Structured Methodology for Repurposing of Existing Pipelines for CCUS Service

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Why Repurpose Offshore Pipelines for CCUS?

Project enabler
especially when connected to depleted gas reservoirs

Reduced CAPEX
– up to £2M/km

Reduced environmental impacts
avoidance of new infrastructure in environmental sensitive zones

Reduced project lead times

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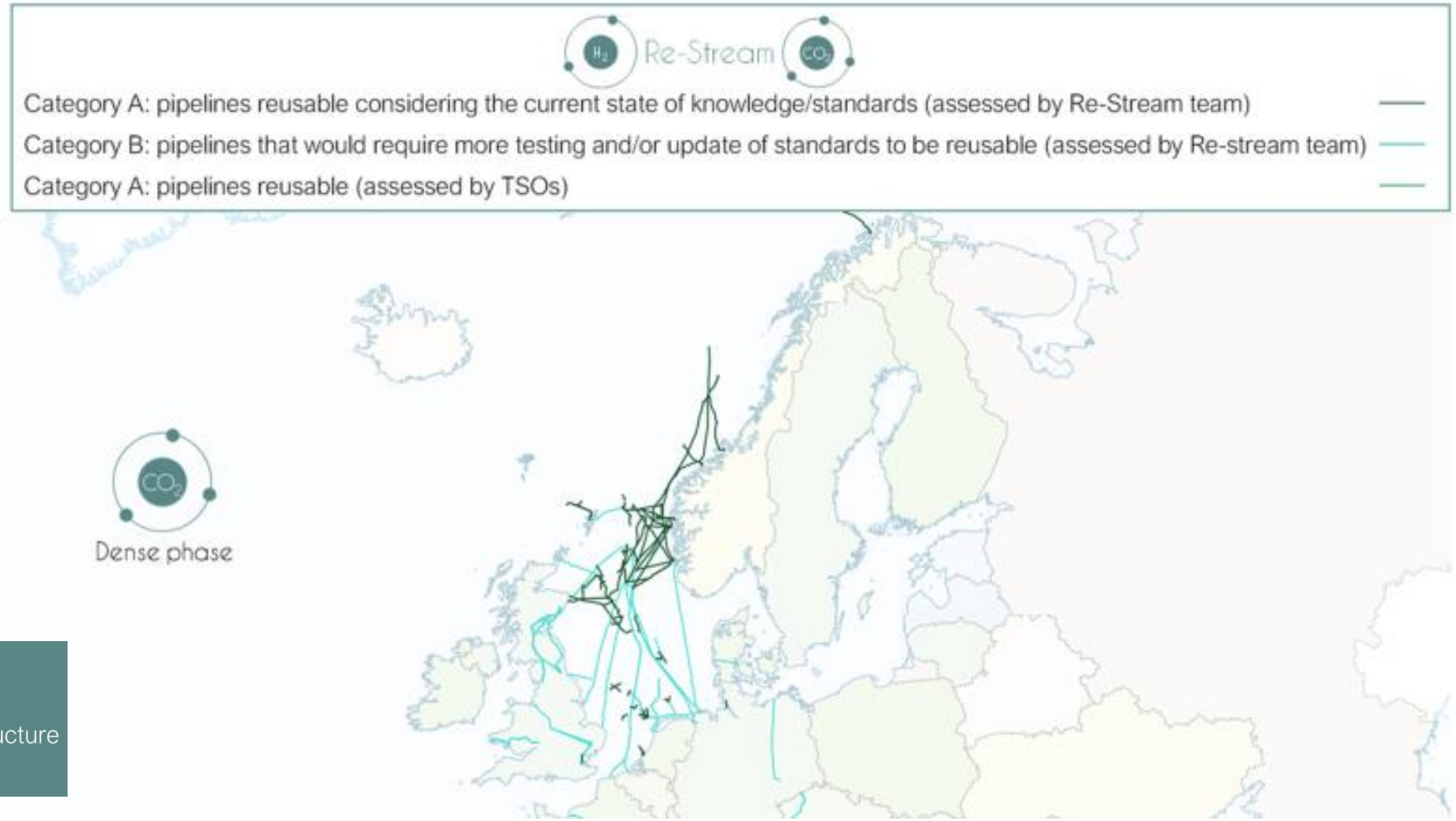
Potential for Repurposing

