MC150
Fracture Mechanics and other Methods for Fatigue and Fracture Analysis of Pressure Equipment

Day 1

- Overview of Fatigue Analysis Methods
  - Fatigue Curves (S-N method)
  - Structural Stress Method for Welded joints
  - Fracture Mechanics

- Introduction to Fracture Mechanics
  - Why do cracks initiate and propagate?
  - Concept of plastic zone
  - Concept of constraint to yielding
  - Crack growth under cyclic loading
  - Crack growth due to environmental effects
  - Fast fracture (brittle fracture)

- Discussion of Initial Flaw Size
  - Minimum detectable flaw size using NDE
  - Sizing known flaws

- Characterization of Flaws (cracks)
  - Flaw depth and length
  - Branched cracks
  - Multiple flaws in close proximity
  - Flaw recategorization
  - Inspection techniques and sizing

- Level 1 Assessment
  - Screening Curves

- Level 2 Assessment
  - Determining partial safety factors (PSFs)
  - General procedure for computing stress intensity and reference stress
    - Primary, secondary and residual stress
  - Determining load and toughness ratios
    - Plasticity interaction factors
• Failure Assessment Diagram (FAD)
  – Construction and use of the FAD

Day 2

• Determining Crack Tip Stress Intensity and Reference Stress
  – Stress intensity solutions based on closed form equations for plates and shells
  – Finite Element Analysis Requirements for a Fracture Mechanics Analysis
  – Stress intensity factor solutions using third or fourth order polynomial curve fits
  – Stress intensity factor solutions using Weight Function methods
  – Solutions for reference stress in the un-cracked ligament

• Determination of Fracture Toughness
  – Fracture toughness parameters and inter-relationships
  – Relation of fracture toughness to Charpy V-Notch impact values
  – Fracture toughness testing
  – Charpy V-Notch testing
    ▪ Sub-size specimens
  – Conversion of Charpy V-Notch energy to fracture toughness
  – Concept of Transition Temperature
  – Calculation of lower bound fracture toughness when test results are not available.
  – Concept of static and dynamic fracture toughness (loading rate effects)
  – Effect of environment (e.g. hydrogen charging) on apparent fracture toughness
  – Effect of aging (embrittlement) on fracture toughness

• Determination of crack growth rates
  – Fatigue crack growth
  – Crack growth by stress corrosion cracking
  – Crack growth by hydrogen assisted cracking
  – Corrosion fatigue
  – Paris' law and its variants
  – Fatigue crack growth data in API 579-1/ASME FFS-1
  – Threshold stress intensity for crack growth

• Summary and Wrap-up