

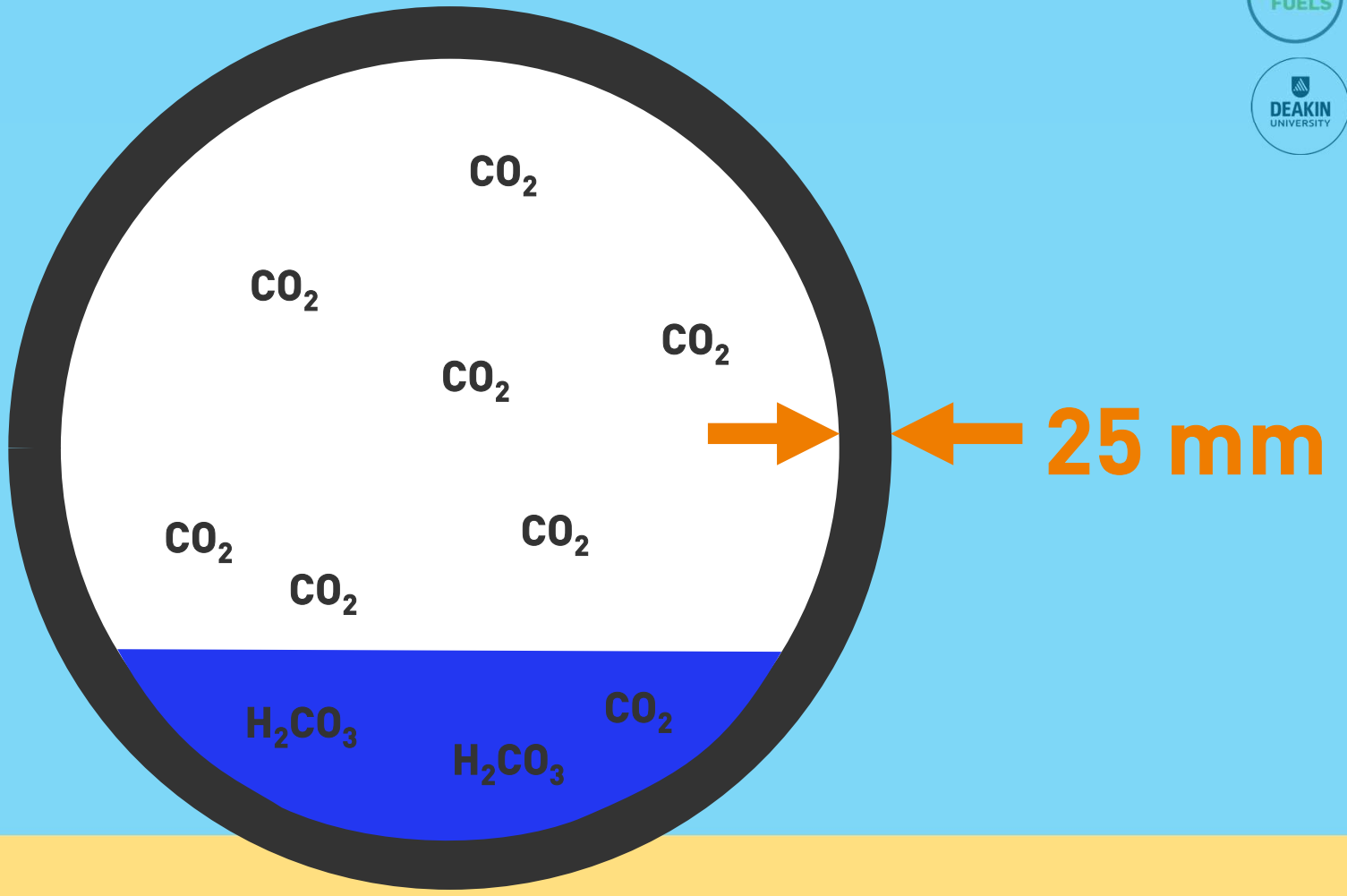


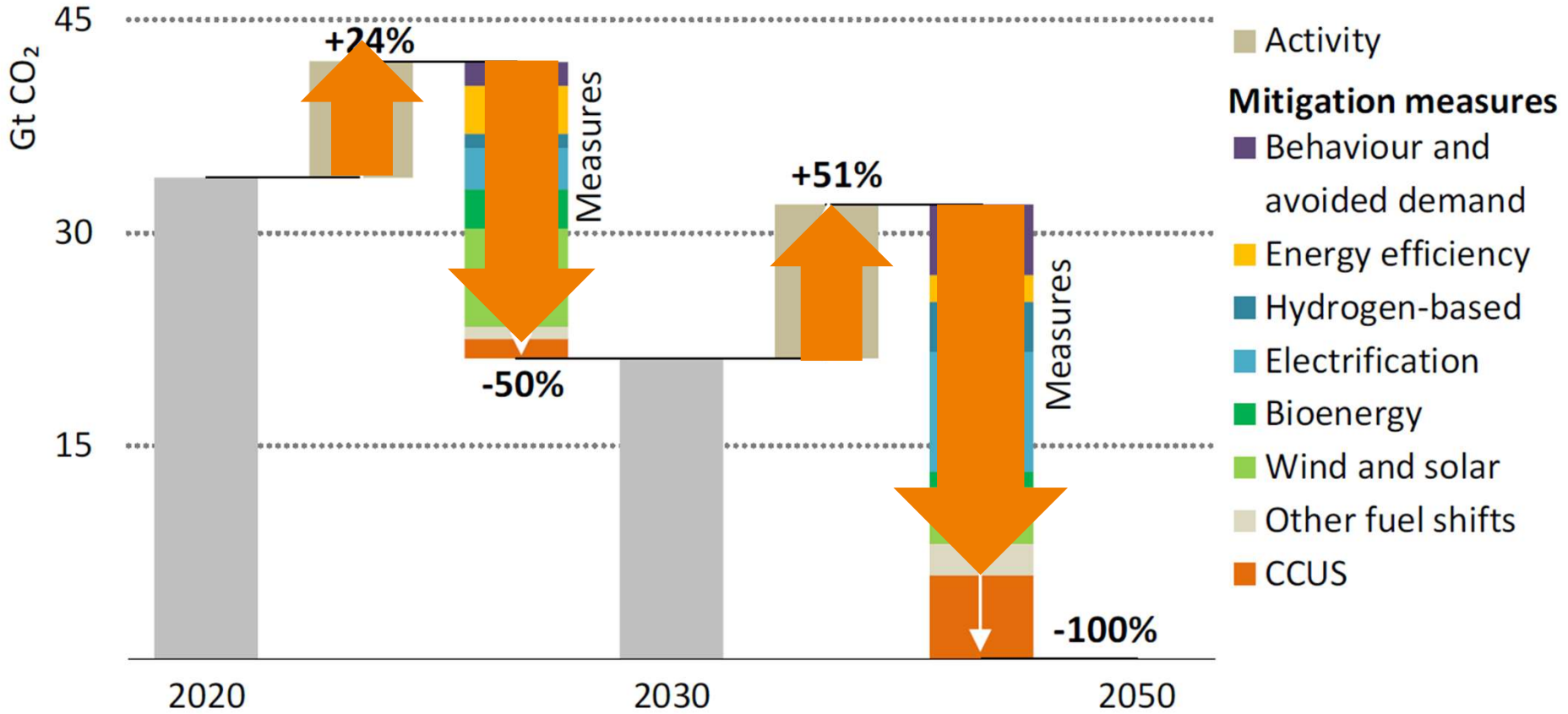
Researching Aggressive Corrosion in CO₂ Pipelines

