

## 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