
SmartSleeve

Monitoring Repairs of Existing Pipelines

Alan Turner

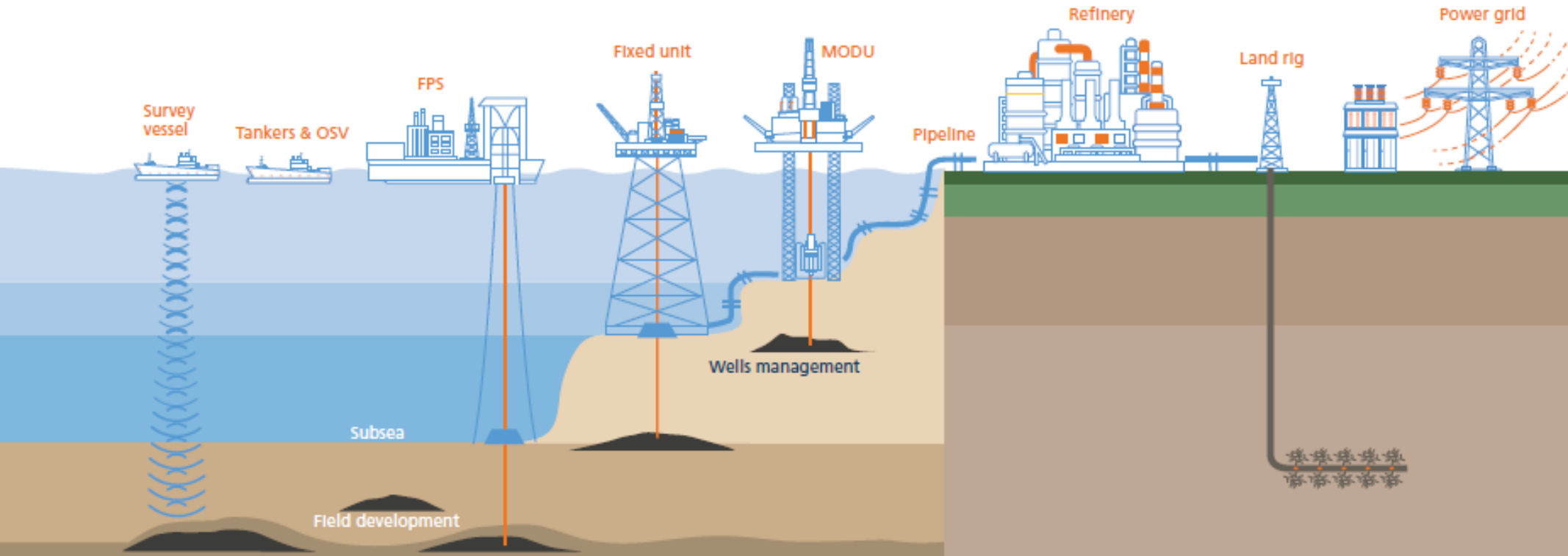


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From reservoir to refinery and beyond

We improve the safety, reliability and performance of assets, people, systems and processes across the oil and gas industry.



Industry Challenge



US \$550,000,000

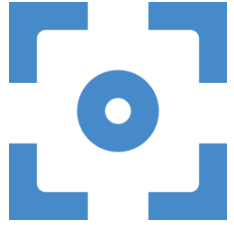
Average annual spend for onshore US operational pipeline failures



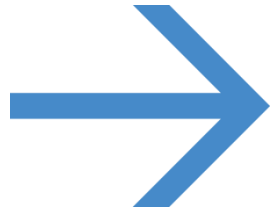
< 10%

Leaks that are determined by the SCADA system; remaining balance identified visually

