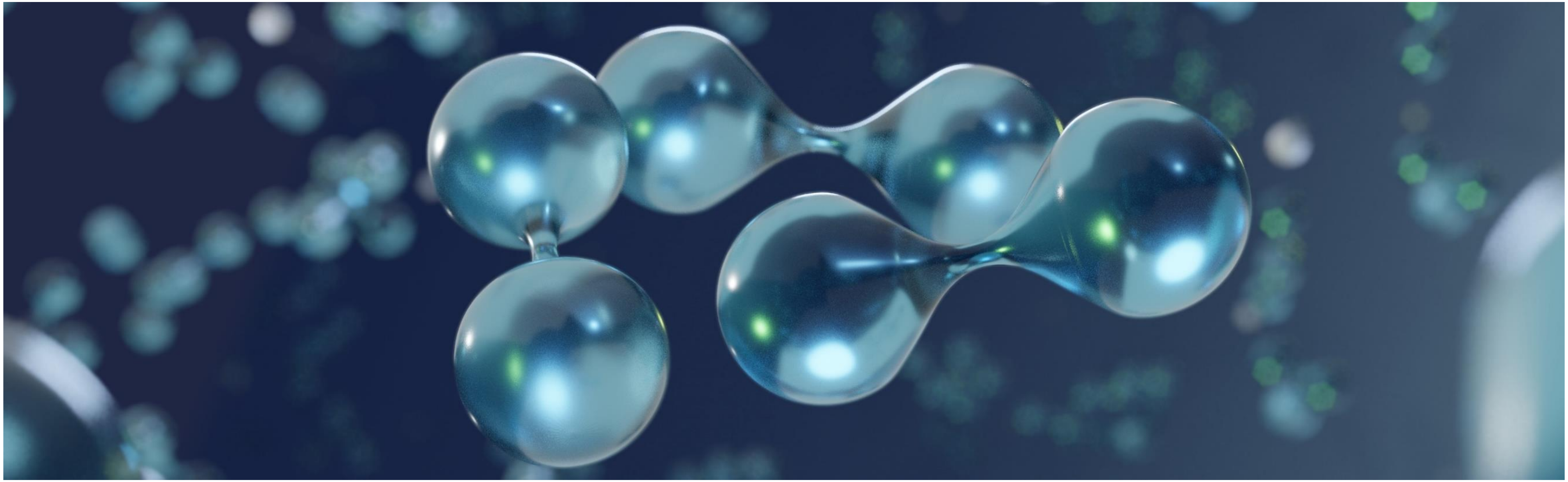

DE-RISKING SUBSEA HYDROGEN PIPELINE OPERATION

Dom Wynne · Subsea Expo 2024 · De-Risking Subsea Hydrogen Pipeline Operation

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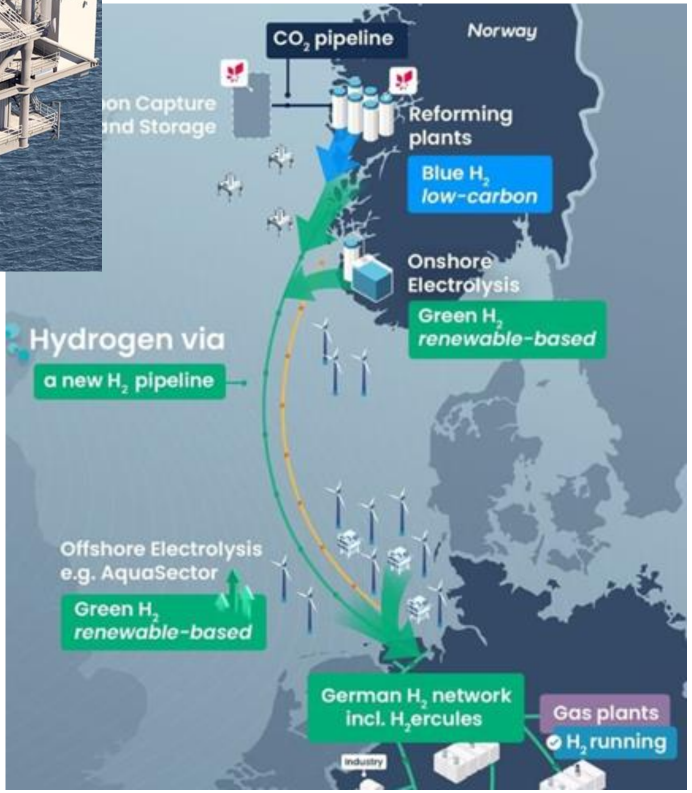
HYDROGEN ECONOMY
THE ROLE OF SUBSEA HYDROGEN PIPELINES