70% of the existing offshore pipeline length may be suitable for CO_2 transport



International Association of Oil & Gas Producers

Re-Stream

Study on the reuse of oil and gas infrastructure for hydrogen and CCS in Europe

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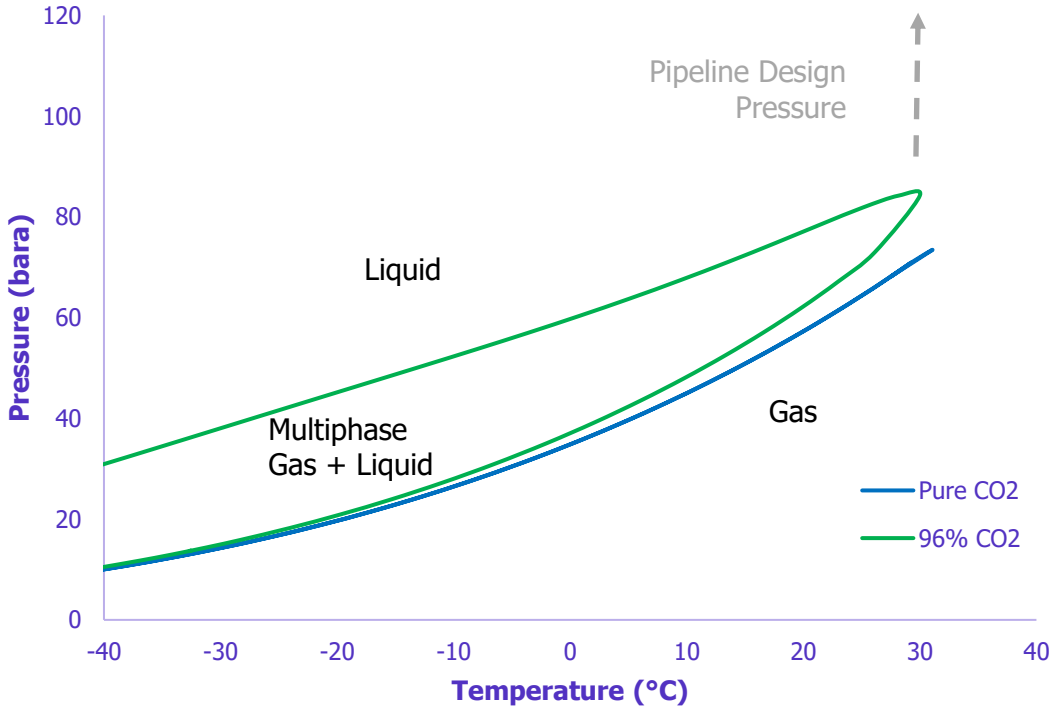
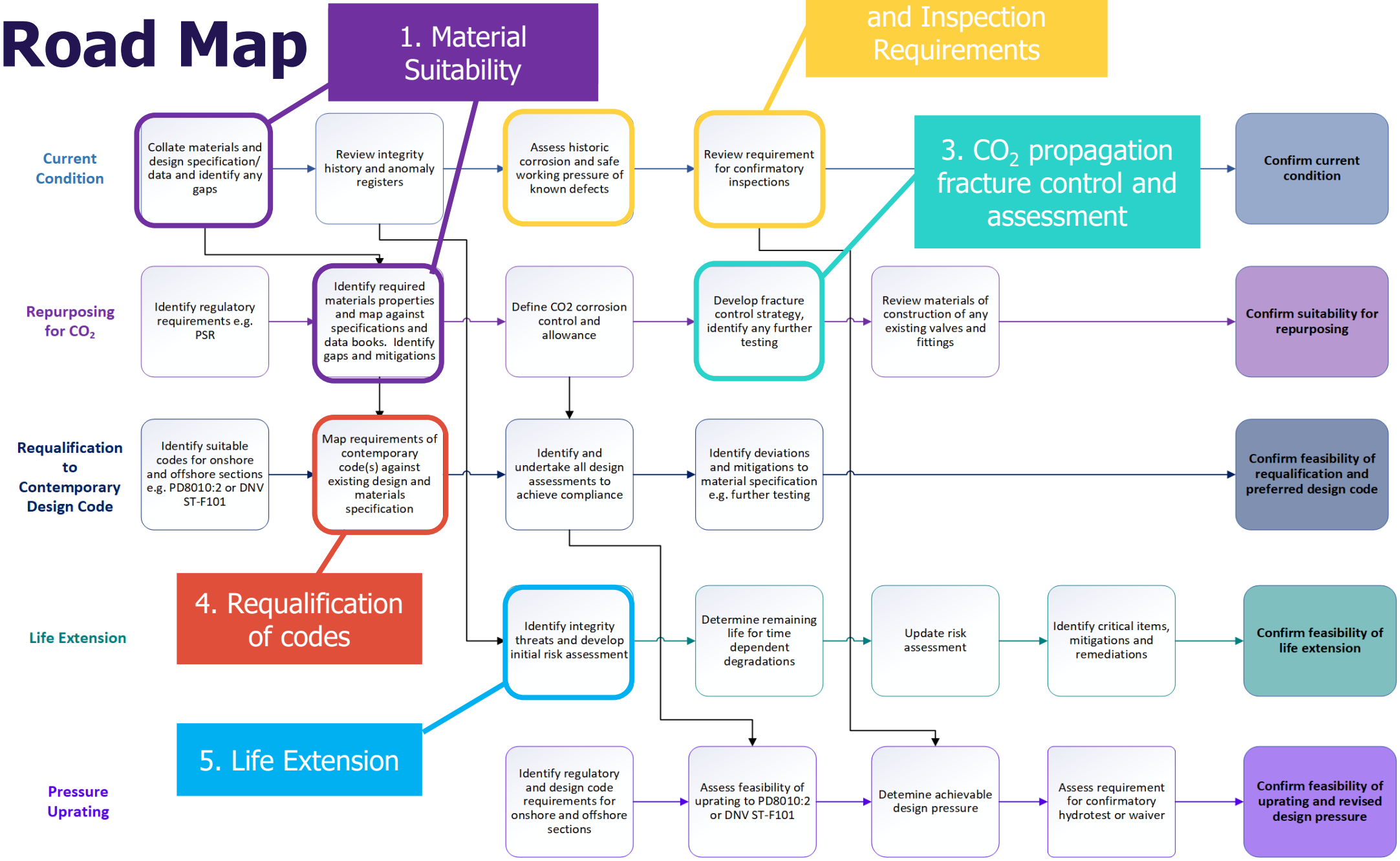
Repurposing Challenges