Tom Seeber – Atteris

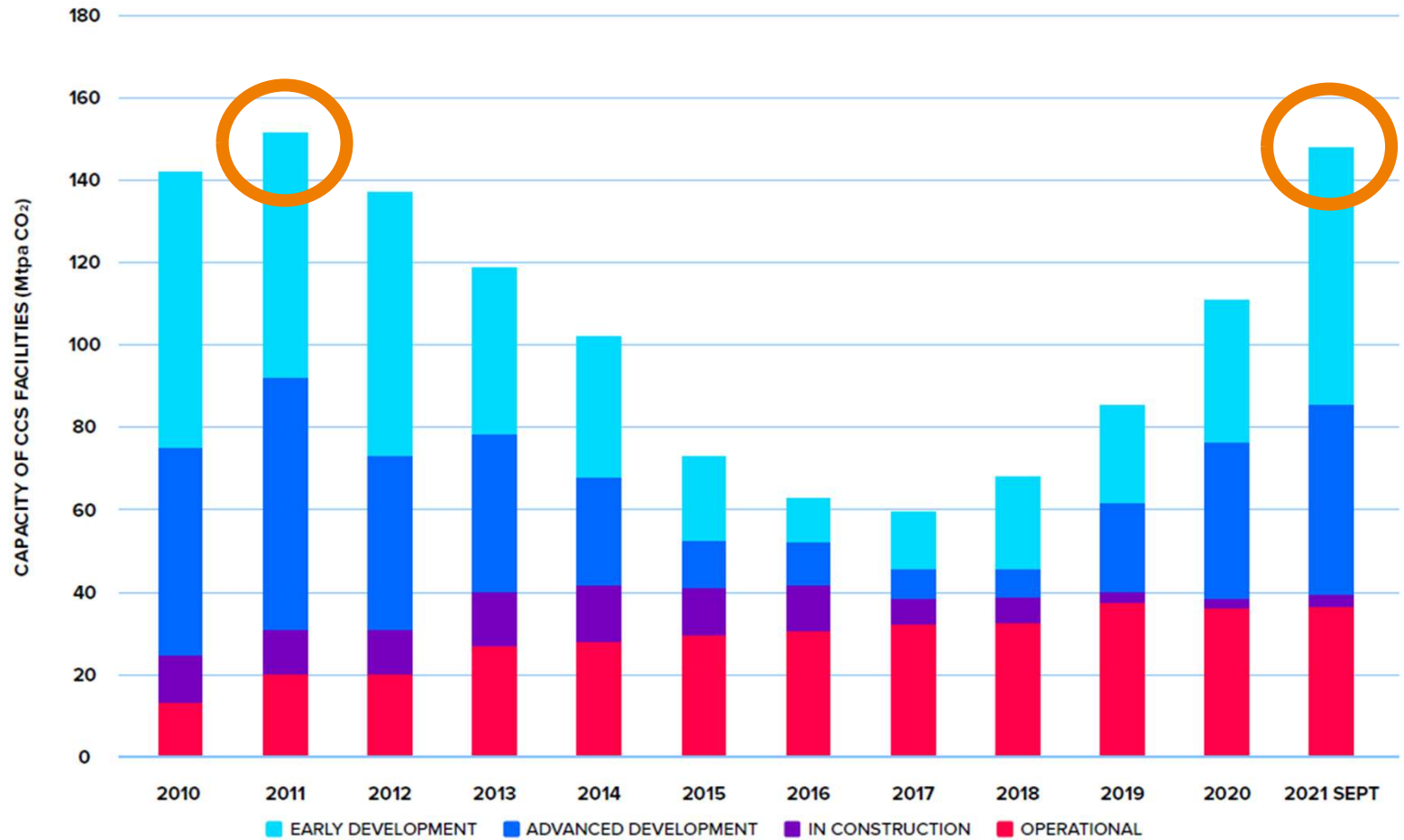
APGA Convention 2023







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The Product delivered by Seller or Seller's representative to Buyer at the Canyon Reef Carriers Delivery Meter shall meet the following specifications, which herein are collectively called 'Quality Specifications':

