CONCEPT

Pressure Vessel Design, Fabrication and In-Service Inspection

Pressure Vessel Design, Fabrication and In-Service Inspection

Introduction:

Pressure vessel design errors and missed wall loss rarely announce themselves until a shell bulges, a nozzle weld cracks or a hydrotest fails. Most failures trace back to an unclear design basis, a head formed too thin, a material that cannot tolerate cold starts, incomplete examination records or corrosion rates nobody recalculated. This Core Concept course follows a vessel from calculation sheet to nameplate and then through years of operation under ASME BPVC Section VIII Division 1 and API 510. Participants finish with a Pressure Vessel Design and Inspection File Review for one vessel from their own site.

Course Objectives:

- Establish design pressure, design temperature, corrosion allowance and loading cases for a new or existing pressure vessel
- Calculate required shell and formed head thickness and check nozzle opening reinforcement using ASME BPVC Section VIII Division 1 rules
- Select plate, forging and bolting materials and confirm minimum design metal temperature and impact test needs
- Specify weld joint categories, post-weld heat treatment, examination extent and hydrostatic or pneumatic test conditions for a vessel
- Plan in-service inspection, corrosion rate and remaining life calculations, repairs, alterations and rerating in line with API 510
- Audit a complete vessel design and inspection file and rank the gaps that threaten safe operation

Target Audience:

- Mechanical engineers who prepare or approve pressure vessel calculations and datasheets
- Static equipment and integrity engineers who set inspection intervals and decide whether vessels stay in service
- Pressure vessel inspectors who examine shells, heads and nozzles and record wall thickness
- Fabrication and QA/QC staff who review welding, heat treatment, NDE and pressure test records
- Maintenance and turnaround engineers who scope vessel repairs, alterations and reratings

Course Outline:

Day 1: Pressure Vessel Types, Components and Failure Lessons

- Vessel Families: Separators, Reactors, Columns, Drums, Air Receivers and Spheres
- Shell Courses, Formed Heads, Conical Transitions and Skirt or Saddle Supports
- Nozzles, Manways, Flanged Connections and Internal Attachments
- Hoop and Longitudinal Stress Behaviour in Cylindrical and Spherical Shells
- Vessel Failure Case Files: Brittle Fracture, Overpressure and Wall Loss

Day 2: ASME BPVC Section VIII Structure and Code Responsibilities

- Section VIII Divisions 1, 2 and 3 Scope Boundaries by Pressure and Design Approach
- Division 1 Subsection A and Part UG General Requirements
- Subsection B Fabrication Parts UW, UF and UB
- Subsection C Material Parts UCS, UNF and UHA
- Manufacturer, Owner-User and Authorised Inspector Duties and the Certification Mark

Day 3: Design Basis and Pressure Part Thickness Calculations

- Design Pressure, Static Head and Maximum Allowable Working Pressure Definition
- Design Temperature, Allowable Stress Values and Joint Efficiency Selection
- Cylindrical Shell Thickness Under Internal Pressure Worksheet
- Ellipsoidal, Torispherical and Hemispherical Head Thickness Comparison
- External Pressure and Vacuum Checks With Stiffening Ring Options

Day 4: Nozzle Reinforcement, Materials, MDMT and Weld Requirements

- Opening Reinforcement Area Replacement Concept and Limits of Reinforcement
- Carbon, Low-Alloy and Stainless Plate and Forging Specifications for Vessels
- Minimum Design Metal Temperature and Impact Test Exemption Curves
- Weld Joint Categories, Radiography Extent and Joint Efficiency Links
- Post-Weld Heat Treatment Requirements by Material Thickness and Service

Day 5: Week-One Integration Case: Separator Vessel Design Review

- Case Datasheet Review: Operating Envelope, Fluids and Upset Conditions
- Independent Thickness and MAWP Recalculation for Shell and Heads
- Nozzle Load and Reinforcement Check on a Large Inlet Connection
- Material and MDMT Verification Against Start-Up and Depressurisation Cases
- Design Review Comment Sheet Drafting and Peer Challenge

Day 6: In-Service Inspection Under API 510 and Remaining Life

- API 510 Scope, Inspector Role and Owner-User Inspection Organisation
- Internal, External and On-Stream Inspection Techniques for Vessels
- Damage Mechanisms: General Thinning, Pitting, Cracking and Corrosion Under Insulation
- Thickness Measurement Location Grids and Ultrasonic Data Quality
- Short-Term and Long-Term Corrosion Rate, Remaining Life and Inspection Interval Setting

Day 7: Repairs, Alterations, Rerating and Overpressure Protection Interface

- Repair Versus Alteration Classification and Authorisation Steps
- Weld Build-Up, Insert Plates and Nozzle Replacement Repair Methods
- Rerating Calculations and Nameplate Update After Design Condition Changes
- Pressure Testing After Repair: Hydrostatic Test, Pneumatic Test and Exclusion Zones
- Relief Device Set Pressure, Accumulation and MAWP Consistency Check

Day 8: Fabrication Surveillance, Records and Stakeholder Coordination

- Inspection and Test Plan Hold Points for Vessel Fabrication
- Manufacturer Data Report, Nameplate Stamping and U-1 Form Content Review
- NDE Technique Selection: Radiography, Ultrasonic, Magnetic Particle and Penetrant
- Turnaround Vessel Entry Scope Negotiation With Operations and Maintenance
- Inspection Findings Reporting and Fitness-for-Continued-Service Recommendations

Day 9: Vessel Integrity Data, Performance Indicators and Improvement

- Equipment Master Data and Thickness History Database Structure
- Integrity KPIs: Overdue Inspections, Recommendation Close-Out and Wall Loss Trends
- Corrosion Monitoring Coupons and Probes Versus Thickness Surveys
- Inspection Effectiveness Grading and Coverage Benchmarking
- Lessons-Learned Loop From Vessel Incidents Into Design Specifications

Day 10: Capstone: Pressure Vessel Design and Inspection File Review

- Walkthrough Case: Refinery Knock-Out Drum With Corrosion Under Insulation
- Walkthrough Case: Chemical Plant Reactor With Nozzle Cracking History
- Own-Vessel File Audit: Calculations, Data Report, Test Records and Inspection History
- Remaining Life and Next Inspection Date Justification for the Selected Vessel
- Pressure Vessel Design and Inspection File Review Presentation and Peer Challenge

Skills You Will Gain:

- Pressure Part Thickness Calculation
- Opening Reinforcement Checking
- Brittle Fracture Screening
- Weld Joint Efficiency Selection
- Vessel Damage Mechanism Recognition
- Corrosion Rate Analysis
- Repair and Rerating Planning
- Vessel Record Auditing

Why Attend This Course:

- Leave with a Pressure Vessel Design and Inspection File Review completed on one vessel from your own site
- Spot thin heads, unreinforced openings and unsuitable materials before a vessel reaches the hydrotest or the process
- Defend inspection intervals, repair methods and rerating decisions with calculations traceable to the code
- Compare vessel practice with engineers from refining, gas processing, petrochemicals, power and water treatment

Conclusion:

A pressure vessel stays safe only while its design basis, materials, welds, test records and measured wall thickness agree with the service it sees today. Week one builds design capability under ASME BPVC Section VIII Division 1, from vessel components and code structure to thickness, reinforcement, materials and weld requirements. Week two adds in-service inspection under API 510, remaining life, repairs, rerating, fabrication records and integrity data, then closes with the Pressure Vessel Design and Inspection File Review for each participant's own vessel.