LR Solution



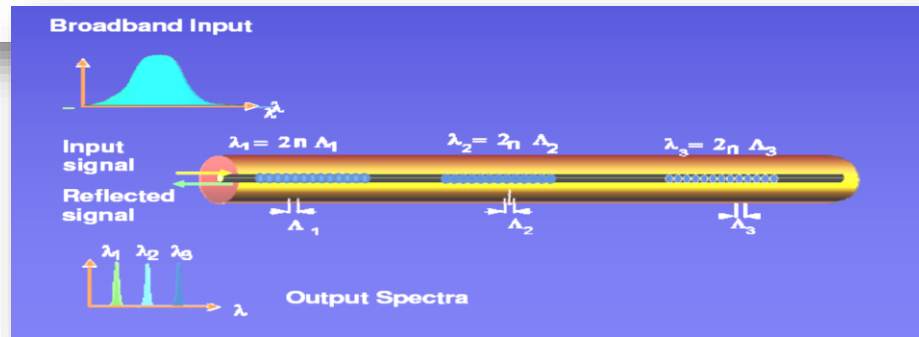
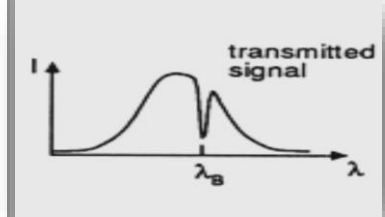
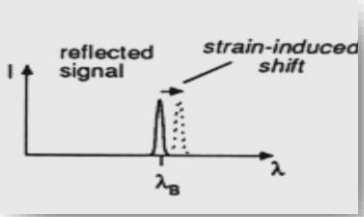
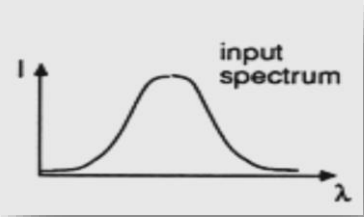
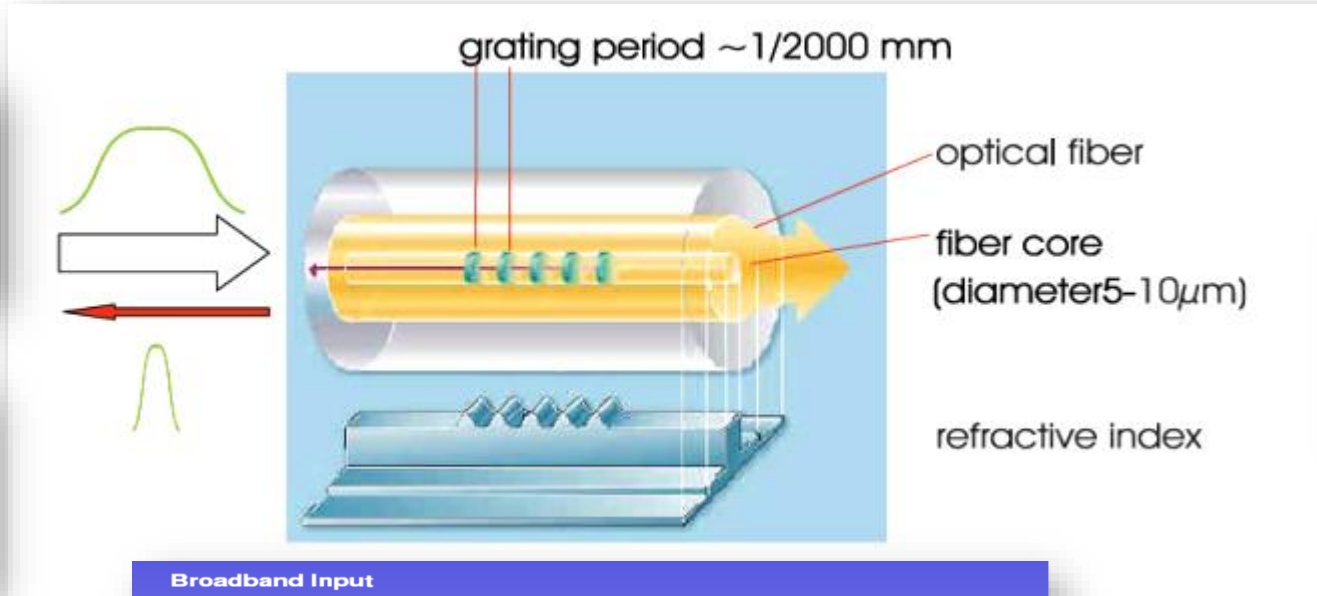
LR has leveraged our previous SHM solutions to monitor the health of pipeline repairs



Also leveraging LR's advanced analytics to manage integrity, risk, performance and reliability