- (a) **Carbon Dioxide.** Product shall contain at least ninety-five mole percent (95%) of Carbon Dioxide as measured at the SACROC delivery meter.
- (b) **Water.** Product shall contain no free water, and shall not contain more than 0.48 9 m⁻³ in the vapour phase.
- (c) **Hydrogen Sulphide.** Product shall not contain more than fifteen hundred (1500) parts per million, by weight, of hydrogen sulphide.
- (d) **Total Sulphur.** Product shall not contain more than fourteen hundred and fifty (1450) parts per million, by weight, of total sulphur.
- (e) **Temperature.** Product shall not exceed a temperature of 48.9 °C.
- (f) **Nitrogen.** Product shall not contain more than four mole percent (4%) of nitrogen.
- (g) **Hydrocarbons.** Product shall not contain more than five mole percent (5%) of hydrocarbons and the dew point of Product (with respect to such hydrocarbons) shall not exceed -28.9 °C.
- (h) **Oxygen.** Product shall not contain more than ten (10) parts per million, by weight, of oxygen.
- (i) **Glycol.** Product shall not contain more than 4 x 10⁻⁵ L m⁻³ of glycol and at no time shall such glycol be present in a liquid state at the pressure and temperature conditions of the pipeline.



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**Future Fuel Technologies,
Systems and Markets**



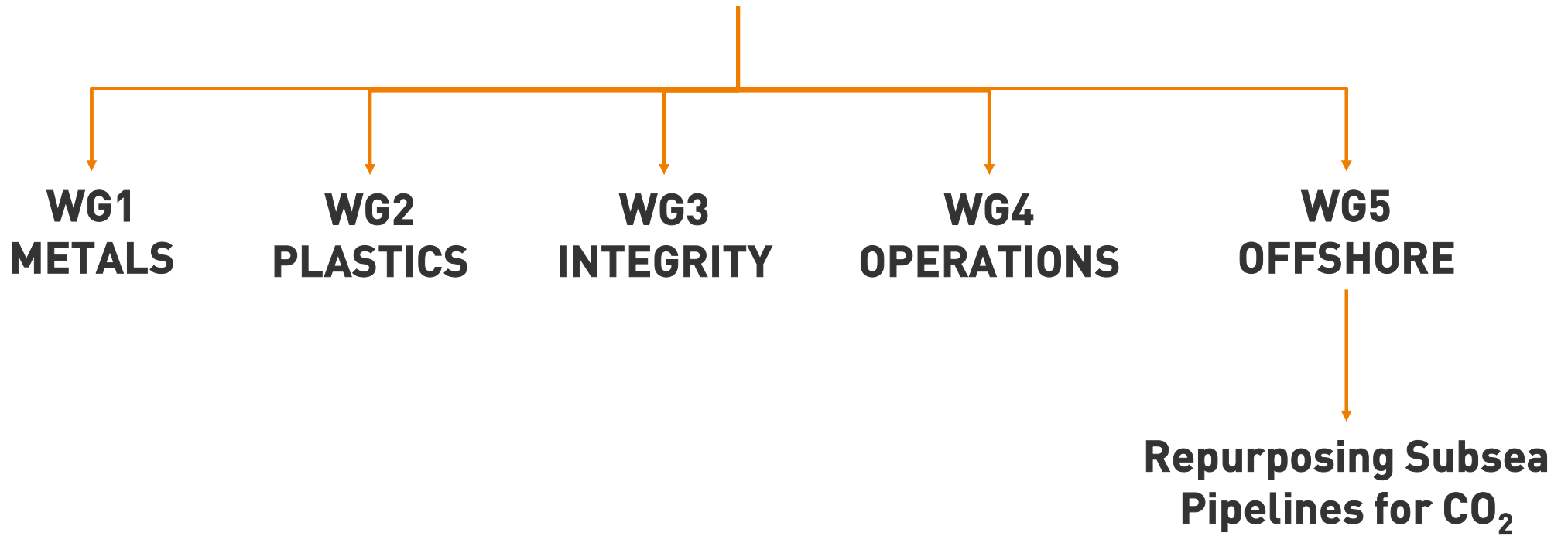
**Social Acceptance, Public Safety
and Security of Supply**