- Gathering Hydrogen from Production Sites
- Interconnectors
- Storage
- Repurpose or new build?
  - Cost
  - Utilising existing asset base
  - Practicality
  - Environmental Impact

Reference: https://poshydon.com



Reference: https://www.equinor.com/news/20230105-equinor-rwe-cooperation

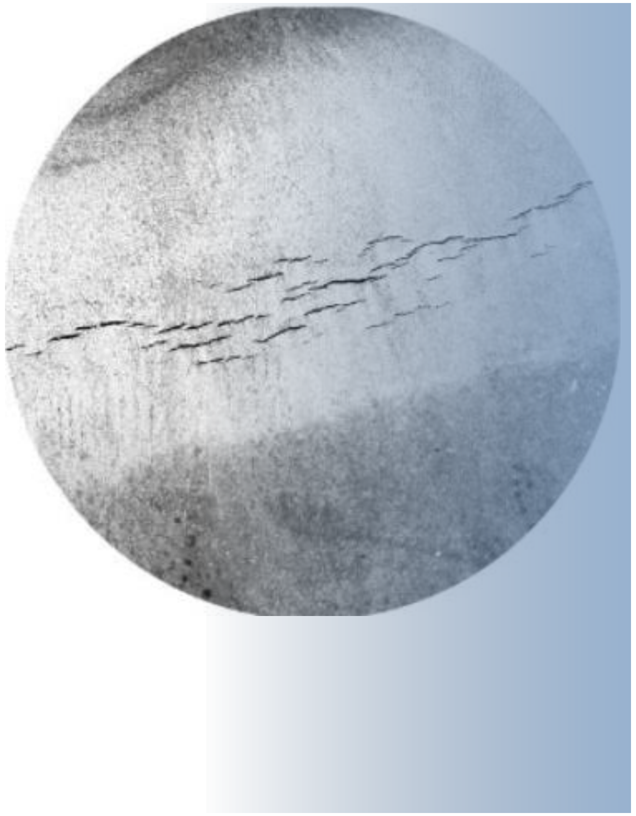
HYDROGEN PIPELINES
DEFINING HYDROGEN IMPACT ON INTEGRITY

- What impact does hydrogen have on current integrity threats?
- What new threats need to be considered with the introduction of Hydrogen into the pipeline?
- Has my consequence of failure changed?
- How do I manage my operational risk?

De-risking Hydrogen Operation

Defining the Threats

DEGRADATION OF MECHANICAL PROPERTIES



Hydrogen Embrittlement → Degradation of Mechanical Properties

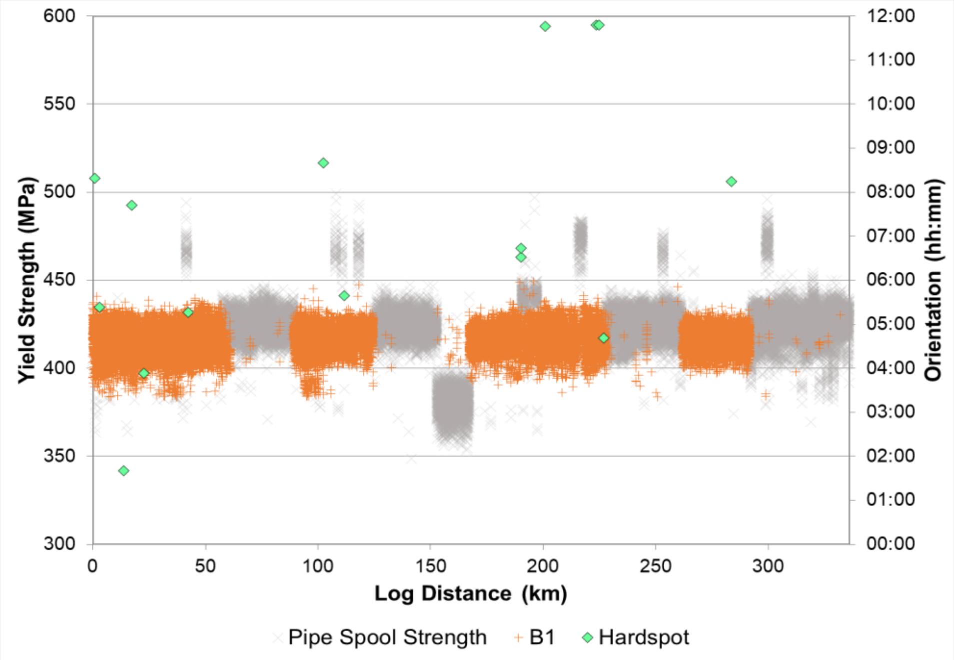
Property	Effect of Hydrogen
Strength	↔ (?)
Ductility	↓
Fracture Toughness	↓
Fatigue Crack Growth Rate (FCGR)	↑