- Does the pipeline have sufficient capacity for CO_2 transportation?
- Is the pipeline pressure rating sufficient for dense phase CO_2 operation?
- Is the current condition of the pipeline known?
- Are the pipeline materials and design suitable for repurposing?
- Does the pipeline comply with contemporary design codes?
- Does the pipeline have sufficient remaining life?

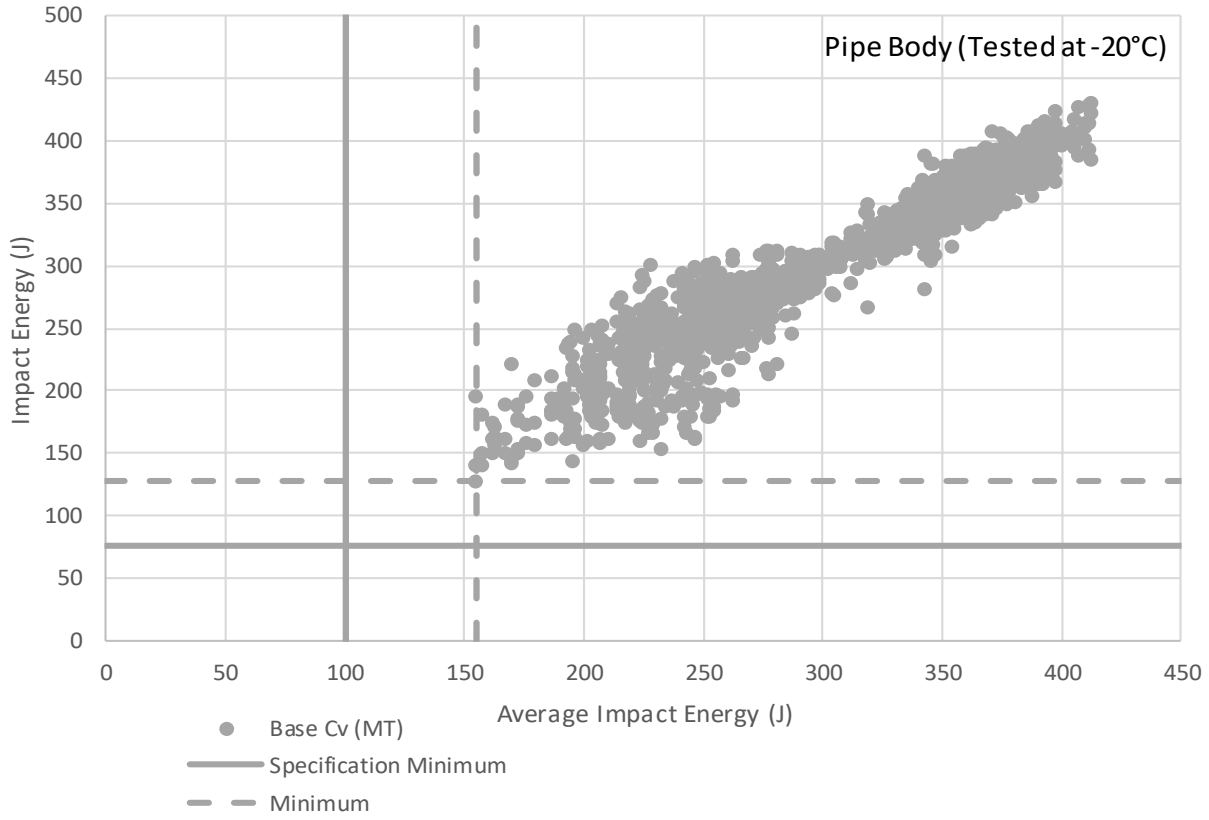


Road Map


1. Material Suitability
2. Current Condition and Inspection Requirements
3. CO_2 propagation fracture control and assessment
4. Requalification of codes
5. Life Extension
Current Condition
Collate materials and design specification/ data and identify any gaps
Review integrity history and anomaly registers
Assess historic corrosion and safe working pressure of known defects
Review requirement for confirmatory inspections
Confirm current condition
Repurposing for CO_2
Identify regulatory requirements e.g. PSR
Identify required materials properties and map against specifications and data books. Identify gaps and mitigations
Define CO2 corrosion control and allowance
Develop fracture control strategy, identify any further testing
Review materials of construction of any existing valves and fittings
Confirm suitability for repurposing
Requalification to Contemporary Design Code
Identify suitable codes for onshore and offshore sections e.g. PD8010:2 or DNV ST-F101
Map requirements of contemporary code(s) against existing design and materials specification
Identify and undertake all design assessments to achieve compliance
Identify deviations and mitigations to material specification e.g. further testing
Confirm feasibility of requalification and preferred design code
Life Extension
Identify integrity threats and develop initial risk assessment
Determine remaining life for time dependent degradations
Update risk assessment
Identify critical items, mitigations and remediations
Confirm feasibility of life extension
Pressure Uprating
Identify regulatory and design code requirements for onshore and offshore sections
Assess feasibility of uprating to PD8010:2 or DNV ST-F101
Detemine achievable design pressure
Assess requirement for confirmatory hydrotest or waiver
Confirm feasibility of uprating and revised design pressure

