Digitalize Corrosion Monitoring and Inspection for Improved Decision Making

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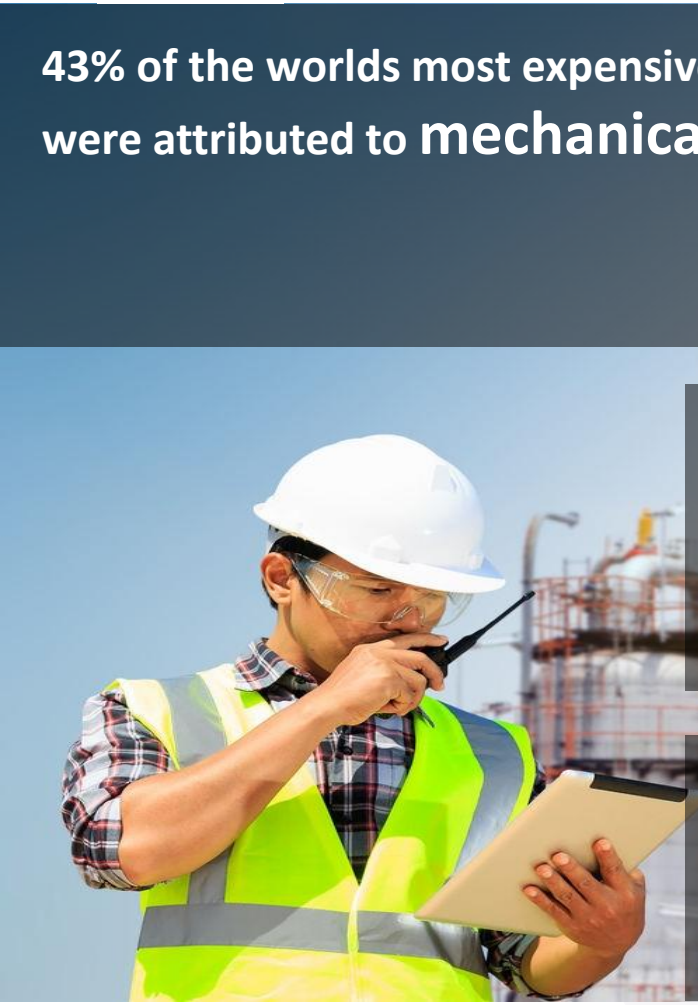
Emerson Corrosion & Erosion Solutions

Agenda

- Corrosion Monitoring Challenge & Technology Trends
- High Quality Data Collection is a Pre-Requisite for Digitalization & AI
- Software Enabled Solutions to Deliver Real-Time Asset Insight to Desk
- The Future - Intelligent Corrosion Management
- Summary - Monitoring Drives Top Quartile Performance

43% of the worlds most expensive dowstream loss incidents (>$50 million) were attributed to **mechanical integrity failure.**

source: Lloyd's Market Association (LMA) of data from the Willis Energy Loss Database 1996 - 2016



Through an increased spending on reliability and best practices, the world's best refineries spend **20-25%** less on maintenance costs than the US average

