SUSTAINABLE PIPELINE SYSTEMS

Advanced Digitalization and Threat Monitoring for Hydrogen Pipeline Infrastructure.

All-Energy & Dcarbonise 2023,
Glasgow, May 10-11

By Suji Kurungodan

A key Risk Factor is Hydrogen Embrittlement shortening girth welded steel pipe life
MASiP is an alternative approach to reduce this risk

SUSTAINABLE PIPELINE SYSTEMS

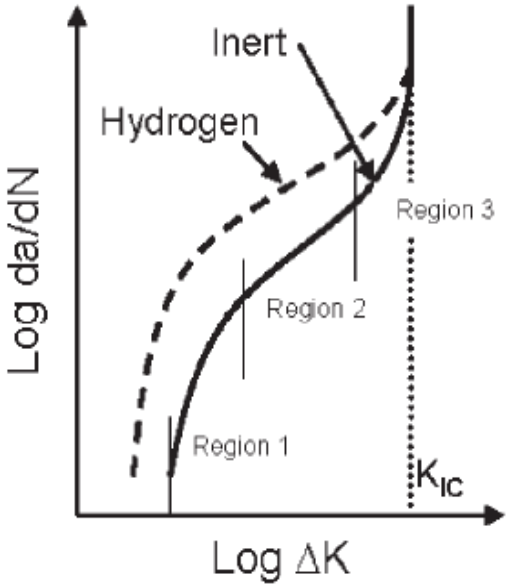
- ***HYDROGEN EMBRITTLEMENT***

Hydrogen atom ingress accelerates fatigue

- ***Fatigue crack growth rates 10x -100x faster***

Girth weld zones especially vulnerable

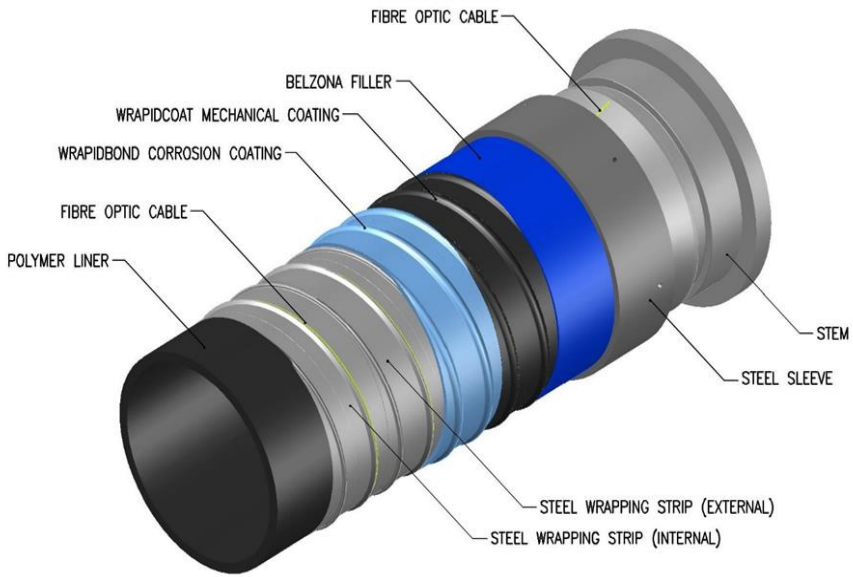
- ***Mechanical stress changes drive fatigue***

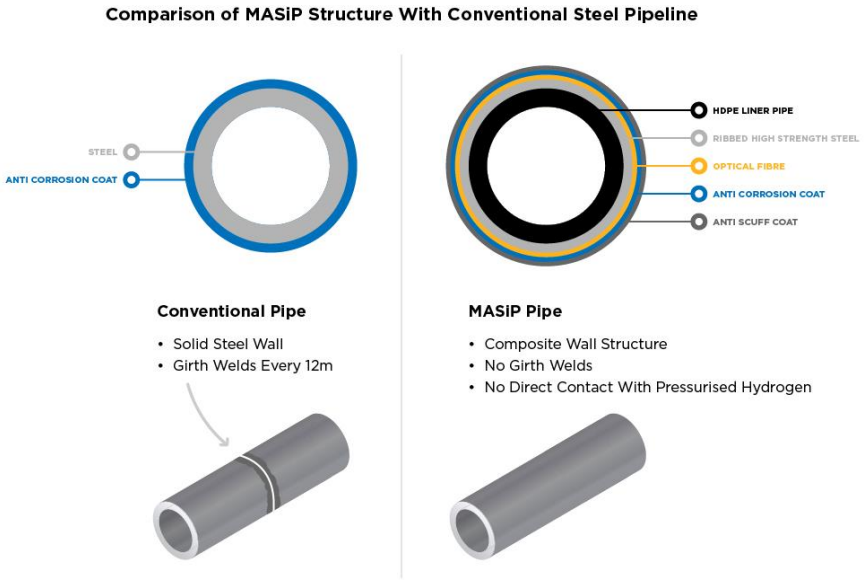


- ***Girth welded steel pipe of any grade***
- ***has HE risk with high pressure hydrogen***
- ***PUBLISHED REFERENCES***

- *Pipeline Systems for the Hydrogen Era – PTC Berlin 2021*
- *Sandia National Laboratories, "Technical Reference on the Hydrogen Compatibility of Materials," 2005.*
- *A review of Fatigue crack growth for Pipeline steels exposed to Hydrogen-White et al J Res N I S T 437 2010*

MASiP Pipe Structure





PIPE STRUCTURE :

- **HDPE liner- resists H2 embrittlement**
- **High strength steel reinforcement**
- **Optical fibre cable**
- **2 layers of environmental coating**