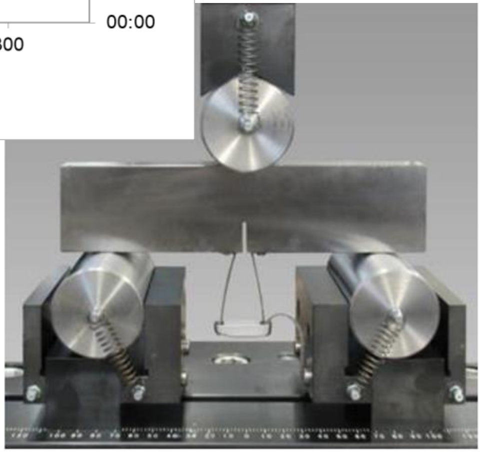
THE IMPORTANCE OF MICROSTRUCTURE

- Identify different populations
  - Mill Test Records (MTRs)
  - Yield Strength ILI Tools

- Characteristics normally unique to particular pipe mill, pipe type and vintage

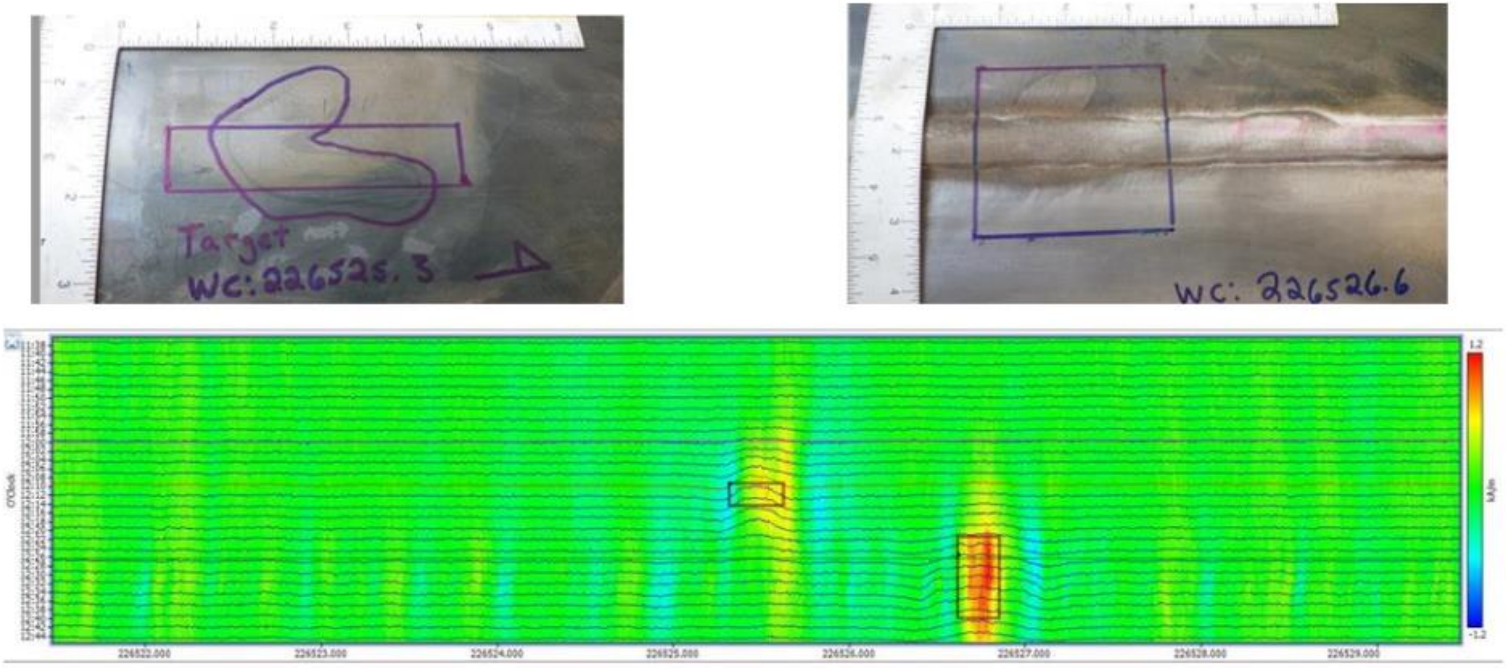
- Targeted test programs to understand properties in H_2