Fiber Bragg Gratings Explained

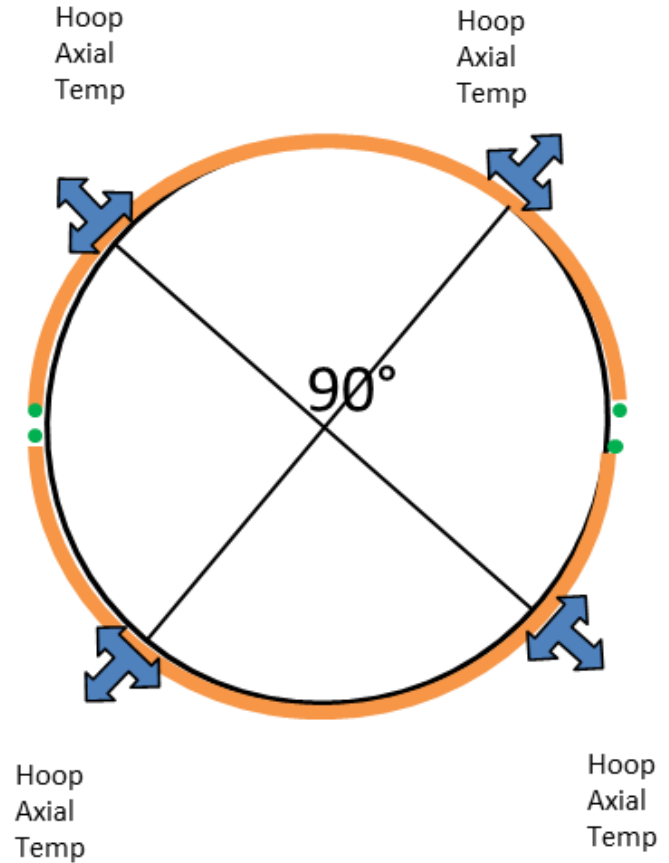
A Fiber Bragg Grating is a periodic change of the refractive index in the core region of an optical fiber.



Smart Sleeve

Parameters

- Sensors cluster at every 90 degrees
- Hoop for pressure and compression
- Axial for bending and deflection
- Temperature for compensation and leak detection



Composi-Sleeve™

Details



- Western Specialties manufactures and installs the Composi-Sleeve™ and Ultra-Wrap™ pipeline repair solutions
- Composi-Sleeve is a novel, non-welded anomaly repair solution that uses a combination of steel sleeves and composite overwrap
- SmartSleeve marries the pipeline repair Composi-Sleeve™, manufactured by Western Specialties, with LR's fiber optic technology, data monitoring solution and integrity engineering expertise

Composi-Sleeve™

Details (Cont.)

- Reinforces and strengthens damaged or weak pipeline sections
- The sleeve is a non-welded anomaly repair solution that uses a combination of steel sleeves and composite overwrap
- Utilises a military-grade, steel to steel, adhesive to secure it onto the pipe without the need of typical hot welding

Composi-Sleeve™

Details (Cont.)

- Composite overwrap over the top to give additional support as well as protect the steel sleeve from future corrosion
- Ideal for thin wall pipes, covering girth welds and raised long seams
- No need of grinding down and provides the extra needed support for vulnerable areas

