



Course FAT

Fatigue, Damage Tolerance, & Airworthiness of Aging Aircraft

Course Summary

This course is **offered by Fatigue Concepts** at Abaris' Reno, NV facility. It is designed for anybody interested in learning about aging aircraft, metal fatigue, corrosion, and many other related issues.

Please visit this link to enroll: <https://flipt.wufoo.com/forms/fatcon-enrollment-and-payment-form-4-day-course/>

Introduction

Topics

- **Prologue**
- **Cost of Fracture**
- **The Danger of Metal Fatigue**
 - Early transportation failures from centuries past
 - Bridges
 - Trains
 - Titanic and Liberty ships
 - Wright Flyer, Comet, ...
 - F-111 crash
 - What is a Failure? USAF-Navy-FAA-NASA Guidelines
 - Structural Failure Modes
 - Environmentally induced and/or time-dependent failure modes
 - Creep, Fatigue, Corrosion, Wear, Fretting, Hydrogen Embrittlement
 - Synergistic processes
 - Corrosion fatigue, fretting fatigue, SCC, high temperature fatigue
 - Why High Strength materials are weak in fatigue!
 - Crack Initiation and Propagation
 - Design Strategies to combat Metal Fatigue
 - Safe Life
 - Safety Factor fantasies
 - Fail Safe
 - 1. Crack Arrest
 - 2. Multiple Load Path (Structural Redundancy)
 - Design for inspectability
- **Fractography**
 - What does a fatigue crack look like?
 - Macro and Micro Aspects
 - Striations and Beach Marks
 - Quantitative and qualitative use
 - Ratchet lines
 - Marker cycles
 - Guides on using Fractography
 - Scanning Electron Microscope
 - Use of fractography to perform failure analysis
- **Stress Concentration K_t , Finishes**
 - Stress Concentrations
 - Load Flow Lines (Streamlines): a useful analogy
 - Surface finish
 - Pitfalls in grinding
 - Chrome-plating dangers, zinc and other platings
 - Size effects
 - Leonardo da Vinci
 - Similitude or lack thereof
 - Scatter, Reliability
 - High Temperature Effects
- **Fatigue Life Prediction**
 - Cycle parameters
 - Range, amplitude, mean stress, R ratio
 - S-N Curves
 - Endurance Limit is largely a myth: Use Fatigue Strength
 - Fatigue Strength
 - Mean stress effects
 - Constant Life Diagrams, Haigh Diagrams
 - Low cycle fatigue
 - Neuber's Notch strain analysis
 - Miner's Myth
 - Extremely limited applicability and lack of defensibility
 - It is not a RULE
 - Fracture Mechanics
 - Griffith Criterion
 - George Irwin, Naval Research Lab: Father of Fracture Mechanics
 - Stress intensity factor SIF K_I
 - Beta factors
 - Residual strength
 - Fracture toughness
 - Effect of thickness, orientation, impact, temperature

- Dynamic fracture toughness and crashworthiness
 - Crack propagation
 - Thresholds
 - Inspection intervals
 - Classroom problem-solving exercises
 - NDE, detectable crack sizes
 - Visual, eddy current, radiographic, ultrasonic, penetrant, magnetic particle
 - Applicability, comparison
 - POD (Probability of Detection)
 - Reliability of Inspections
 - Case Study: MD-88 uncontained engine failure
 - Initial quality, EIFS equivalent initial flaw size
 - Multiaxial stresses, Mixed mode cracking
 - Short cracks
 - Can be deadly
 - Classroom tutorials in Fracture Mechanics
 - Rigorous, parametric evaluations of various interconnected variables: fracture toughness, initial flaw size, inspection interval, fastener holes, corrosion effects, coldworking, shot-peening, da/dN, material properties C, m, ...
 - Damage Tolerance
 - MIL-A-83444 -> MIL-A-87221 -> JSSG2006
 - 1. Fail-safe structure
 - Arrest of a rapidly running crack
 - Safe partial failure of a load path
 - Skin-stringer partnership
 - Titanium crack stoppers
 - 2. Slow crack growth structure
 - Degree of inspectability
 - Initial flaw assumptions
 - Retardation Models
 - Willenborg
 - Wheeler
 - Closure
 - Onera...
 - Continuing damage
 - ASIP, IATP
- **Environmentally Assisted Cracking**
 - Corrosion Fatigue
 - Effect of frequency, waveform, hold-time, ...
 - Stress Corrosion
 - K_{ISCC}
 - SCC ratings for aircraft alloys
 - Case study: SCC of a High Strength Steel Frame in a US Navy Fighter
 - Fretting Fatigue
 - How surface finish, similar materials in contact, slip amplitude, temperature, and environment affect Fretting Fatigue
 - Contact fatigue
 - Gear failures
 - Aging aircraft issues
 - Durability vs Damage Tolerance
 - Multi-Site Damage, Widespread Fatigue Damage
 - The Aloha accident
 - Continued airworthiness
 - Supplemental inspection programs
 - Limit of Validity (LOV)
- **Testing for Substantiation and Data accumulation**
 - Cycle Counting methods
 - Rain flow method
 - In-flight loads monitoring
 - Testing
 - Coupons, specimen, component, and Full-Scale
 - Standardized Testing
 - Coupon preparation, precracking guidelines
 - E-399 K_{Ic}
 - E-647 da/dN
 - Service duplication Testing
 - Environmental chambers
 - Time compression issues in corrosion fatigue testing
 - Load Spectrum Generation
 - Canned Spectra
 - TWIST, MINITWIST, TURBISTAN, HELIX, FELIX, ...
 - Sequence effects

- Truncation, clipping
 - Scatter, Reliability, Risk management
 - Weibull Paper, Example problem
 - Material Properties & Useful Data handouts and Sources
 - S-N curves
 - Crack initiation data
 - da/dN crack growth data
 - Fracture Toughness K_{Ic} s
 - Data sources and handbooks
 - Journals
- **Special Topics (Optional)**
 - Cracking in aircraft engine components
 - ENSIP
 - Sioux City DC-10 crash landing
 - Thermo-mechanical Fatigue
 - Creep Fatigue
 - Thermal Fatigue
 - Concorde
 - Sonic fatigue (Acoustic Fatigue)
 - Fatigue of composites
 - Polymers
 - ARALL, GLARE and other newer materials to fight fatigue
- **Do's and TABOOs**
 - Methods to improve fatigue resistance
 - Clever use of favorable residual stresses
 - Cold-working of holes
 - Shot Peening
 - Residual Stress control measures
 - Bolts, Rivets, Springs, Bearings, Welds, ...
 - Failure Analysis: useful learning tool
 - Care and handling of fractures
 - Repair techniques
 - Japan Air Lines 747 crash
 - "stop"-drill?
 - Helpful treatments and processes
 - plating
 - Hi-Tigue and other fatigue rated fasteners
 - Guidelines based on experience
- **Epilogue**
- **No highway**

Course Benefits

Attending Delegates will

- Gain solid understanding of the fundamentals of Metal Fatigue, Corrosion, and Aging Composites
- Receive knowledge and tool that'd enable them to operate aging fleet of aircraft and helicopters in an economical, yet safe fashion
- Study very practical case histories in a relaxed setting with interactive facilitation and be able to learn extremely valuable and real-life lessons
- * Understand technical expertise required to minimize the probability of a catastrophe or accident
- * Perform in-class fracture mechanics calculations with instructor's individual attention

Prerequisites

None

Teaching Method

Classroom instruction

CEU