, Laboratory Personnel, Maintenance Supervisors and Plant Managers.

Training Requirement:

“Hand’s on practical sessions, equipment and software will be applied during the course if required and as per the client’s request.”

Contents can be adapted to your specific wishes. It is therefore possible to focus on specific modules of the training course as per client's learning needs and objectives. Further, it should be forwarded to us a month prior to the course dates.

Training Program:

DAY ONE:

FUNDAMENTALS OF METALLURGY AND FAILURE MECHANISMS

- ❖ **Module 1: Introduction to Metallurgical Failure Analysis**
 - Importance of failure analysis
 - Cost of material failures
 - Engineering investigation process
 - Failure analysis methodology
 - Case study examples
- ❖ **Module 2: Fundamentals of Physical Metallurgy**
 - Crystal structures
 - Grain structure
 - Phase diagrams
 - Heat treatment principles
 - Mechanical properties
 - Material strengthening mechanisms
- ❖ **Module 3: Engineering Materials**
 - Carbon steels
 - Alloy steels
 - Stainless steels
 - Cast irons
 - Aluminum alloys
 - Copper alloys
 - Nickel alloys
 - Titanium alloys
- ❖ **Module 4: Mechanical Behavior of Materials**
 - Elastic deformation
 - Plastic deformation
 - Stress-strain relationships
 - Toughness
 - Hardness
 - Ductility
 - Brittleness
- ❖ **Practical Exercises:**
 - Material identification
 - Mechanical property interpretation
 - Material selection exercises

DAY TWO:

FAILURE INVESTIGATION TECHNIQUES

- ❖ **Module 5: Failure Investigation Methodology**

- Collection of failure information
- Service history review
- Visual examination
- Documentation procedures
- Sample selection

❖ **Module 6: Fracture Analysis**

- Brittle fracture
- Ductile fracture
- Cleavage fracture
- Intergranular fracture
- Transgranular fracture
- Overload failures

❖ **Module 7: Fractography**

- Macroscopic examination
- Optical microscopy
- Scanning Electron Microscopy (SEM)
- Fracture surface interpretation
- Fracture origin identification

❖ **Module 8: Laboratory Examination**

- Metallography
- Sample preparation
- Etching techniques
- Grain size analysis
- Inclusion analysis
- Microstructure evaluation

❖ **Practical Exercises:**

- Fracture surface examination
- Metallographic interpretation
- Failure investigation workflow

DAY THREE:

COMMON FAILURE MECHANISMS

❖ **Module 9: Fatigue Failures**

- Fatigue mechanisms
- Crack initiation
- Crack propagation
- High-cycle fatigue
- Low-cycle fatigue
- Thermal fatigue

❖ **Module 10: Creep Failures**

- Creep stages
- High-temperature failures
- Life assessment
- Creep damage mechanisms

❖ **Module 11: Wear Mechanisms**

- Abrasive wear

- Adhesive wear
- Fretting wear
- Erosive wear
- Cavitation
- Surface degradation

❖ **Module 12: Corrosion Failures**

- Uniform corrosion
- Galvanic corrosion
- Crevice corrosion
- Pitting corrosion
- Stress corrosion cracking
- Hydrogen embrittlement
- Corrosion fatigue

❖ **Practical Exercises:**

- Failure mechanism identification
- Industrial failure case studies
- Root cause discussions

DAY FOUR:

ADVANCED FAILURE ANALYSIS

❖ **Module 13: Manufacturing-Related Failures**

- Casting defects
- Forging defects
- Rolling defects
- Heat treatment errors
- Machining defects
- Welding defects

❖ **Module 14: Non-Destructive Testing (NDT)**

- Visual inspection (VT)
- Ultrasonic Testing (UT)
- Magnetic Particle Testing (MT)
- Liquid Penetrant Testing (PT)
- Radiographic Testing (RT)
- Eddy Current Testing (ECT)

❖ **Module 15: Destructive Testing**

- Tensile testing
- Hardness testing
- Impact testing
- Bend testing
- Chemical analysis
- Microhardness testing

❖ **Module 16: Root Cause Failure Analysis (RCFA)**

- RCA methodologies
- Fishbone Diagram
- 5 Whys
- Fault Tree Analysis (FTA)

- Failure Mode and Effects Analysis (FMEA)
- Evidence-based conclusions
- ❖ **Exercises:**
 - Complete metallurgical failure investigation
 - RCFA team exercise

DAY FIVE:

FAILURE PREVENTION AND RELIABILITY IMPROVEMENT

- ❖ **Module 17: Material Selection**
 - Material compatibility
 - Service environment assessment
 - Corrosion resistance
 - Temperature limitations
 - Mechanical loading considerations
 - Standards and specifications
- ❖ **Module 18: Design for Reliability**
 - Stress reduction
 - Fatigue-resistant design
 - Corrosion allowance
 - Wear protection
 - Design verification
- ❖ **Module 19: Quality Assurance and Inspection**
 - Manufacturing quality control
 - Heat treatment verification
 - Welding quality assurance
 - Inspection planning
 - Acceptance criteria
- ❖ **Module 20: Preventive Maintenance Strategies**
 - Condition monitoring
 - Risk-based inspection (RBI)
 - Asset integrity management
 - Predictive maintenance
 - Life extension strategies
- ❖ **Final Case Studies**
 - Pressure vessel failures
 - Pipeline failures
 - Rotating equipment failures
 - Heat exchanger failures
 - Structural steel failures
 - Fastener failures
 - Bearing failures
- ❖ **Final Exercises:**
 - Comprehensive metallurgical failure analysis project
 - Team presentations and recommendations
- ❖ **Course Conclusion**
- ❖ **POST-ASSESSMENT and EVALUATION**

Throughout the course, participants will engage in:

- Metallographic specimen examination
- Fracture surface interpretation
- Failure investigation simulations
- Material identification exercises
- Root cause analysis workshops
- Corrosion assessment exercises
- Fatigue failure investigations
- Creep damage evaluation
- NDT result interpretation
- Industrial case study discussions

Training Methodology:

This interactive training course includes the following training methodologies as a percentage of the total tuition hours:

- 30% Lectures, Concepts, Role Play
- 70% Workshops & Work Presentations, Techniques, Based on Case Studies & Practical Exercises, Gamification, Software & General Discussions
- Pre and Post Test

Training Certificate(s):

CMCT Internationally recognized certificate(s) will be issued to each participant who completed the course.

Training Fees:

USD\$ TBA - This rate includes participant's manual, hand-outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Note: The 5% VAT (Value Added Tax), will be effective starting 01st of January 2018 as per the new regulation from the UAE Government. The VAT applies for all quotation both for local and abroad.

Training Timings:

Daily Timings:

07:45 - 08:00	Morning Coffee / Tea
08:00 - 10:00	First Session
10:00 - 10:20	Recess (Coffee/Tea/Snacks)
10:20 - 12:20	Second Session
12:20 - 13:00	Recess (Prayer Break & Lunch)
13:00 - 14:00	Last Session

For training registrations or in-house enquiries, please contact:

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