1. Material Suitability

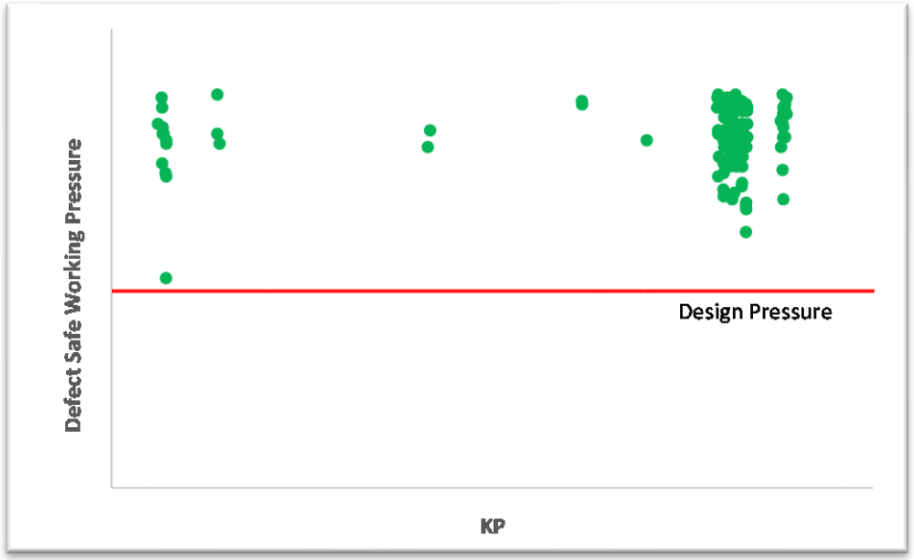
- Identify desirable properties
  - Low carbon equivalent (CE)
  - Good ductility, avoidance of high Y/T
  - Good fracture toughness
  - Avoidance of high hardness
  - Sour service rating (ideally)
  - Control of inherent defects
- Confirmation of achieved properties:
  - Review linepipe specification, data books, WPQR
- Identify mitigations for any data gaps



2. Current Condition and Inspection Requirements

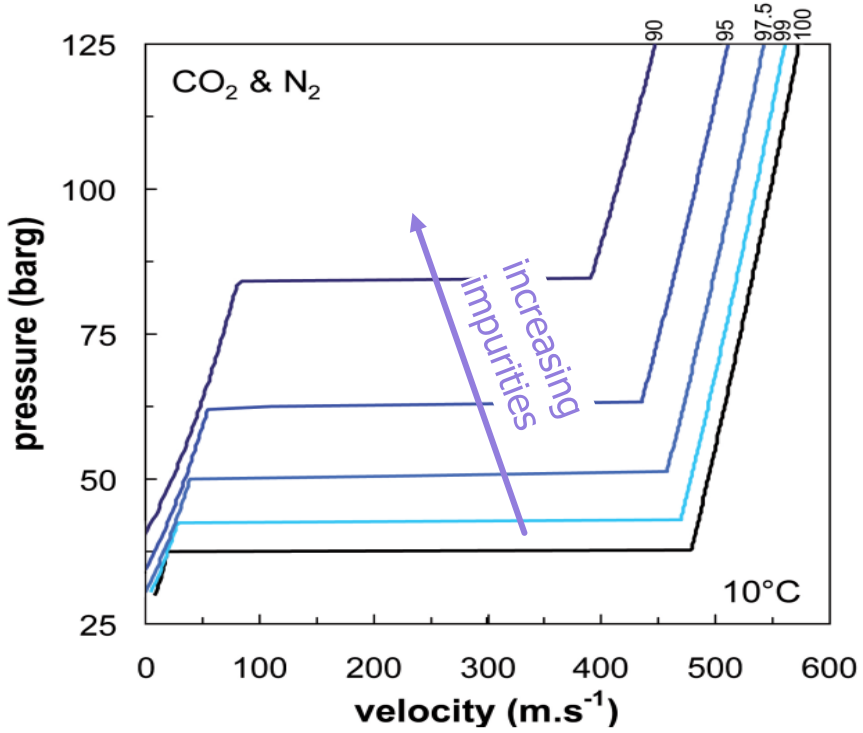
- Review historical inspections
- Assess known defects e.g. safe working pressure
- Consider historical corrosion and damage mechanisms (general loss, pitting, cracking etc.)
- Review resistance to future CO_2 damage mechanisms