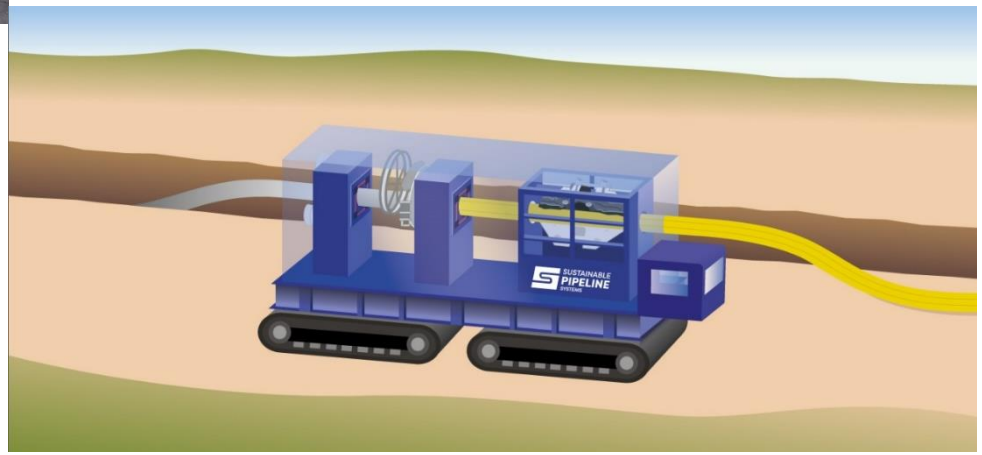
PIPE BENEFITS :

- **c10X more flexible than steel pipe**
- **Cost effective automated in-field process**
- **Lighter and easier to handle**
- **73% reduced carbon footprint**

MASiP Pipe Technology

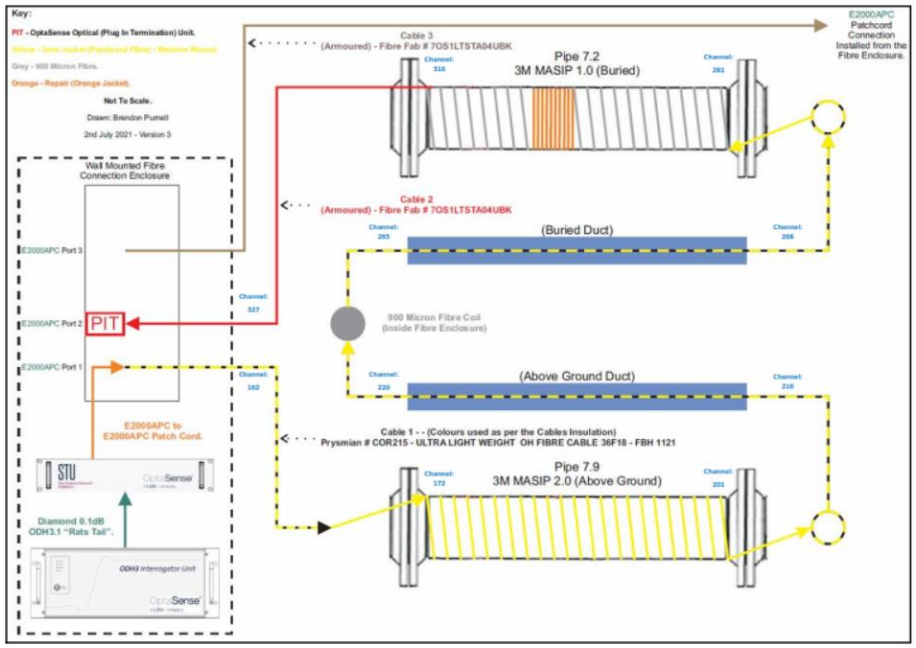
- Designed for continuous infield pipe production.
- Mobile factory for direct trench laying
- Real time threat monitoring and built-in digital quality control.

- Integrated machine applies steel strip reinforcement , optical fibre and environmental coating in a single operation



Infield Manufacture and Trench Installation Trials

MASiP – Intelligent Pipeline Solution



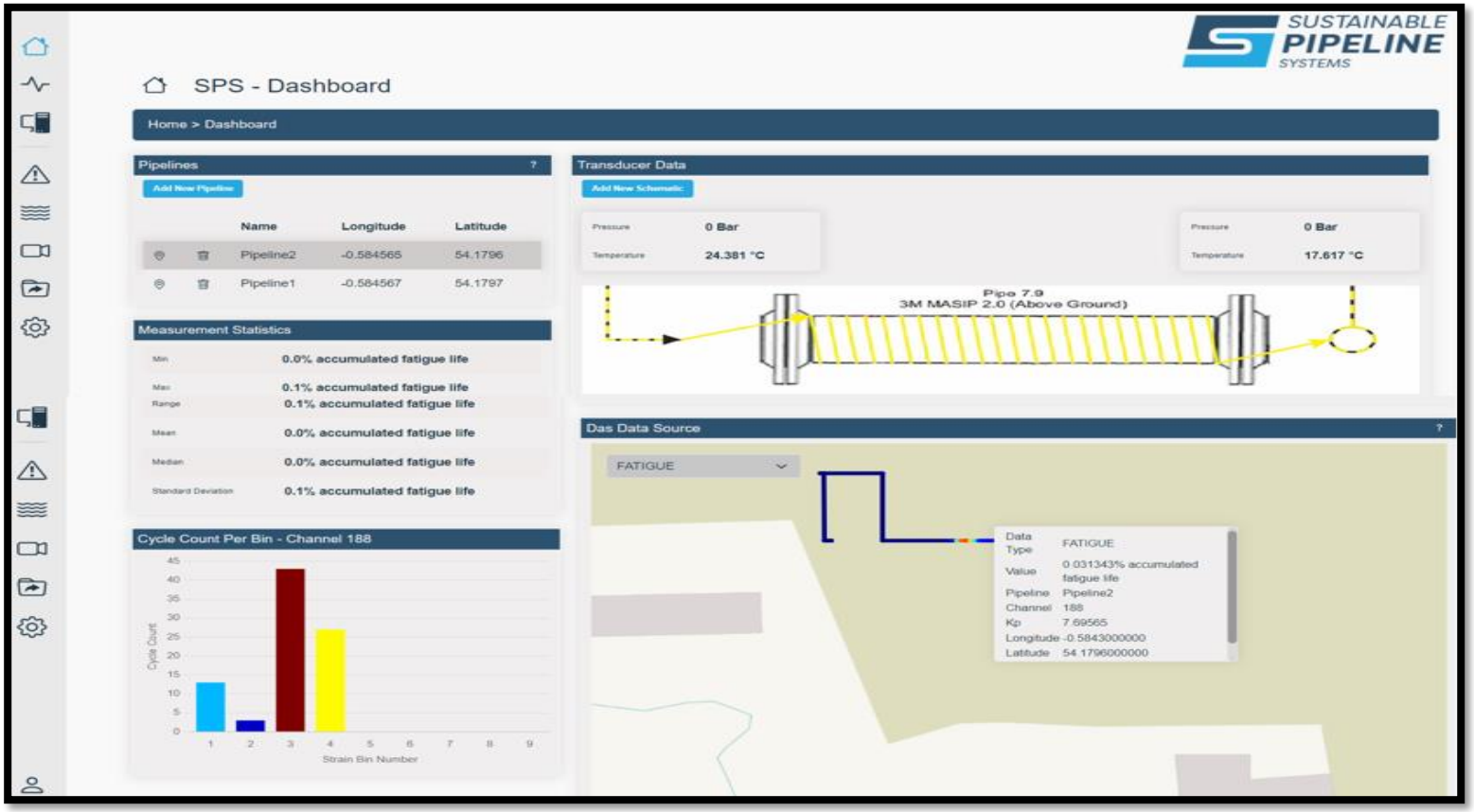
Basic Optical Fibre Parameters
Strain
Temperature
Acoustics