SmartSleeve

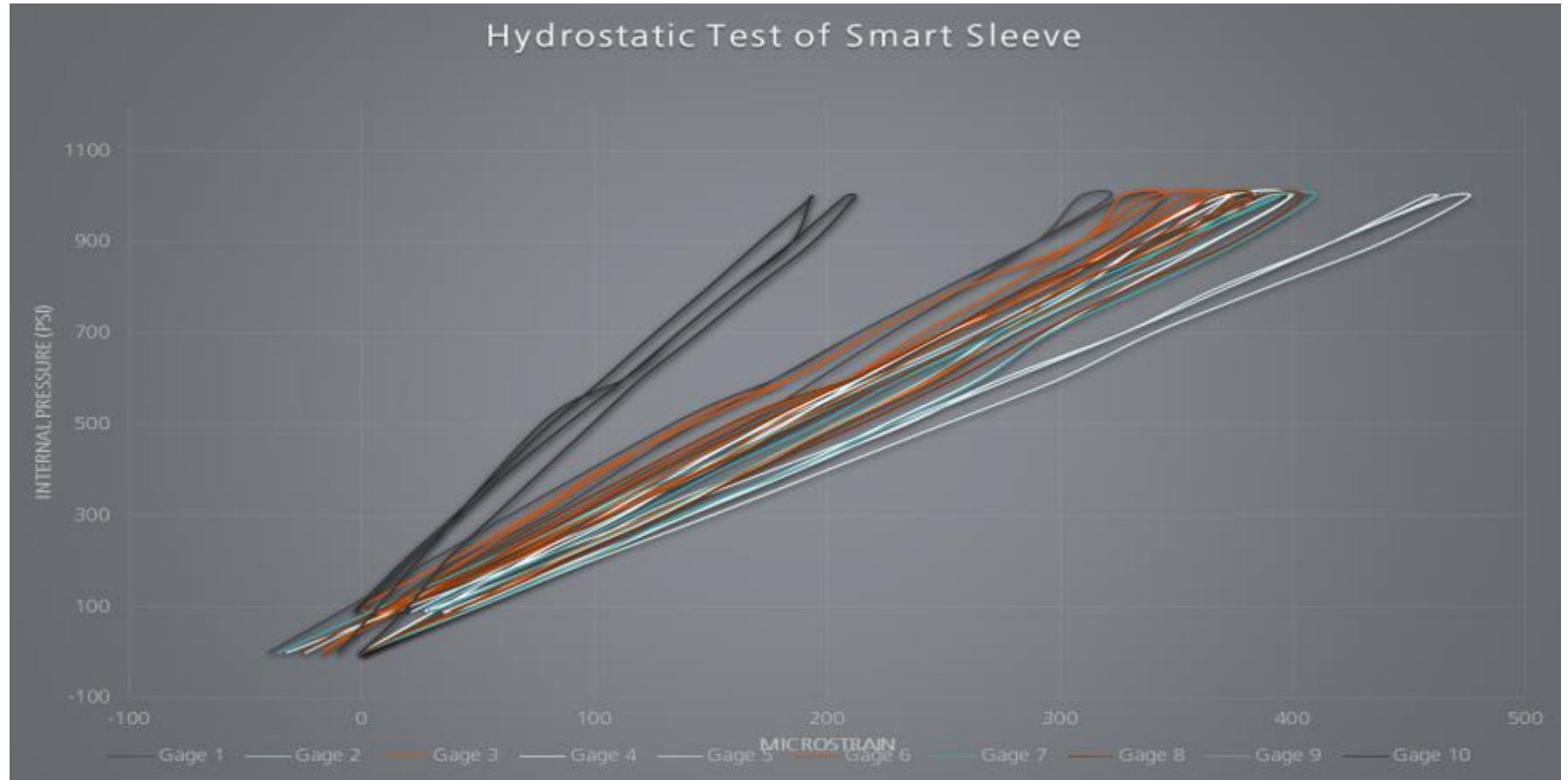
Testing

- Prototypes have been manufactured and tested
- Hydrostat Testing for proof of calibration of strain to pressure
- Burst Testing to correlate strain on the surface of the pipe to strain in the repair