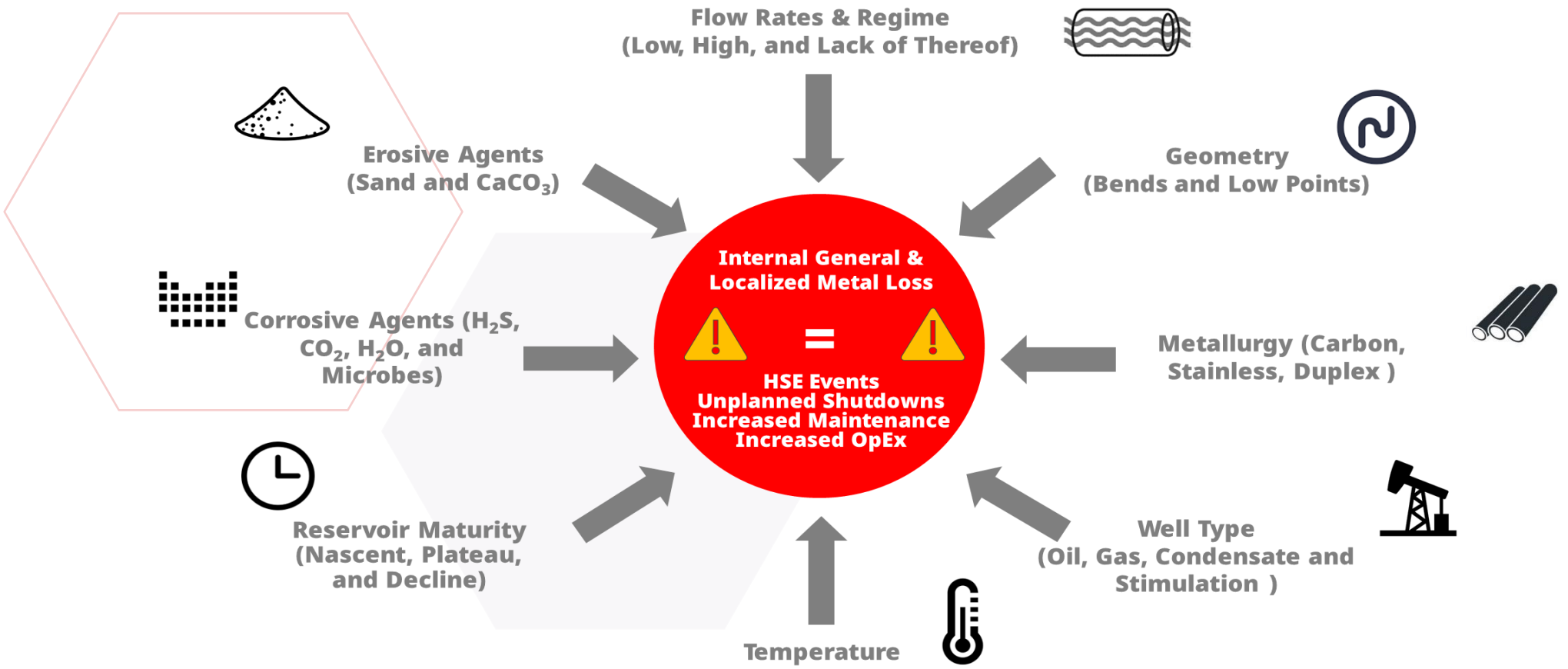
Source: Solomon Associates

As much as **36%** of all maintenance costs in refineries can be linked to corrosion remediation and repairs

Source: Saudi Aramco Journal of Technology


Cost of Corrosion in Chemical, Petrochemicals & Pharmaceutical totals to
USD 1.7 billion anually
AMPP (formerly NACE)

Corrosion and Erosion Depend on Time-Varying Factors and Affect Operator's Profitability



Accelerating Technology Shift Enabled By Innovation

Offline to on-line

Inline to Non-Intrusive

1900's - Inline coupons

Instrumented coupons (Invented by Roxar in the 1990's)

Non- Intrusive Wireless UT monitoring (Invented By Permasense ~2010's)

Digitalization & AI

- Elimination of manual rounds
- Actionable data enabled by software and system integration
- Machine Learning and Artificial Intelligence next

Traditional corrosion monitoring are <u>indirectly</u> assessed by weight-loss coupons and inline probes

Modern Non-Intrusive technology <u>directly</u> <u>measures the Impact</u> of corrosion through remaining thickness

Integrity Management Without Monitoring Can Lead To Sub-Optimal Performance

Upgraded Corrosion Resistant Metals

- Expensive!
- Never corrosion “proof”
- Need extensive shutdown

Manual, Periodic Inspections

- Handheld ultrasonics - poor repeatability
- Removable coupons & offsite analysis
- X-ray, eddy current, robotics, etc.