Real time integrity threat alerts and fatigue life system based on fibre strain measurements with 20cm spatial resolution.

Targeted Integrity Threats

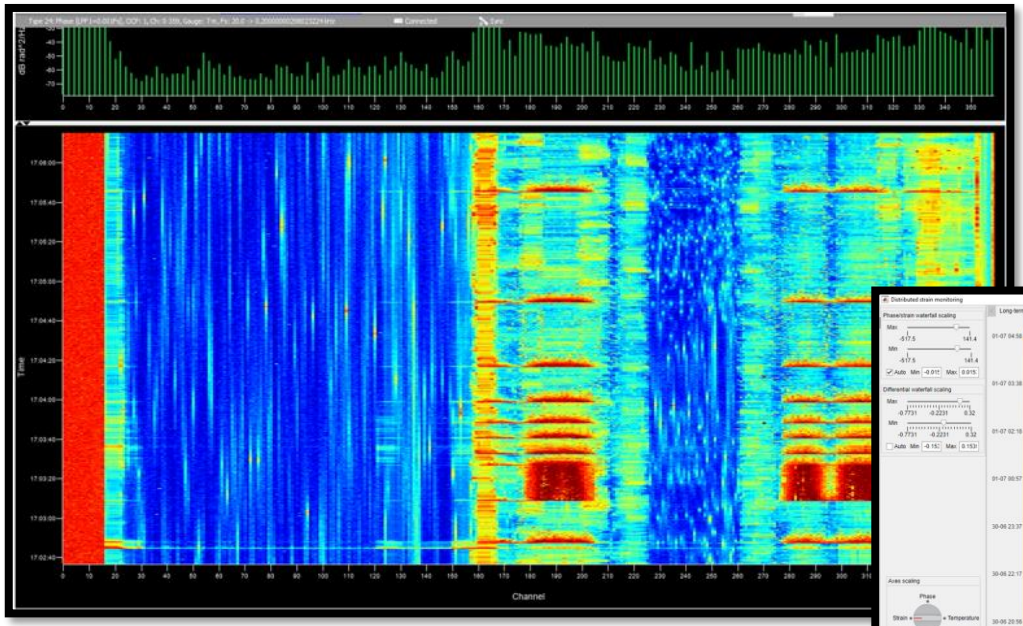
- **Geohazard / Buckling**
- **Pipeline Bending / Deformation**
- **Third Party Interference**
- **Leak Detection**
- **Fatigue / Cyclic Loading**
- **Anomalies – Dents, Corrosion*, Cracks***