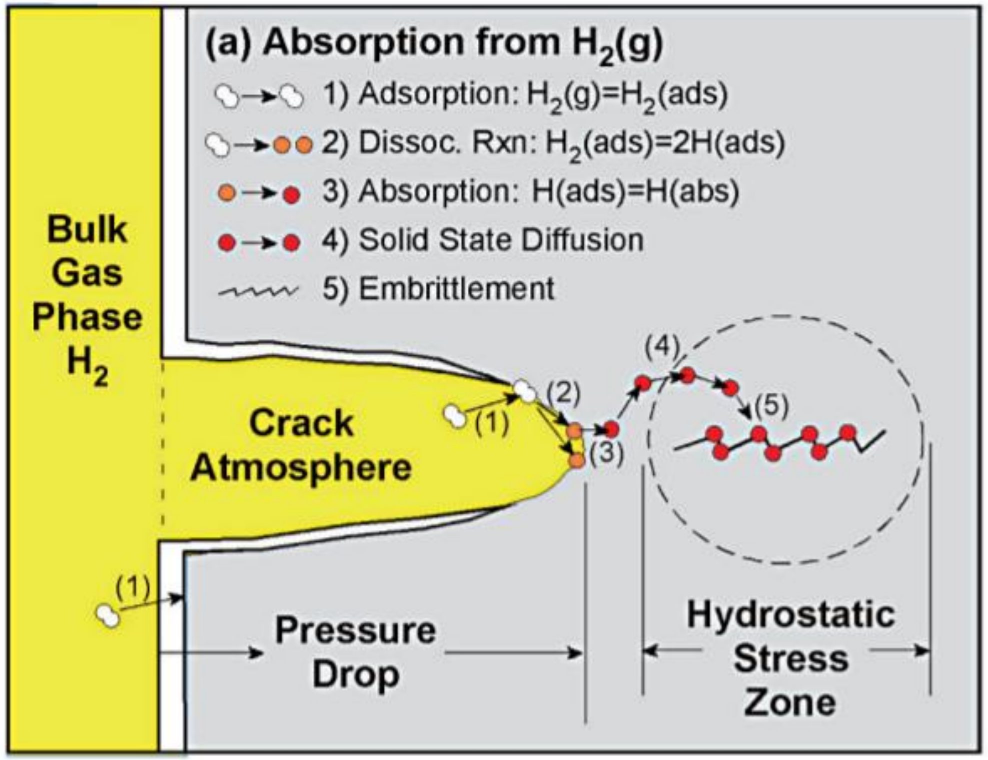
THE IMPORTANCE OF MICROSTRUCTURE

- Is my pipeline susceptible to hardspots?
- How will the properties of my hardspots change with the introduction of hydrogen?
- What mechanical tests in H_2 can I do?
- Are they a concern?



THE THREAT FROM CRACKING

- In H_2, smaller cracks will fail compared to oil/gas operation
- An increase in FCGR will decrease the remaining life of the pipeline due to fatigue loading
- Typically, Natural gas pipelines have a low fatigue load, how will H_2 compare?