Identify any requirement for confirmatory inspections



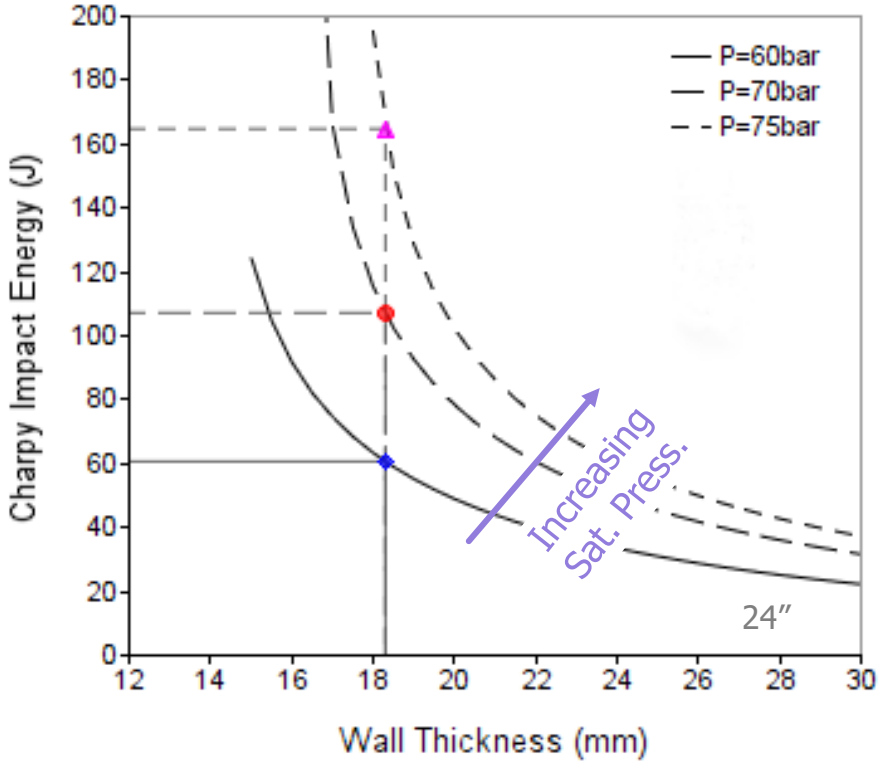
3. CO_2 Propagation Fracture Control

- Upon rupture dense phase CO_2 experiences a long decompression plateau – *saturation pressure, P_s*
- Saturation pressure is increased by impurities
- Fracture resistance is increased by wall thickness, grade and toughness - *arrest pressure, P_a*
- Propagation fracture is halted when $P_a > P_s$