Helical Optical Fibre: Digital Integrity Dashboard

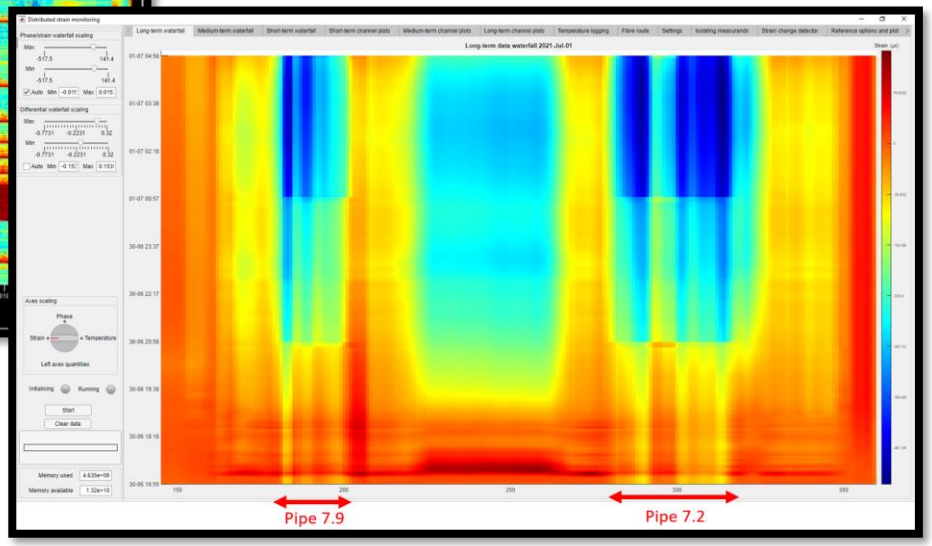


We now have a live dashboard collecting data from our site trials

ACOUSTIC & STRAIN MONITORING



Acoustic waterfall



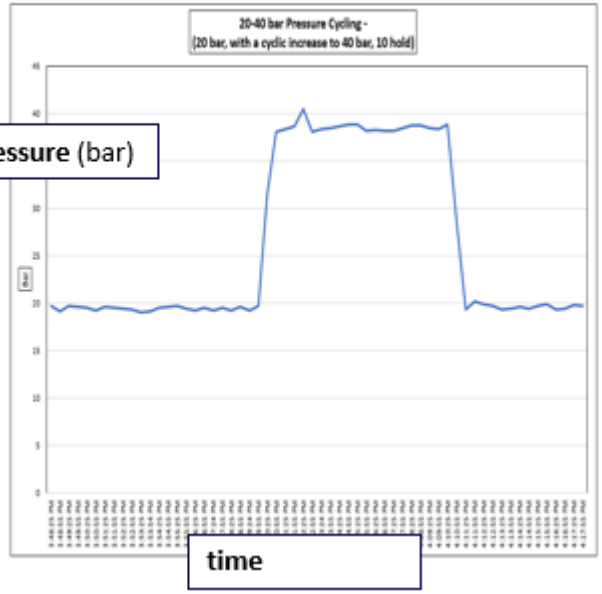
Strain waterfall

Third party intrusions, leaks and failure can be detected in real time!

High Sensitivity – <0.5 bar changes measured on top of 20-40bar underlying pressure cycle