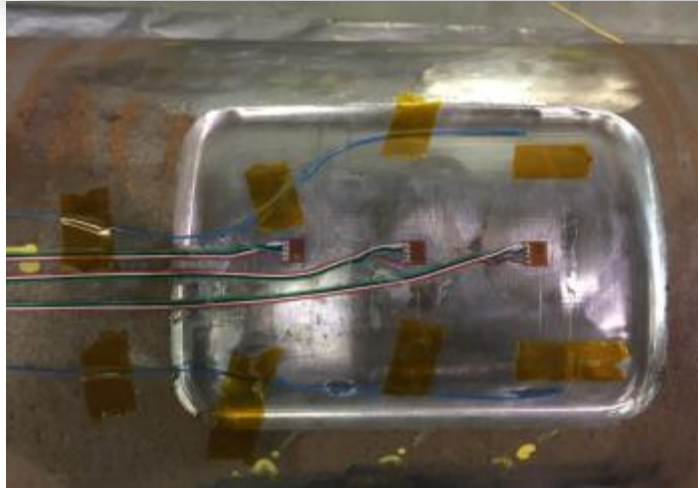
Hydrostat Test Setup



Hydrostatic Test Results



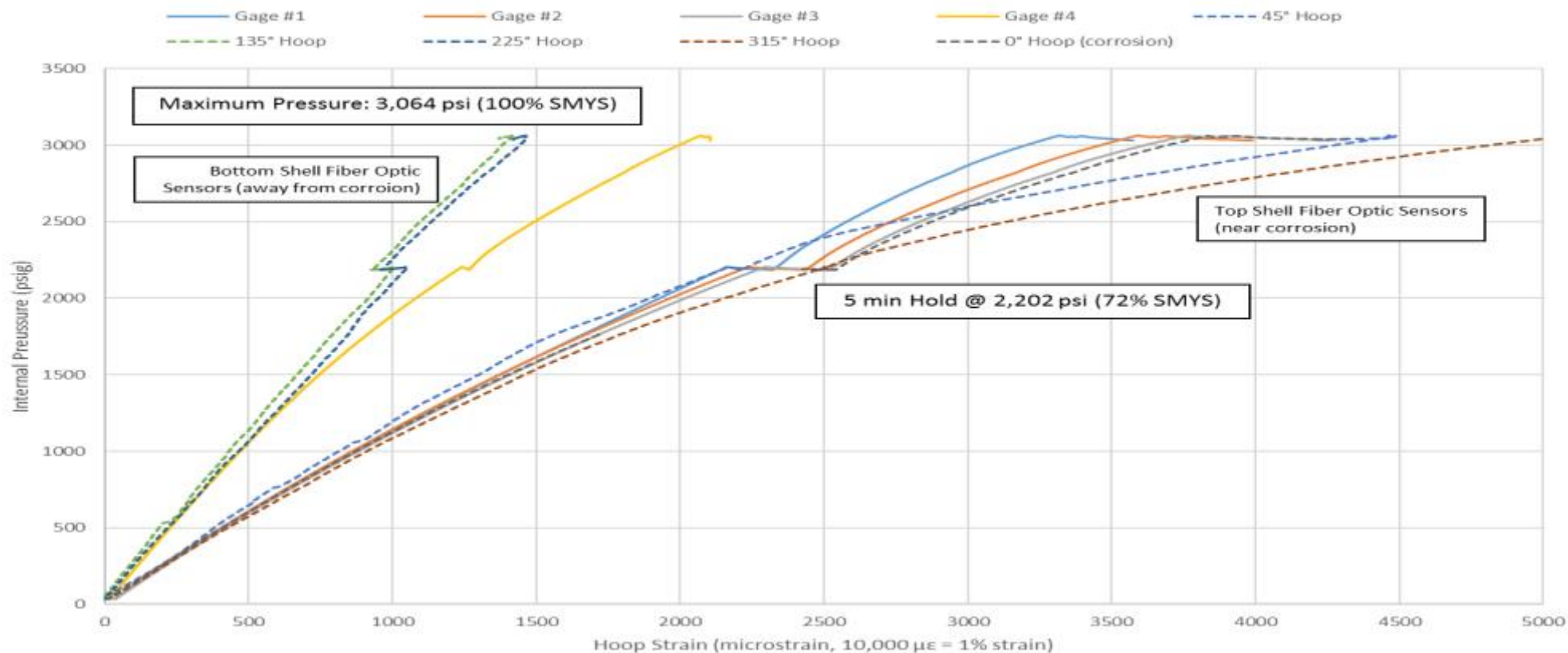
Burst Test Setup



Burst Test Results

Pressure Test of the ComposiSleeve™ Test Sample

12.75-inch x 0.375-inch, Grade X52 pipe with 75% corrosion defect | $P_{failure} = 3,064$ psig (Corrosion @ 0°)



Burst Test Results

Repair Type	Hoop Strain ($\mu\epsilon$)				Burst Pressure (psi)
	Center Under Repair (Gage #1)	2-inch off Center (Gage #3)	Fiber Optic (near Gage #3)	Base Pipe	
ComposiSleeve™	2,192	2,432	2,441	1,260	3,064 (100% SMYS)

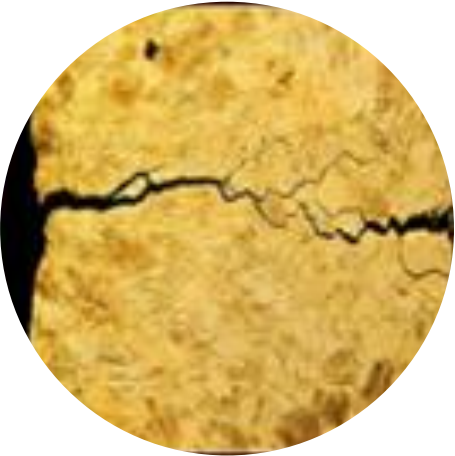
- The results associated with this study show the fiber optic sensors embedded within these repair systems can measure the health of the pipeline anomaly as well as the actual repair itself

What does good look like in 20 years?

A Lloyd's Register Foundation Perspective

1

*Structural integrity
and systems
performance*



2

*Resilience
engineering*



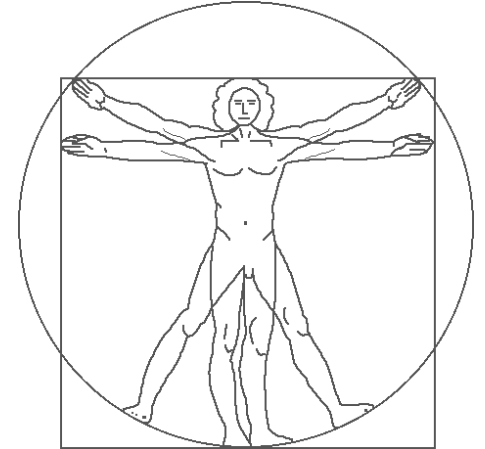
3

*Emergent
technologies*



4

*Human & social
factors*



Thank you

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Strategic Initiatives

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