DEFINING FLOW SCENARIOS

- Different composition scenarios i.e. hydrogen blends
- Different gas velocities and input and outlet pressures
- Calorific output requirements
- Multiple natural gas shippers and potential multiple hydrogen shippers
- Potential variance in hydrogen production linked to renewable capacity
- Compression requirements i.e. compression stages

Define MAOP and potential pressure cycling to feed into design stress and fatigue life calculations

De-risking Hydrogen Operation

Consequence of Failure

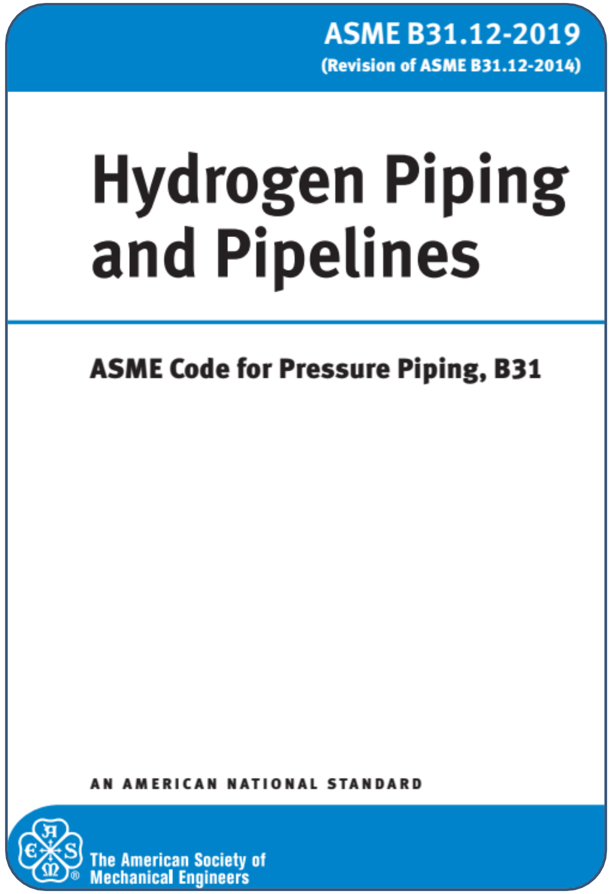
DE-RISKING HYDROGEN OPERATION CONSEQUENCE OF FAILURE

- Hydrogen is light and buoyant
- Easier to ignite compared to Natural Gas
- More inspections underneath the platforms?
- Gathering lines vs interconnectors, level of shipping
- Public perception of hydrogen safety

De-risking Hydrogen Operation

Robust Repurposing or Design

DE-RISKING HYDROGEN OPERATION
ROBUST DESIGN



H2Pipe JIP

‘Aims to develop a new code for the design, Re-qualification, construction and operation of offshore pipelines’