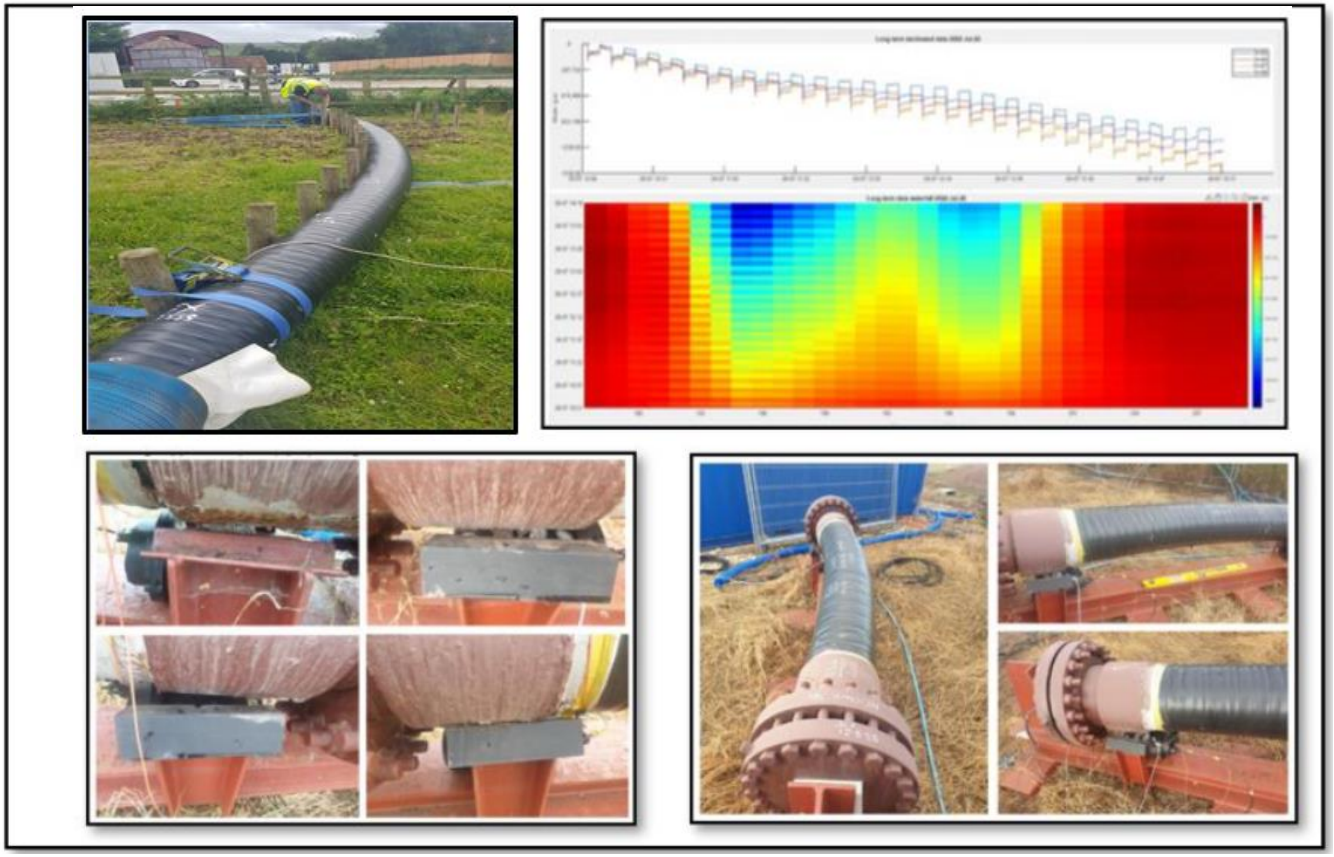
SUSTAINABLE PIPELINE SYSTEMS

Pressure transducer output



HOF strain output

HOF: Pipe Bending Signature

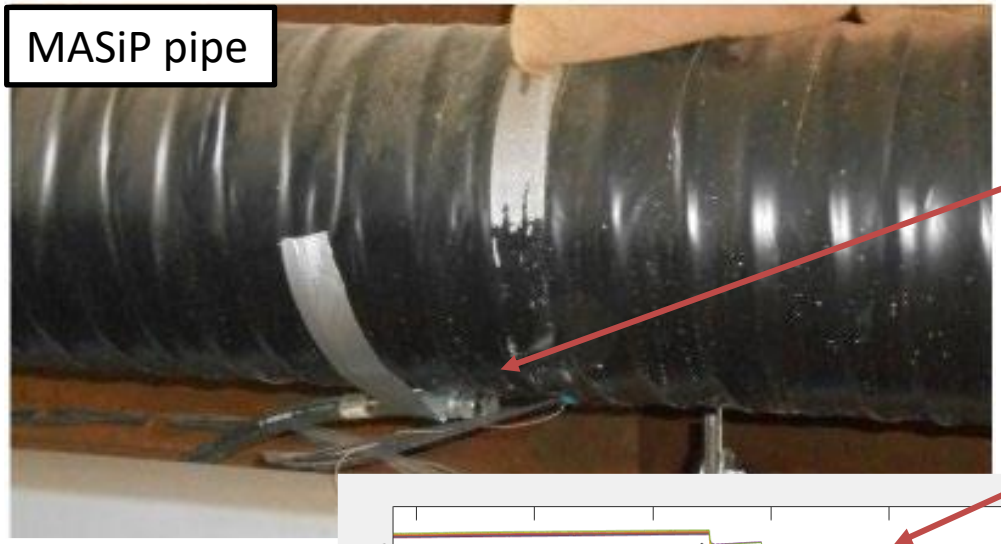


SPS is working on developing interpretive algorithms to detect pipeline bending and deformation from fibre optic strain signatures.