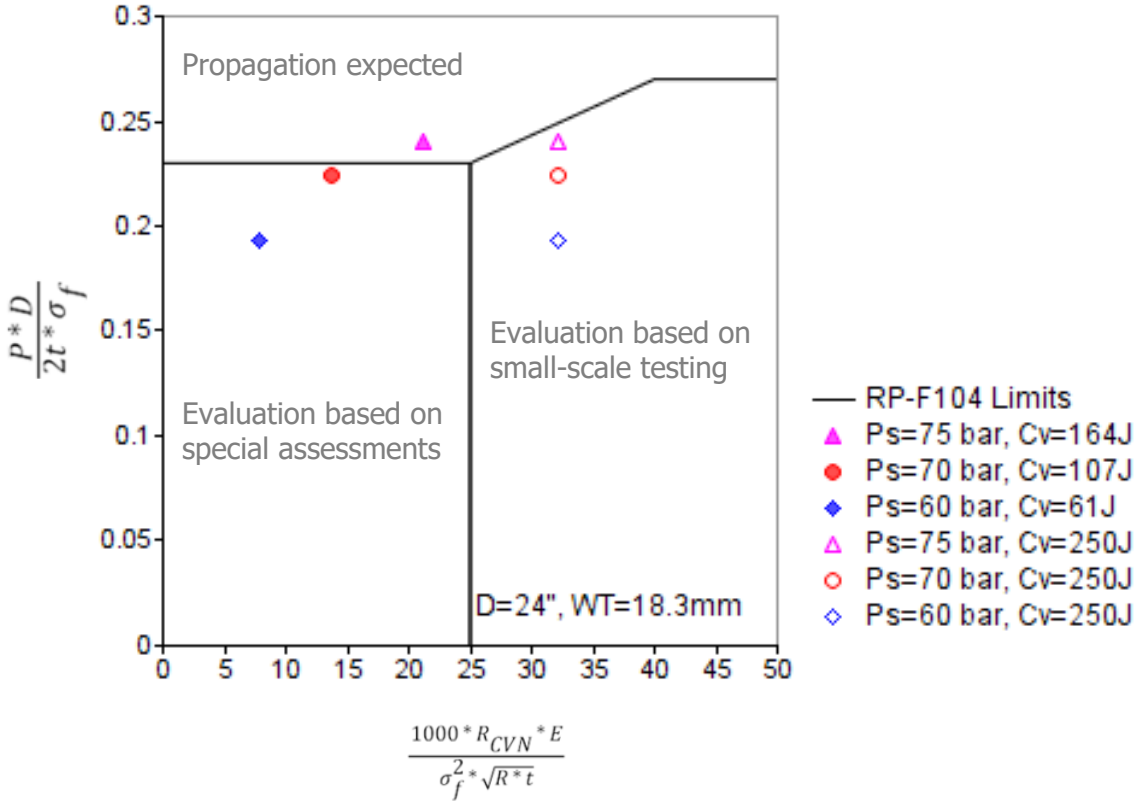


3. CO_2 Fracture Assessment Methodology

BS ISO 27913
Utilises Battelle TCM with correction factors
Not fully calibrated and non-conservative for CO_2

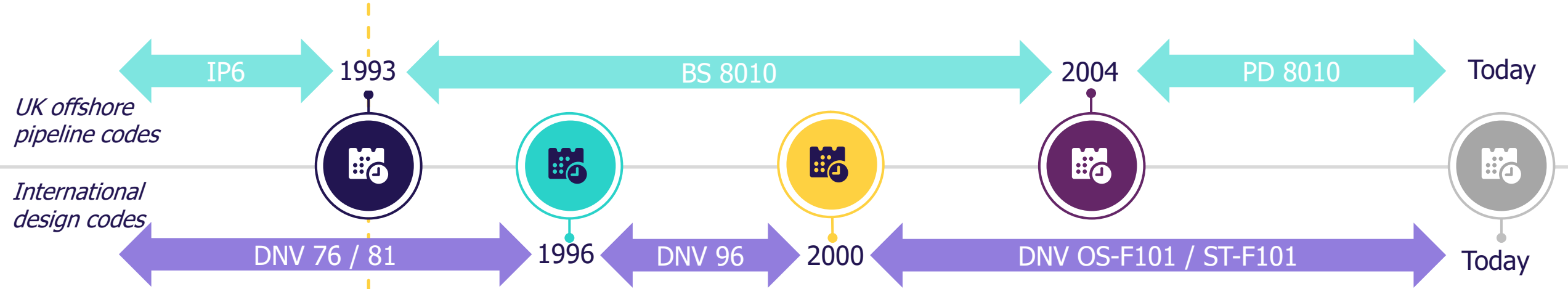


DNV RP-F104 (2021)
Empirical model



- Ongoing research area, industry methodology not mature
- Project specific testing may be required

4. Requalification to Contemporary Codes



Paths to requalification:

Identify key threats / failure modes and focus on relevant code updates

Full mapping of updates between design codes

CO_2 Guidance

PD8010 and DNV ST-F101 give some guidance for CO_2 pipelines, with further guidance in:

