LETSGLOBAL

life extension of technical structures

Fatigue Hotspot Assessment & Structural Integrity Studies

Course Description

This NDA-safe course provides a comprehensive engineering framework for identifying, assessing, and mitigating fatigue hotspots in welded steel structures subjected to cyclic loading. The content is generalized for structural assets operating under variable loading conditions and is suitable for both offshore and onshore applications.

The course integrates probabilistic fatigue assessment, deterministic stress analysis, and structural integrity improvement techniques, with a strong emphasis on fatigue life extension and engineering decision-making under uncertainty. It is grounded in internationally recognized engineering practices and standards.

Target Audience

Structural Engineers, Fatigue & Fracture Engineers, Structural Integrity Engineers, Reliability Engineers, Asset Life-Extension Engineers, and Engineering Managers responsible for integrity and life-extension programs.

Entry Requirements

- Bachelor's degree in Mechanical, Structural, Civil, or Marine Engineering
- Minimum 3–5 years of professional experience in structural analysis, fatigue, integrity, or design
- Prior exposure to fatigue analysis, welded structures, or finite element analysis is recommended

This is not an introductory course; it is intended for practicing engineers.

Course Duration

Total Duration: 3 Days

Day 1: Fatigue fundamentals, hotspot identification, fatigue assessment methodologies
Day 2: Fatigue result interpretation, life extension principles, engineering justification of treatments
Day 3: Quality assurance, integrity integration, and case-based engineering decision workflows

General Learning Outcomes

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

- Analyze fatigue damage mechanisms in welded structures
- Evaluate fatigue hotspots using probabilistic and deterministic approaches
- Interpret fatigue life predictions for engineering decision-making
- Justify fatigue life extension strategies using recognized engineering principles
- Integrate fatigue mitigation measures into long-term structural integrity management plans

Module 1 – Fundamentals of Fatigue in Welded Structures

• Fatigue mechanisms in welded steel details

• Crack initiation versus crack propagation

• Influence of geometry, weld quality, and residual stresses

• High-cycle versus low-cycle fatigue regimes

• Introduction to S–N curves and fatigue classes

Learning Outcomes from this Module:

- Describe fatigue mechanisms in welded joints (Understand)

- Explain the influence of geometry and residual stresses on fatigue behavior (Understand)

- Differentiate between fatigue regimes and their implications (Analyze)

Module 2 – Fatigue Hotspot Identification

• Definition and characteristics of fatigue hotspots

• Typical hotspot locations in welded structural systems

• Role of geometric discontinuities and stress concentrations

• Influence of fabrication quality and as-built deviations

• Categorization of hotspots by remaining fatigue life

Learning Outcomes from this Module:

- Identify fatigue hotspots in welded structures (Apply)

- Classify hotspots based on fatigue criticality and remaining life (Analyze)

- Explain why cracking may occur outside idealized analytical locations (Understand)

Module 3 – Fatigue Assessment Methodologies

• Deterministic fatigue analysis using local stress and FEA-based approaches

• Probabilistic (stochastic) fatigue assessment concepts

• Comparison of assessment methodologies: assumptions, outputs, and implications

• Risk-based versus optimization-based fatigue management philosophies

Learning Outcomes from this Module:

- Compare deterministic and probabilistic fatigue assessment approaches (Analyze)

- Interpret uncertainty and probabilistic fatigue outputs (Analyze)

- Evaluate the suitability of different methods for integrity decision-making (Evaluate)

Module 4 – Interpreting Fatigue Results for Engineering Decisions

• Conversion of fatigue life (years) into equivalent stress ranges

• Understanding probability of failure and reliability levels

• Remaining fatigue life versus consumed fatigue life

• Prioritization of fatigue-critical structural locations

• Definition of short-life, medium-life, and low-risk categories

Learning Outcomes from this Module:

- Convert fatigue life predictions into equivalent stress ranges (Apply)

- Interpret fatigue results in terms of reliability and risk (Analyze)

- Prioritize fatigue hotspots for mitigation actions (Evaluate)

Module 5 – Fatigue Life Extension Principles

• Fatigue strength improvement mechanisms

• Role of weld toe geometry modification

• Influence of compressive residual stresses

• Rotation of S–N curves and slope effects

• Limitations and boundary conditions of fatigue improvement techniques

Learning Outcomes from this Module:

- Explain fatigue life extension mechanisms (Understand)

- Analyze the influence of residual stresses and geometry modification (Analyze)

- Assess when fatigue improvement techniques are technically justified (Evaluate)

Module 6 – Engineering Basis for Treatment Extent

• Local stress gradients and real-world crack initiation zones

• Differences between numerical hotspots and practical fatigue regions

• Justification of treatment envelope lengths

• Effects of multipass welds and start-stop features

• Conservative engineering allowances versus analytical minimums

Learning Outcomes from this Module:

- Analyze discrepancies between analytical hotspots and observed fatigue damage (Analyze)

- Justify treatment extents using engineering judgment (Evaluate)

- Formulate defensible fatigue mitigation scopes (Create)

Module 7 – Quality Assurance, Verification & Risk Control

• Pre-treatment inspection philosophy

• Identification of unacceptable weld conditions

• Post-treatment verification principles

• Documentation and traceability requirements

• Long-term monitoring and reassessment strategies

Learning Outcomes from this Module:

- Define quality assurance and inspection requirements (Understand)

- Evaluate inspection findings to confirm treatment suitability (Evaluate)

- Develop verification and documentation strategies for integrity management (Create)

Module 8 – Integration into Structural Integrity Management

• Linking fatigue mitigation to inspection planning

• Balancing treated versus untreated fatigue-critical elements

• Avoiding unintended fatigue hierarchy shifts

• Maintenance strategy optimization

• Life-extension decision frameworks

Learning Outcomes from this Module:

- Integrate mitigation into integrity plans (Apply)

- Evaluate system-level impacts of localized fatigue improvements (Evaluate)

- Design long-term fatigue management strategies (Create)