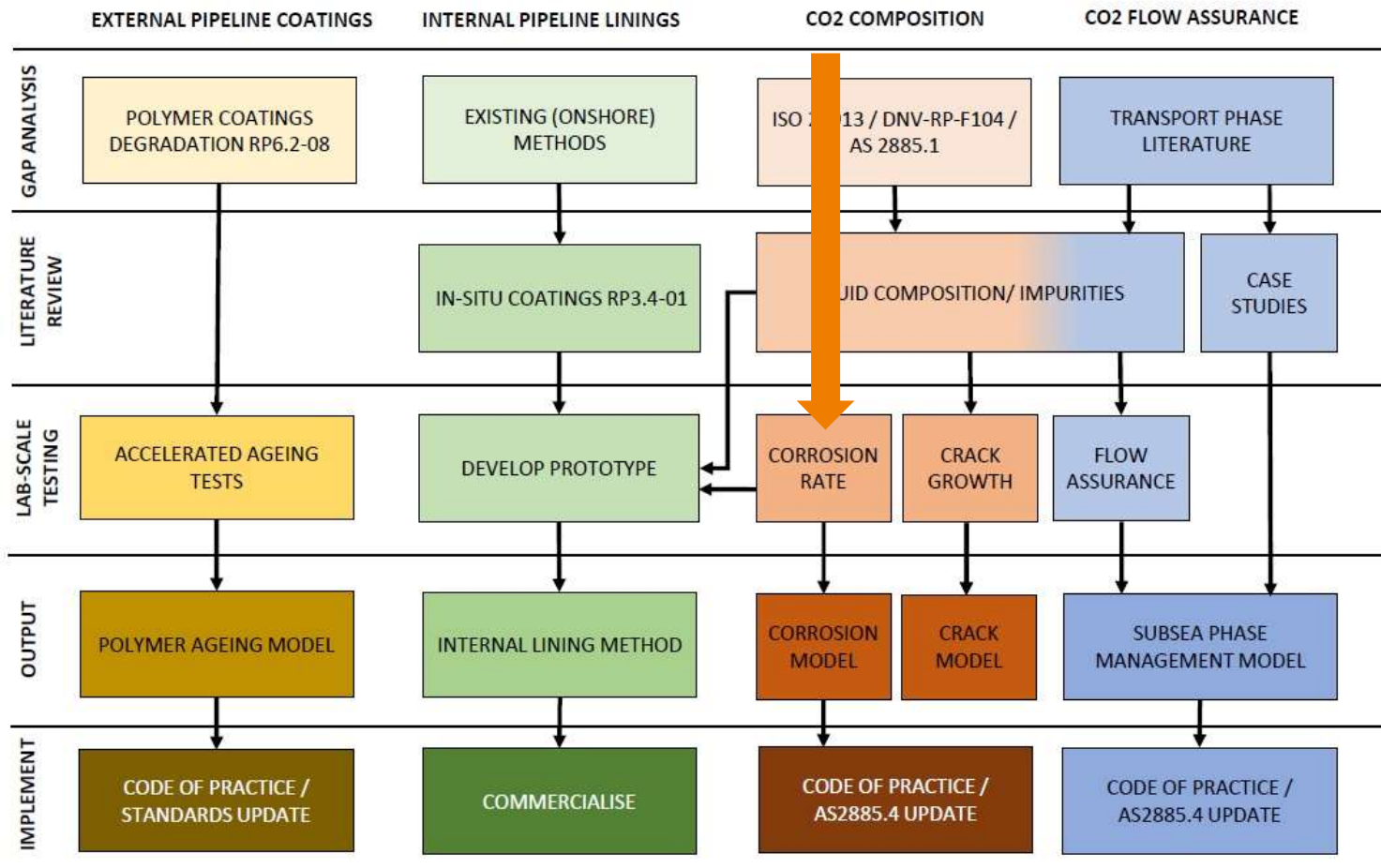
Network Lifecycle Management



Network Lifecycle Management



RESEARCH ROADMAP
REPURPOSING SUBSEA PIPELINES FOR CO₂





**FUTURE
FUELS** ●●●
CRC

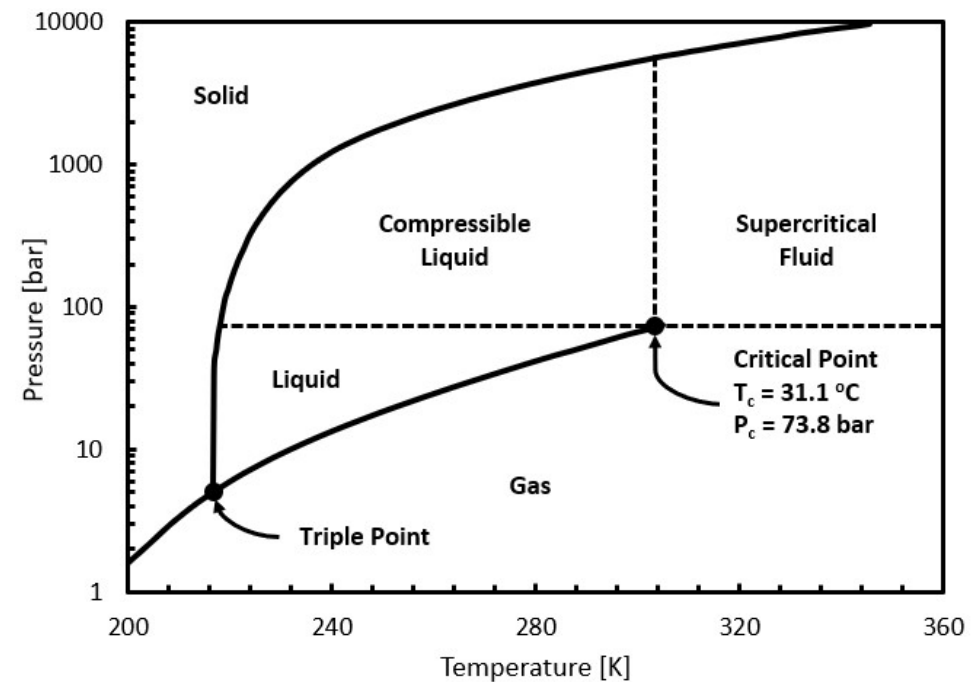
**Literature Review of the
Effects of Common Impurities
Found in High Density CO₂
Pipelines on the Rate of
Internal Corrosion**

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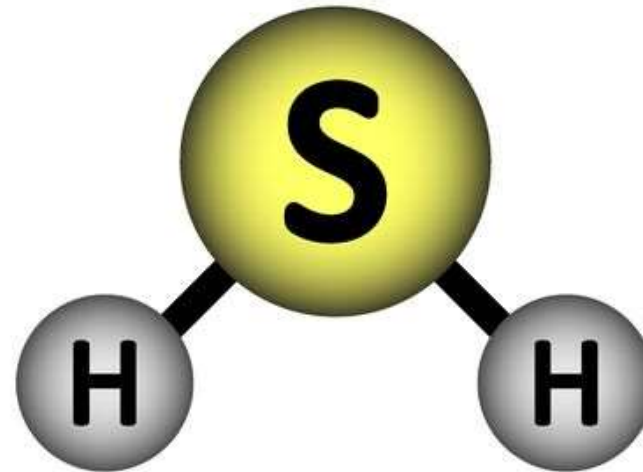
Table of Contents:

- Phase behaviour
- Common Impurities
- Corrosion caused by water



Tertiary CO₂ Mixtures

- NO_x
- SO_x
- Hydrogen Sulfide – sour service
- Hydrogen
- Nitrogen
- Oxygen
- Methane
- Carbon Monoxide
- Mercury



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Complex CO₂ Mixtures

- NO_x+O₂
- SO₂+O₂
- SO₂+NO₂
- SO₂+H₂S+O₂
- SO₂+NO₂+H₂S+O₂

Table 13. Summary of the experimental results obtained by scholars who investigated uniform corrosion rates in supercritical CO₂-H₂O-SO₂-O₂ systems.