- BS ISO 27913
- DNV RP-F104

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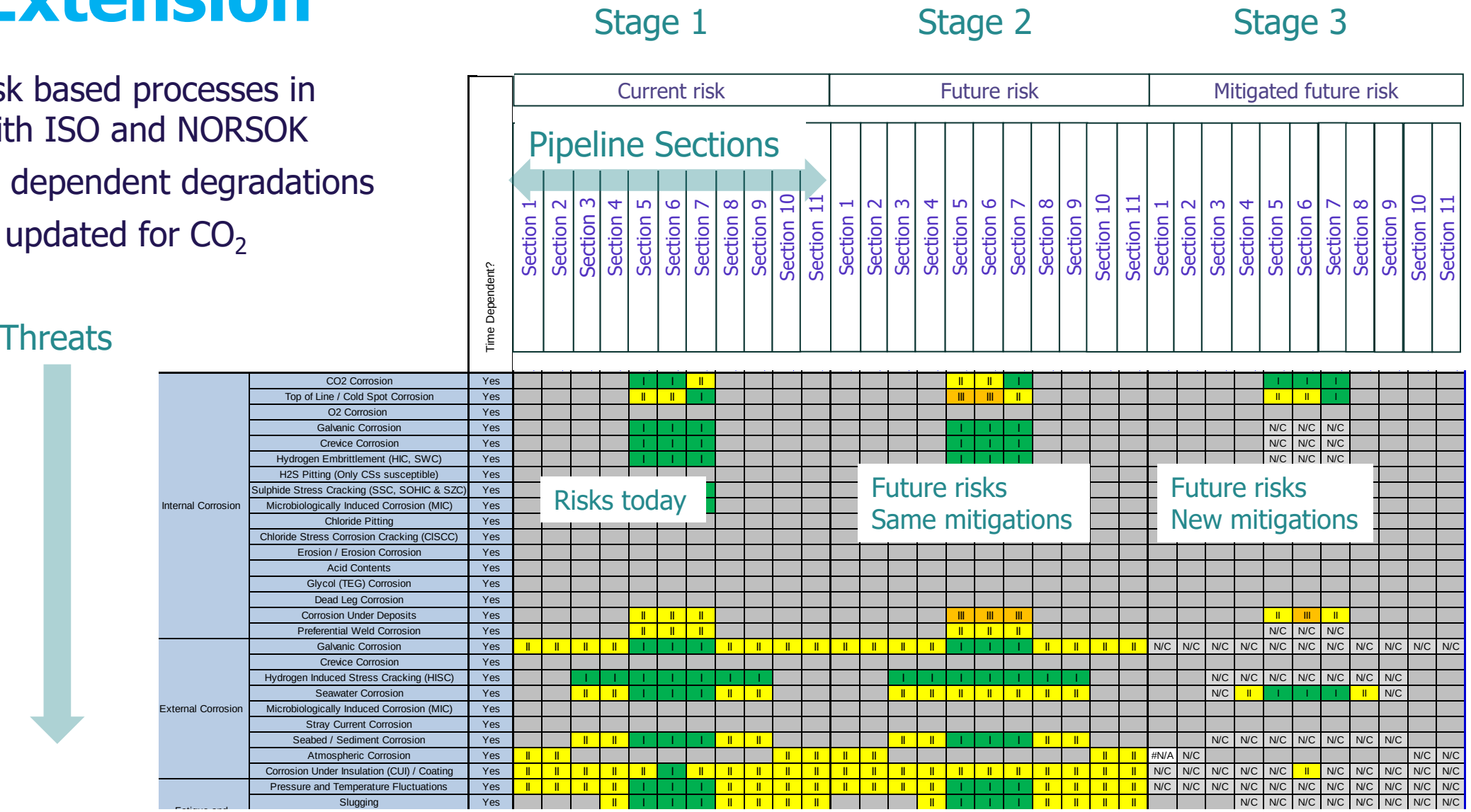
5. Life Extension

- Established risk based processes in accordance with ISO and NORSOK
- Focus on time dependent degradations
- Threat matrix updated for CO_2



Summary

Challenges

- Current condition
- Suitability of materials
- Fracture arrest
- Requalification
- Life extension
- Pressure rating

Benefits

- Project enabler
- Reduced CAPEX
- Lower environmental impacts
- Reduced project lead time
- Meeting stewardship expectations

The benefits can only be achieved by a structured approach to demonstrate safe and assured repurposing of pipelines for CCUS

THANK YOU

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