



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Failure Analysis and Prevention

General Procedure of Failure Analysis: Failure analysis of Weld Joints

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Failure of weldments

- Fabrication stage: identified by inspection and testing
- In service failure: cracking, corrosion, fracture, deformation etc.



Surface features of failures

- Mismatch
- Poor bead geometry: concavity, convexity, irregularity
- Undercut, too high bead angle at toe
- Cracking: hot, cold, crater, toe, transverse, longitudinal
- Open pores
- Lack of penetration
- Spattering



Sub-surface features

- Under-bead cracks
- Porosity: shrinkage, gaseous
- Inclusion: oxides, slag, W
- Lack of fusion



General causes

- Improper filler choice
- Poor workman ship
- Poor weld joint design
- Unfavourable heat input/cooling rate
- Improper preheat/ post weld heat treatment
- Alloy segregation
- High residual stresses
- Unfavourable environmental service conditions



FA procedure for weld joints

- General information about failure
 - How, where, when failure occurred
 - How the failed part was treated/handled
 - Any fire
 - Any protection



FA procedure for weld joints

- Service history of weld joint
 - Loading
 - Atmosphere
 - Service period
 - Any accident
 - Any similar failure



FA procedure for weld joints

- Fabrication aspects: drawing of joint, calculations of service stress, estimation of service life
 - Specified/actual filler
 - Specified/actual base metal properties
 - Specified/actual procedure



FA procedure for weld joints

- Procedure information of welding
 - Specified/actually used cleaning procedure
 - Specified/actual welding process
 - Any repair / post weld heat treatment



FA procedure for weld joints

- Finishing/ testing of weld joints
 - Time of storage, transport and environment for same
 - When shipped for installation
 - How was it installed



Examination procedure

- Visual examination: sketches, photographs
- Macroscopic examination: fracture, wear, corrosion, defects and failure location i.e. weld , HAZ, base
- Size, shape and soundness of weld joint
- These will decide direction of investigation
- No fracture, low magnification macroscopy for corrosion, erosion

Examination procedure

- Analysis of weld, base, HAZ as per location of fracture w.r.t. composition, metallography, EPMA, XRD, mechanical properties
- If fracture,
 - location of fracture with origin
 - Direction of crack propagation and mechanism
 - Type of loading caused fracture

Metallography

- Microscopy of each zone w.r.t. filler, welding process, procedure
- Reveals inclusions, trans-granular/intergranular cracking, secondary cracking, segregation
- Penetration /fusion of base metal
- Microhardness of transverse section to corroborate with tensile data or fracture location

NDT

- Need to be careful for
 - DPT: in SCC and corrosion failures
 - MPT: hard spot formation in medium carbon steel



Analysis of information

- Integration of all the information gathered
 - Defect, stress raiser, welding parameters, process, filler, composition, microstructure, mechanical properties, fracture initiation, fracture mode
 - Not to jump into conclusion based on single discontinuity or deviation in one of the technical parameters



Analysis

- Crack origin: cause e.g. stress raiser or defects
- Heterogeneity in structure: carburizing or loss, segregation, martensite in HAZ / Weld, penetration
- Origin and fracture surface: indicate
 - how fracture began, propagated
 - Single overload or repeated loading
 - Tensile, shear, bending
 - Ductile fracture with dimples
 - Brittle fracture with trans granular cleavage or intergranular

HIC

- Hardness
- Residual stress
- Hydrogen content
- Martensite formation



Failure from HAZ

- HAZ softening
- Embrittlement
- Cracking
- Hardness
- Microstructure