HOF: 30% H2/70% CH4 GAS TEST
Pinhole Leak Detection

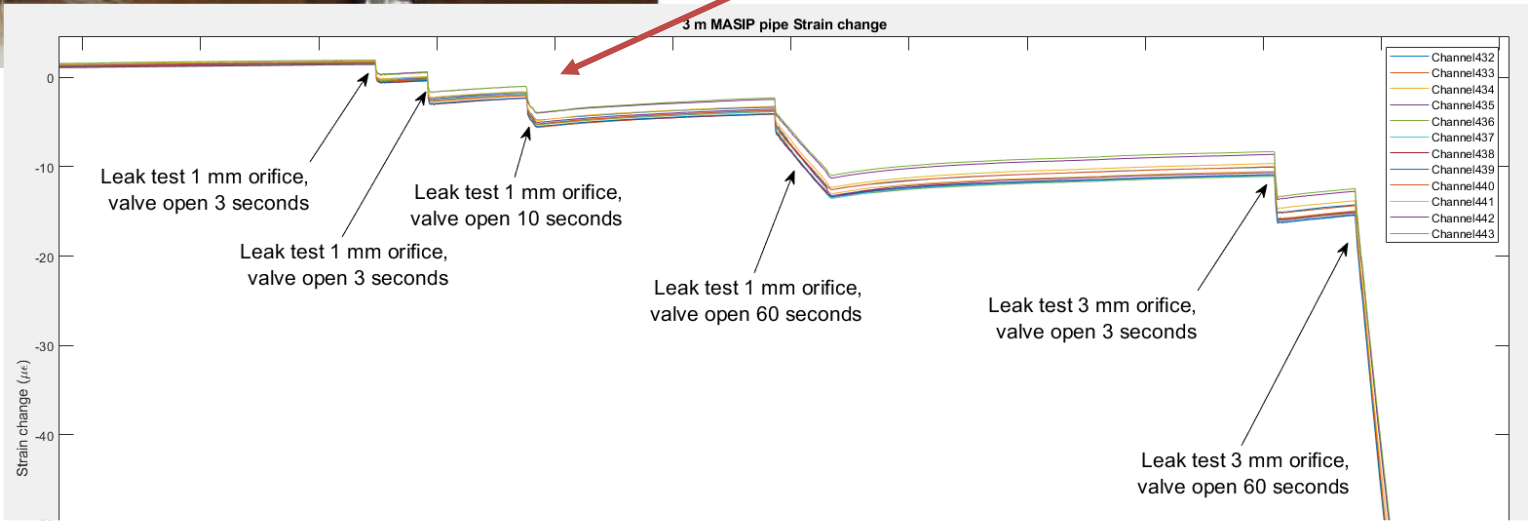
SUSTAINABLE PIPELINE SYSTEMS

MASiP pipe

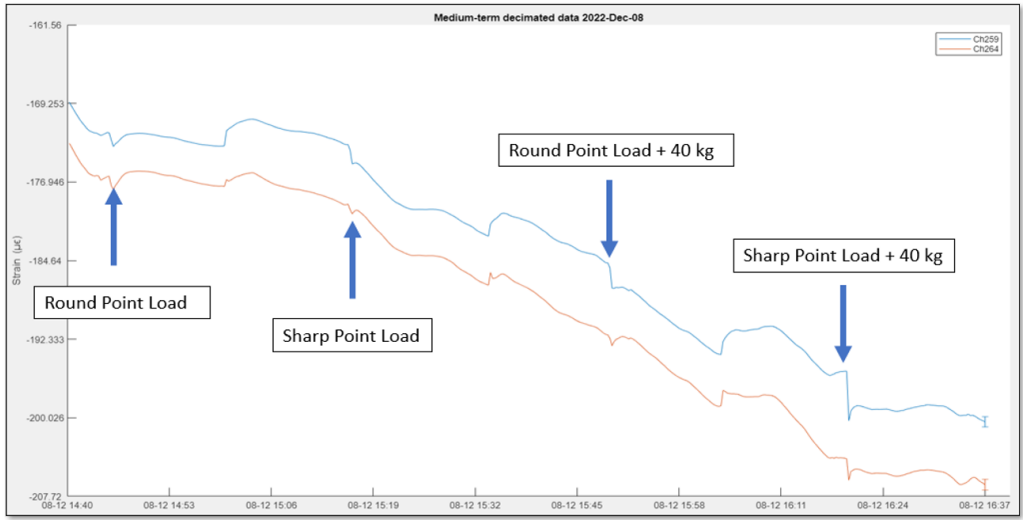


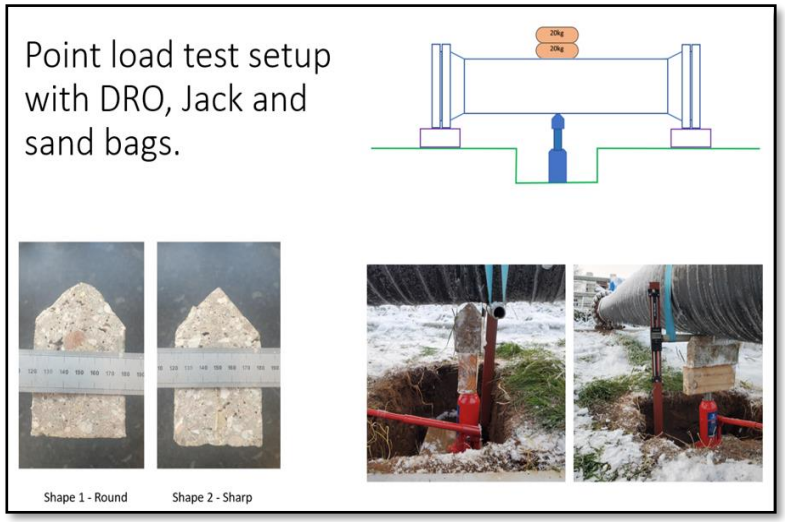
Leak orifice

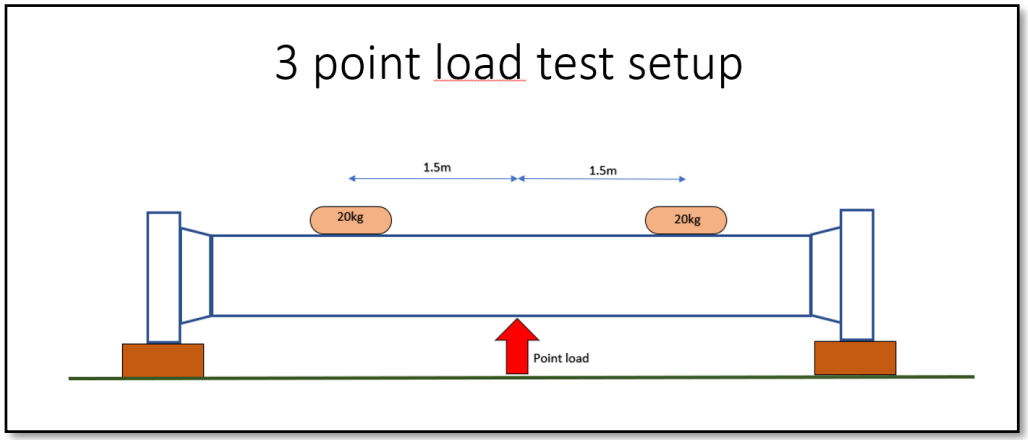
Different diameter leak orifices detected with 20bar Hydrogen/methane pressure