DE-RISKING HYDROGEN OPERATION
ROBUST REPURPOSING

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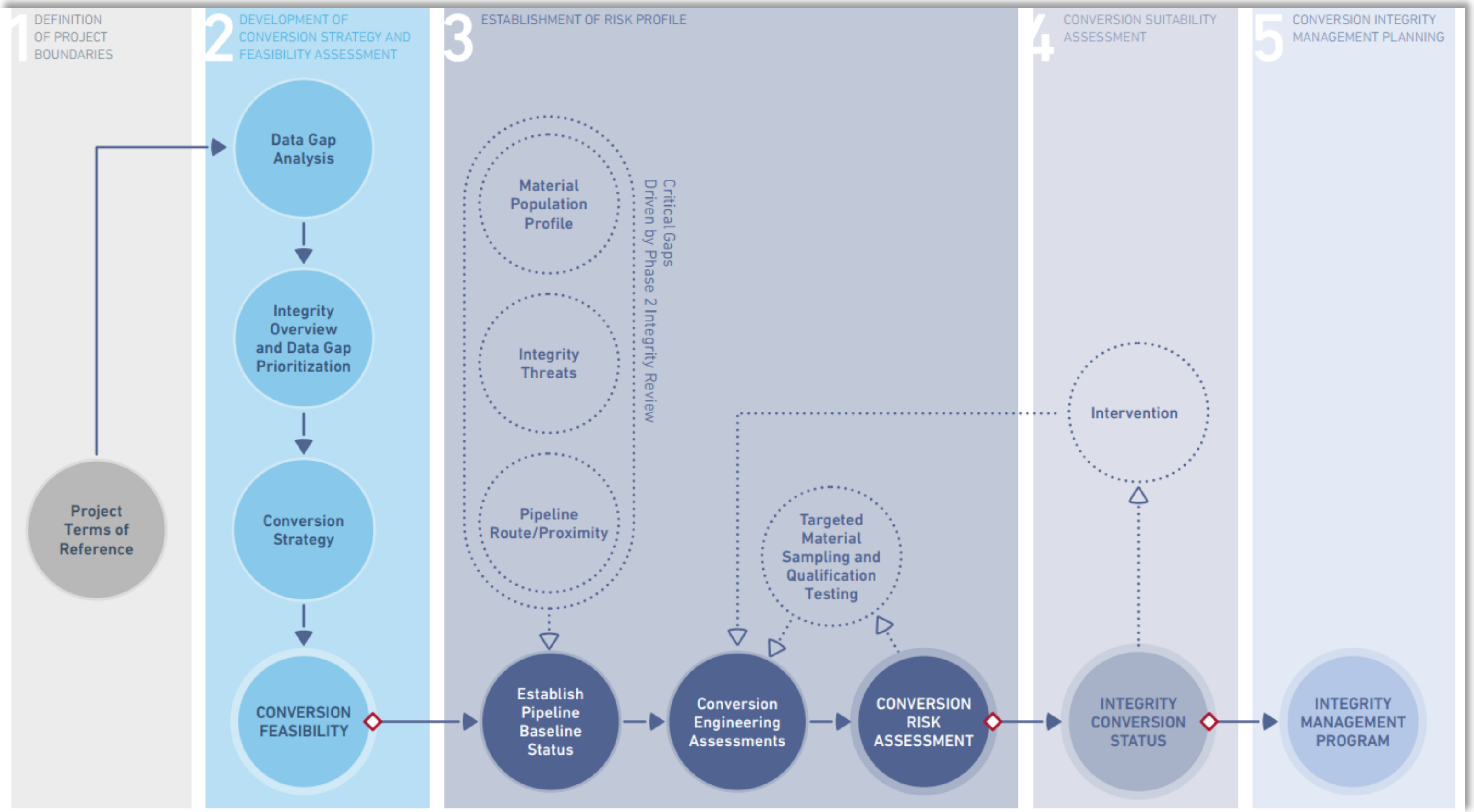

De-risking Hydrogen Operation

H_2 Integrity Management Program

INLINE INSPECTION TOOL OPTIONS
H2 INTEGRITY MANAGEMENT

Integrity Threat	Feature Type	In-Line Inspection Technology
Material Embrittlement	Low fracture toughness under hydrogen	Yield Strength Detection
Hydrogen – Cracking Damages	Cracks	EMAT – Electromagnetic Acoustic Transducer UT-C/UT-A – Ultrasonic Crack Detection (Liquid Couplant)
Additional Considerations	Hard spots	Hardspot Tool
	Geometric Anomalies	Hi Res Caliper Arm
	Bending strain	XYZ Inertia Measurement Unit

INLINE INSPECTION TOOL COMPONENTS
COMMONLY USED TYPES OF MATERIAL

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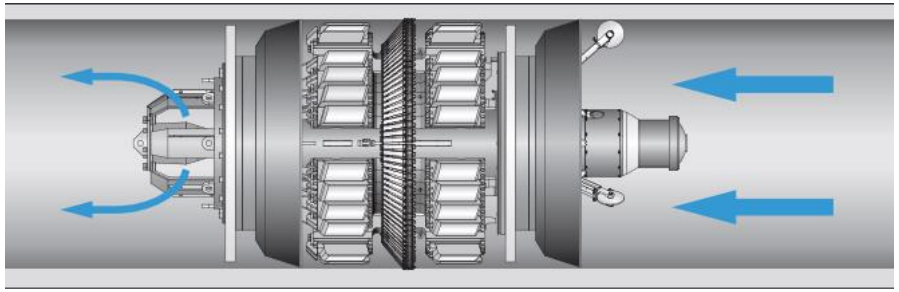
Sealants	Cable jackets	Spacer
Austenitic Steel	Magnets	Carbon Steel with protective coating
Rubber	Ceramics	Polyurethane