Authors and Reference	CO ₂ Mixture Pressure [bar]	O ₂ Content [bar Unless Stated]	SO ₂ Content [bar Unless Stated]	Water Content [ppm mole Unless Stated]	Temperature [°C]	Flow Rate [rpm Unless States]	Exposure Time [hrs Unless Stated]	Corrosion Test Method	Uniform Corrosion Rate [mm/yr]
Choi, Nešić & Young [33]	80	3.3	0.8	0	50	Stagnant Conditions	24	Static Autoclave	No attack
		0	0	Water-saturated CO ₂ (10 g water added to autoclave)					~0.4
		3.3	0						~1.0
		0	0.8 (1 mol%)						~5.6
		3.3	0.8 (1 mol%)						~7.0
Choi & Nešić [35]	80	0	0	650	50	Stagnant Conditions	24	Static Autoclave	< 0.01
		0	0.8 (1 mol%)						3.48
		3.3	0.8 (1 mol%)						3.70
Xiang et al. [56]	100	1000 ppm	0.2 (0.2 mol%)	Water-saturated CO ₂ (6 g water added to autoclave to ensure saturation)	50	120 rpm	288	Rotating Autoclaves	0.2
			0.7 (0.7 mol%)						0.7
			1.4 (1.4 mol%)						0.85
			2 (2 mol%)						0.9
									2.0

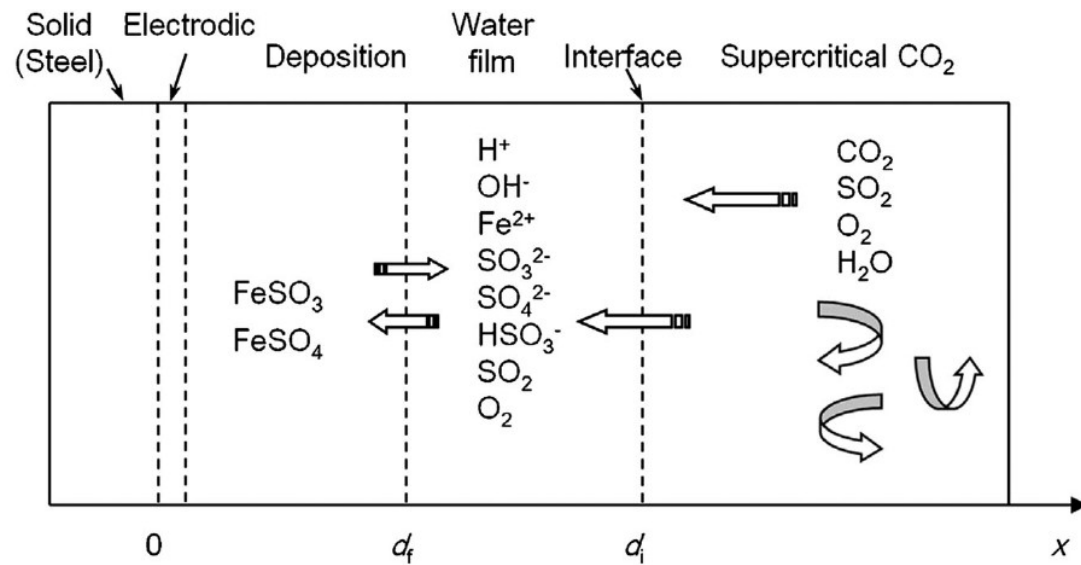
Summary

- Existing corrosion models

- Thermodynamic
- Corrosion rate

- Gaps

- By impurity
- models



Recommendations

- Flow Rate
- Models for high pressure
- Effects of H₂S corrosion products



Flow Assurance Loop for CO₂ transport

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