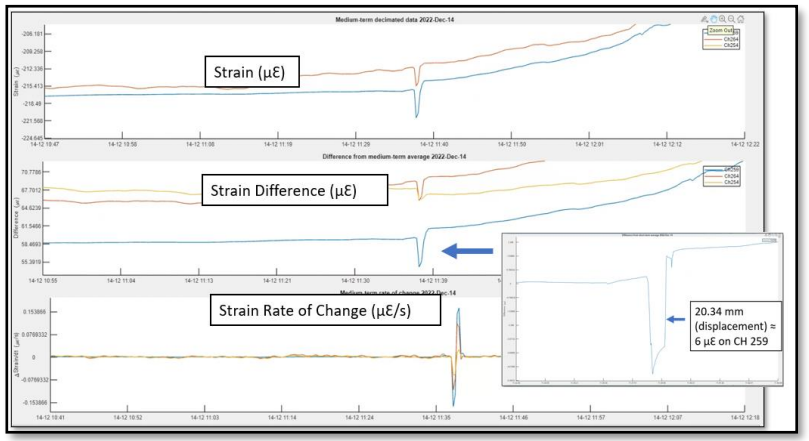


Dent / Deformation Detection

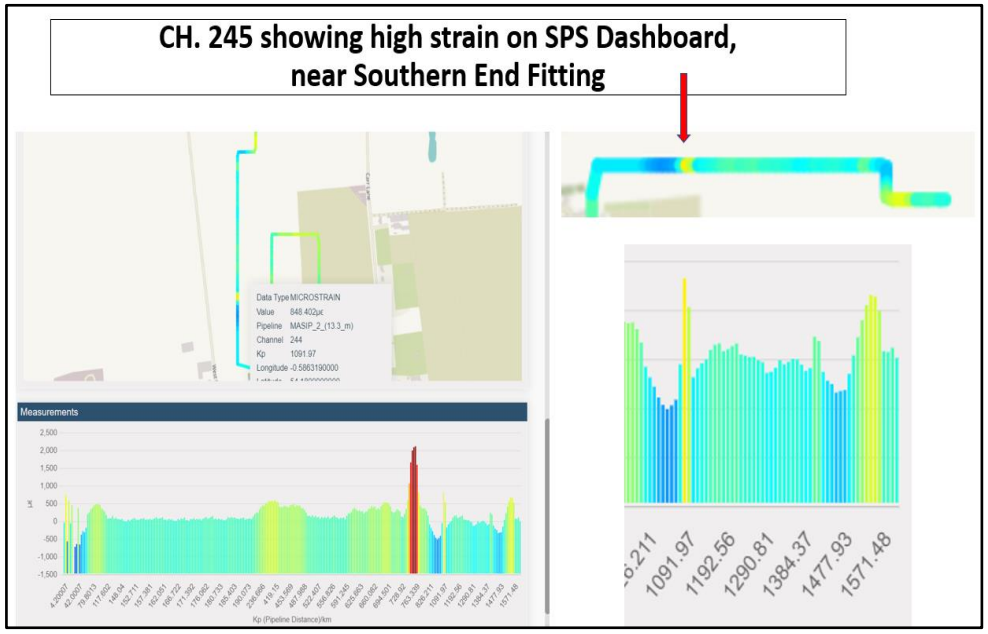






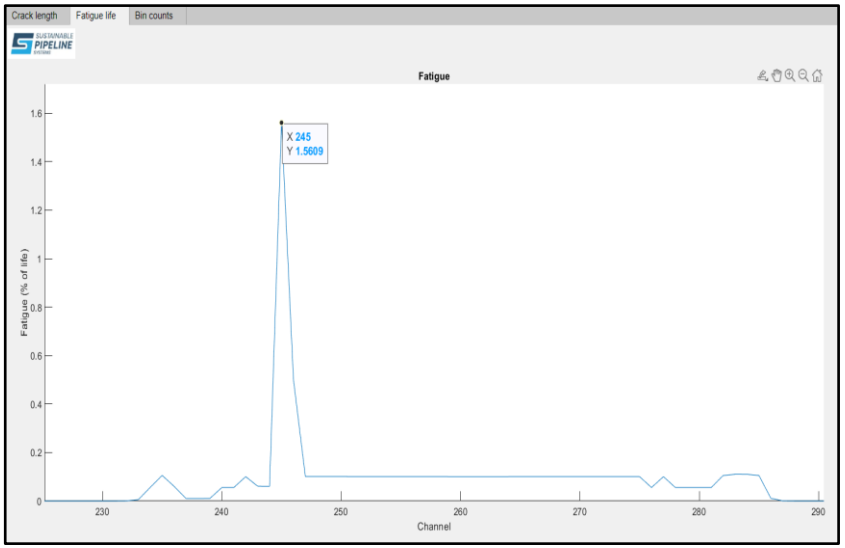


HIGH STRAIN ALERTS – SPS DASHBOARD

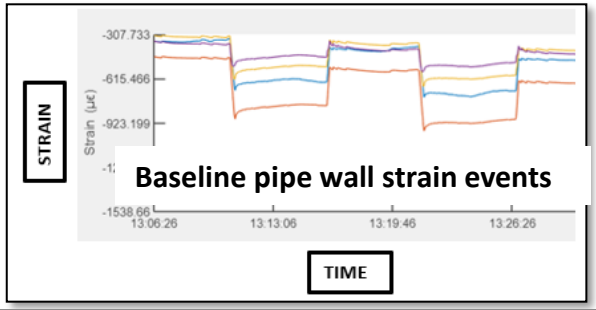


SPS DASHBOARD STRAIN CHANGE MONITORING

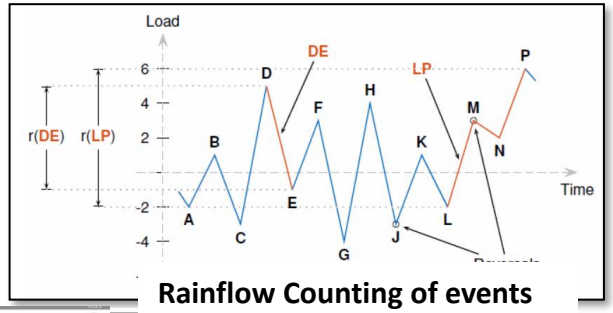
SPS FATIGUE PLOT SHOWING HIGH CUMULATIVE STRAIN @ CH. 245