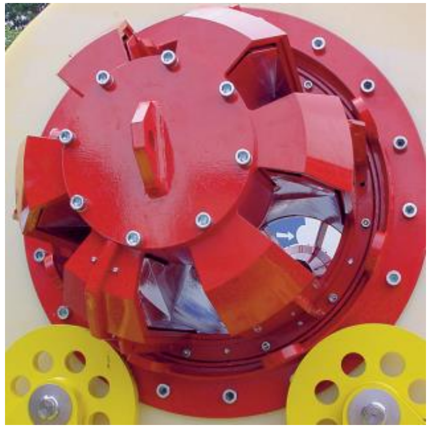
INLINE INSPECTION
FLOW SIMULATIONS IN HYDROGEN

H_2 is considered the more challenging medium for inspection

- Lower density of H_2 compared to NG
- Higher flow rates expected for H_2 transportation compared to NG
  - It is expected that the lower density leads to more dynamic tool run behavior with more tool stops and higher maximum tool velocity including higher speed excursions

To overcome this challenge further simulation work is being done on active speed control valves (SCU) and other speed control options





CASE STUDY
INSPECTION OF A DEDICATED **HYDROGEN** PIPELINE

The Challenge

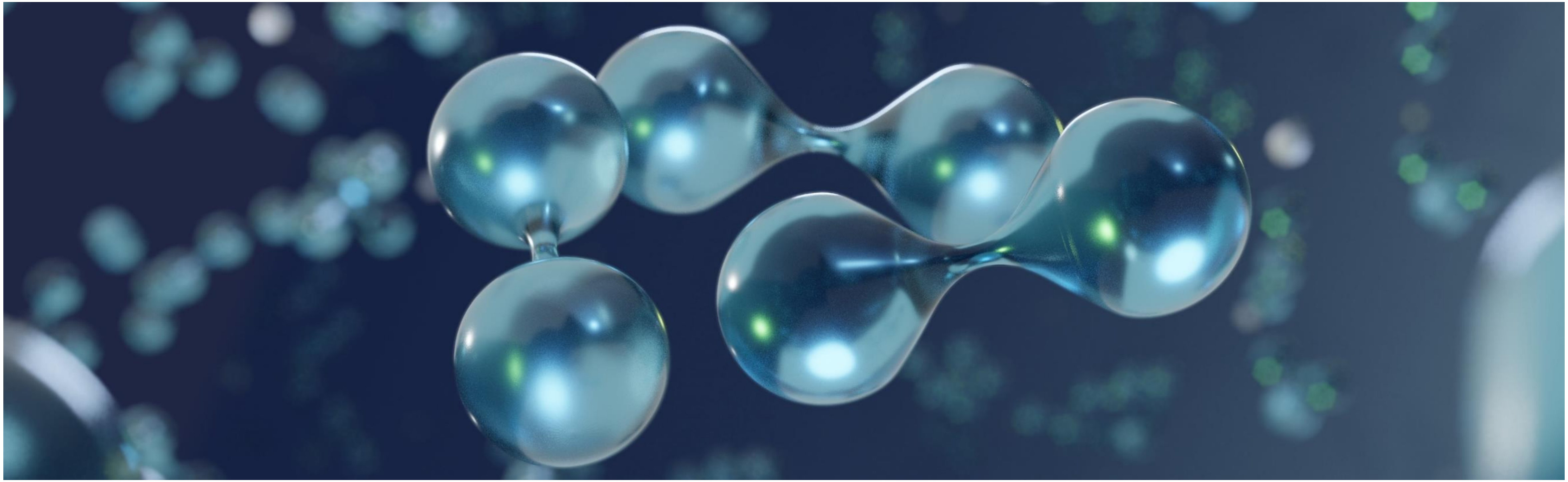
- 19 km pipeline transporting hydrogen
- 10 inch installed in 1996
- Utilising water as a propellant came at a high cost and was time consuming.
- MFL and Geometry Inspection in Hydrogen Required

Our Solution

- Tool setup adapted due to the challenging environment of hydrogen.
- Non-standard cups, differing in shore – meaning hardness.
- Various bypass holes and notches were applied to the tool design
- Protective measures for the magnet circuits were taken

The Results

- 100% sensor coverage and good magnetization levels
- Some velocity spikes in installation areas but data quality acceptable for evaluation.
- Avoided massive costs from pipeline shutdown for water-based inspection
- Data allowed reliable integrity decisions and safe hydrogen transportation



Dom Wynne email: dwynne@rosen-group.com

THANK YOU FOR JOINING THIS PRESENTATION.

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