CONCEPT

Hydrogen and CO2 Pipelines: Embrittlement, Dense-Phase Transport and Repurposing

27 September – 1 October 2027
Barcelona - Eixample district four-star



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Introduction:

Hydrogen and CO2 pipelines fail in ways natural gas lines do not: diffusible hydrogen lowers the fracture toughness of higher-strength line pipe and girth welds, while dense-phase CO2 carrying free water, H2S or SO2 corrodes carbon steel and can drive a running ductile fracture far along a rupture. Operators converting existing gas lines often lack the test data to prove either risk is controlled. This Core Concept course gives pipeline and integrity engineers the methods to qualify materials, set composition limits, check crack arrest and plan conversion. Participants produce a Repurposing Feasibility Study and Design Basis for a case line.

Course Objectives:

- Determine hydrogen and CO2 fluid properties, phase envelopes and flow behaviour needed to size and operate a dedicated or converted line
- Select line pipe grades, weld procedures and hardness limits for hydrogen service using ASME B31.12 material performance factors and fracture mechanics test data
- Set a dense-phase CO2 composition and free-water specification and assess its effect on corrosion, phase boundary and compressor duty
- Calculate crack arrest toughness for a CO2 or hydrogen line with the Battelle two-curve method and choose crack arrestors where toughness falls short
- Analyse rupture depressurisation, dispersion of dense CO2 clouds and hydrogen jet fires to set routing, valve spacing and leak detection requirements
- Build a repurposing feasibility study and design basis that documents records review, material testing, defect acceptance, fatigue life and maximum operating pressure

Target Audience:

- Pipeline design engineers responsible for wall thickness, pressure rating and valve spacing on new or converted transmission lines
- Integrity and inspection engineers responsible for defect assessment, in-line inspection interpretation and fitness-for-service decisions
- Materials, welding and corrosion engineers responsible for line pipe qualification, weld procedure approval and internal corrosion control
- Flow assurance and process engineers responsible for fluid specification, compression and transient operating envelopes
- Pipeline operations and technical safety engineers responsible for leak detection, emergency depressurisation and consequence studies

Course Outline:

Day 1: Hydrogen and CO2 as Pipeline Fluids: Properties and Flow Behaviour

- Hydrogen Density, Compressibility Factor and Energy Flow Versus Methane at Equal Pressure Drop
- CO2 Phase Diagram: Triple Point, Critical Point and Dense-Phase Operating Window
- Equation of State Selection for Hydrogen Blends and Impure CO2 Mixtures
- Hydrogen Blending Into Natural Gas Lines: Blend Ratio Limits, Wobbe Shift and End-User Tolerance
- Converted Line Baseline Review: Pipe Records, Grade, Seam Type and Operating Pressure History

Day 2: Design Codes, Material Qualification and Composition Specifications

- ASME B31.12 Pipeline Part: Prescriptive and Performance-Based Design Options
- Material Performance Factors, Hardness Limits and API 5L Grade Suitability for Hydrogen Service
- Hydrogen Embrittlement Mechanisms: HELP, HEDE and Fatigue Crack Growth Acceleration
- Fracture Toughness and Susceptibility Testing in Gaseous Hydrogen: ASTM F1459, G142 and F1624
- DNV-RP-F104 Scope: CO2 Stream Composition, Free Water Limits and Impurity Interactions

Day 3: Hydraulic Design, Compression and Fracture Control Calculations

- Dense-Phase CO2 Hydraulics: Pressure Profile, Minimum Pressure Margin and Booster Spacing
- Hydrogen and CO2 Compressor Selection: Reciprocating Versus Centrifugal and Interstage Dehydration
- Running Ductile Fracture: Decompression Wave Speed Versus Fracture Velocity
- Battelle Two-Curve Method: Required Charpy Energy for Crack Arrest
- Mechanical and Composite Crack Arrestor Design and Spacing

Day 4: Hazards, Leak Detection and Integrity Management for Both Fluids

- Rupture Depressurisation, Joule-Thomson Cooling and Dry Ice Formation at Release Points
- Dense CO2 Cloud Dispersion and Hydrogen Jet Fire Consequence Modelling for Routing and Valve Spacing
- Leak Detection for Hydrogen and CO2: Mass Balance, Acoustic and Fibre Sensing Limits
- Integrity Management Plan: Pressure Cycling Fatigue, Hard Spots and Internal Corrosion Monitoring
- In-Line Inspection Tool Suitability and Defect Acceptance Adjustments for Hydrogen Service

Day 5: Case Line Repurposing Feasibility and Design Basis Build

- Case Line Data Pack: Pipe Grades, Girth Weld Records, Inspection Results and Target Service
- Feasibility Screening Model: Maximum Operating Pressure, Derating and Fatigue Life Calculation
- Fracture Control and Crack Arrest Worksheet for the Case Line
- Design Basis Document Drafting: Fluid Specification, Code Route and Integrity Programme
- Repurposing Study Presentation to a Technical Authority Review Panel

Skills You Will Gain:

- Hydrogen Material Qualification
- Dense-Phase CO2 Specification
- Crack Arrest Calculation
- Decompression Wave Analysis
- Release Consequence Assessment
- Pipeline Conversion Screening
- Hydrogen Fatigue Life Estimation
- Design Basis Authoring

Why Attend This Course:

- Leave with a Repurposing Feasibility Study and Design Basis for a case line reviewed by a technical authority panel
- Explain to asset owners with test data and calculations whether an existing gas line can carry hydrogen, a blend or CO2
- Challenge supplier and contractor claims on line pipe compatibility, crack arrestors and leak detection sensitivity
- Compare conversion and new-build experience with engineers from transmission, refining, power and carbon storage operators

Conclusion:

Safe hydrogen and CO2 transport depends on treating fluid behaviour, material response and fracture control as one design problem rather than reusing natural gas assumptions. The course moves from fluid properties, phase behaviour and blending, through ASME B31.12 and DNV-RP-F104 material and composition requirements, to hydraulics, compression and crack arrest calculations, then to release hazards, leak detection and integrity management. The final day builds a Repurposing Feasibility Study and Design Basis for a case line, ready for technical authority review.