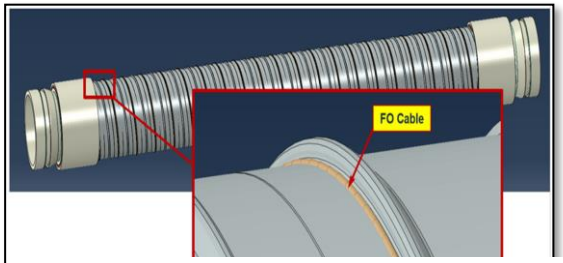
Interpretive Fatigue Life Algorithm



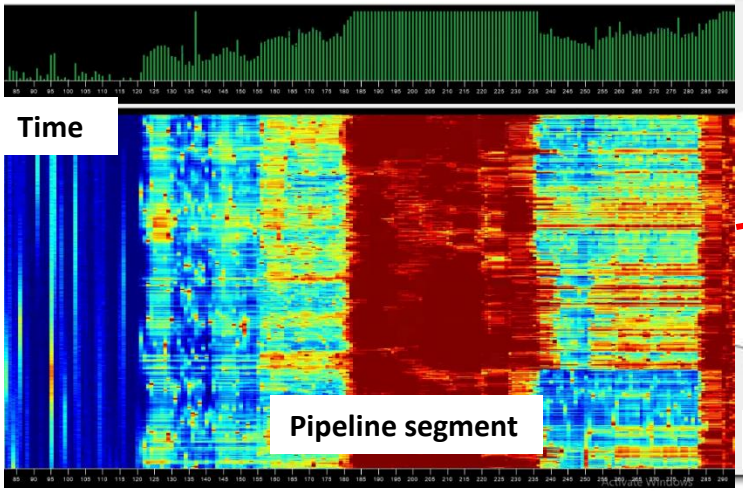
Baseline pipe wall strain events

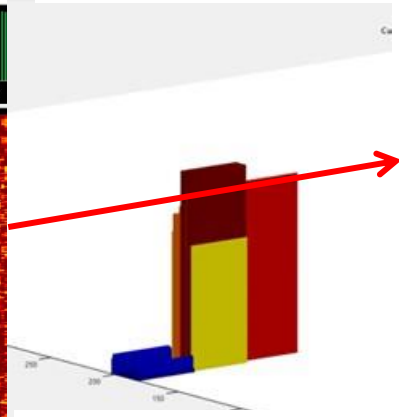


Rainflow Counting of events



Numerical model of pipeline structure

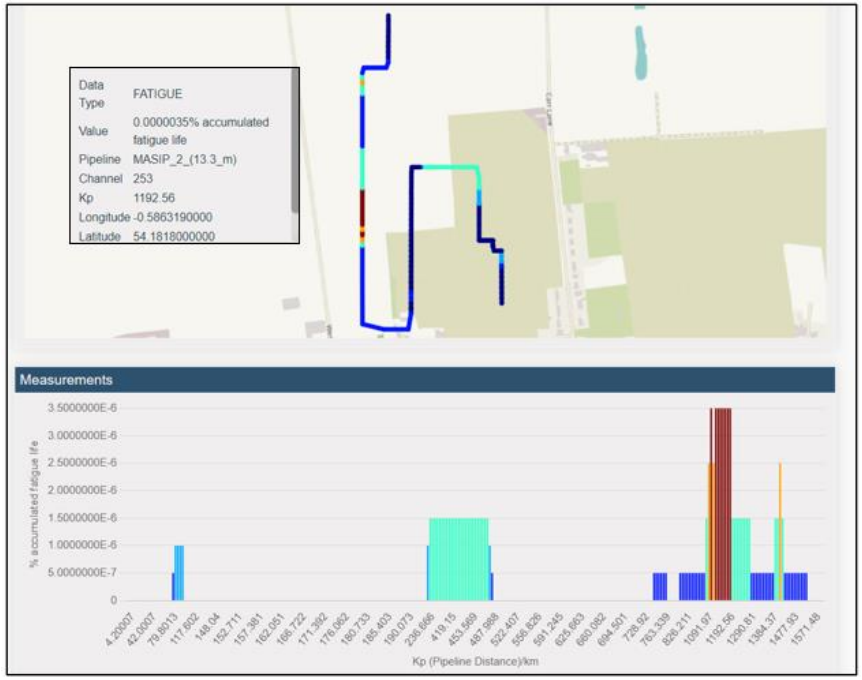



Fatigue life threshold

	Cycles to failure	Pressure Cycle
Bin 1	1	Most Severe
Bin 2	10	
Bin 3	100	
Bin 4	1,000	
Bin 5	10,000	
Bin 6	100,000	
Bin 7	1,000,000	
Bin 8	10,000,000	
Bin 9	100,000,000+	Minimal

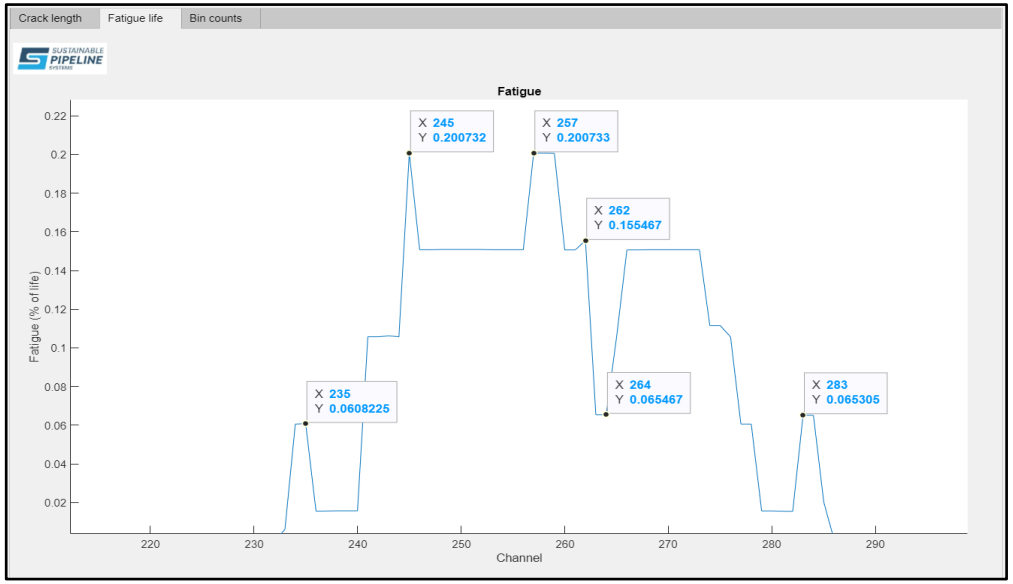
Interpretive Fatigue Life Algorithm using rainflow counting to analyze fibre strain events for real-time residual fatigue life.

FATIGUE FAILURE ADVANCE ALERTS



SPS DASHBOARD
FATIUGE MONITORING

SPS FATIGUE PLOT SHOWING COMBINATION OF EXTENSIVE AND COMPRESSIVE STRAIN @ CH. 263



Hydrogen Advisory Panel Members

SUSTAINABLE PIPELINE SYSTEMS

Hydrogen Advisory Panel Members

nationalgrid

Cadent
Your Gas Network

TRAPIL

Reliance
Industries Limited

bp

sse

HSE

equinor

شركة تنمية طاقة عُمان
ENERGY DEVELOPMENT OMAN

ACCREDITATION & REGULATORY APPROVAL

We have completed several stages of independent accreditation of the technology and are working through the final stages of our type approval test plan.

- **DNV Certificate of Feasibility**
- **FMECA programme and qualification plan**
- **DNV Endorsement of Qualification Plan**
- **ISO 9001 system certification**
- **LLOYDS REGISTER Type Approval**

  Witnessed Test Programme at our own site (API15S + IGEM TD series)

HSE regulatory approval discussions


DNV·GL

ENDORSEMENT OF QUALIFICATION PLAN

No. 2019-10159047

This is to endorse in accordance with the provisions of DNVGL-SE-0160 /1/ that the qualification plan /2/ for

Mobile Automated Spiral Interlocking Pipe (MASIP)

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LRQA

Current issue date: 31 October 2022
Expiry date: 30 October 2025
Certificate identity number: 10479443

Original approval(s):
ISO 9001 - 31 October 2022

Certificate of Approval

Pipeline Safety Regulations IGEM TD1/TD19

Safe Operating Limit (SOL)
Maximum Allowable Operating Pressure (MAOP)

INDEPENDENT PIPE TEST REPORTS – DNVGL
Gas permeation
Burst
Bend
Pressure cycling
Fatigue

Thank you

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