Conservative Integrity Operating Windows (IOW’s)

- *Theoretically* safe process conditions
- Overdosing of Chemicals - Costly
- Known sub-optimal process performance

Adding Value

Non-Intrusive Corrosion Monitoring:

- Enables Data Driven Insight
- Reduces Need for Manual Inspection
- **Enables Optimal Process Performance**

Your Corrosion and Erosion Challenges Require a Complete Sensing Portfolio

MONITOR RISK

Intrusive

Coupons

- Any process
- Verification
- Corrosion mechanism analysis
- MIC verification

⊘ Periodic data only

Inline Probes
(ER / Electrochemical)

- Quick response time
- Detect process changes
- Chemical treatment verification

Non-Intrusive

Sand Acoustic Monitor (SAM)

- Quick response time
- Enables production optimization and sand seperator efficiency monitoring

Highest sensitivity, quickest response

MONITOR IMPACT

Non-Intrusive

Ultrasonic Thickness (UT)

- Flexible, highly distributable, single point wall thickness integrity measurements

Actual metal thickness and loss

High Quality Data Collection a Pre-Requisite for Digitalization

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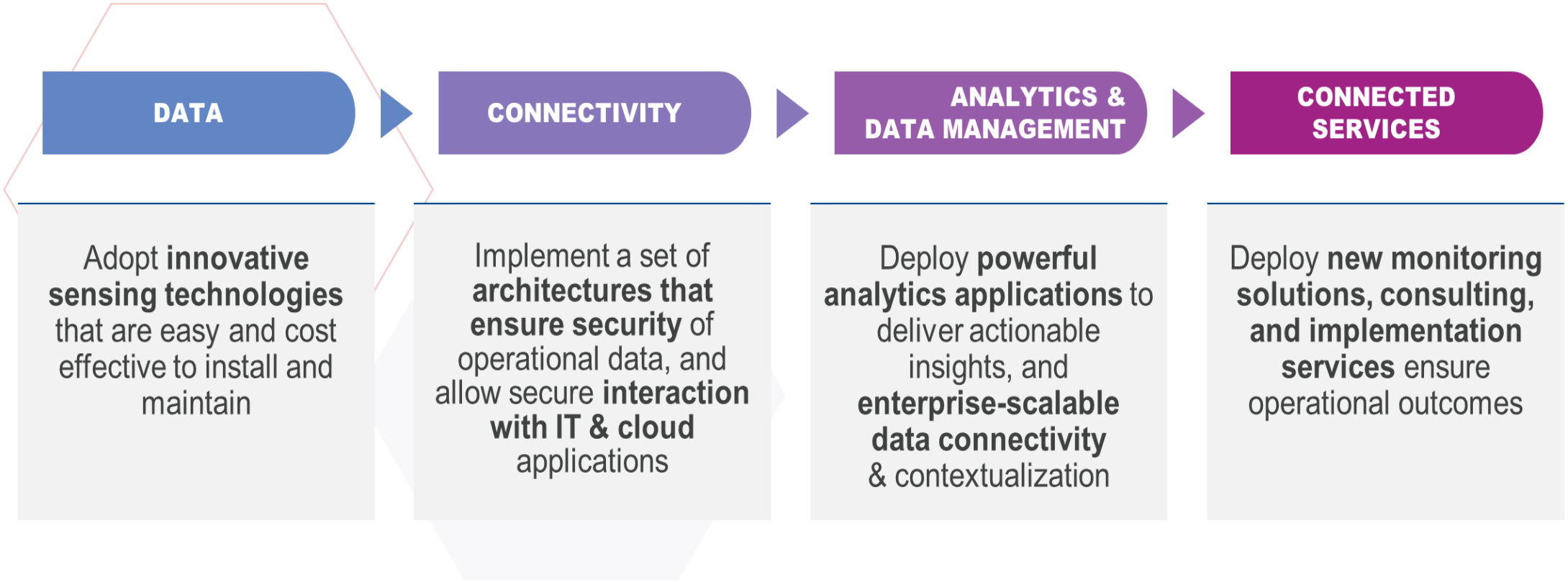
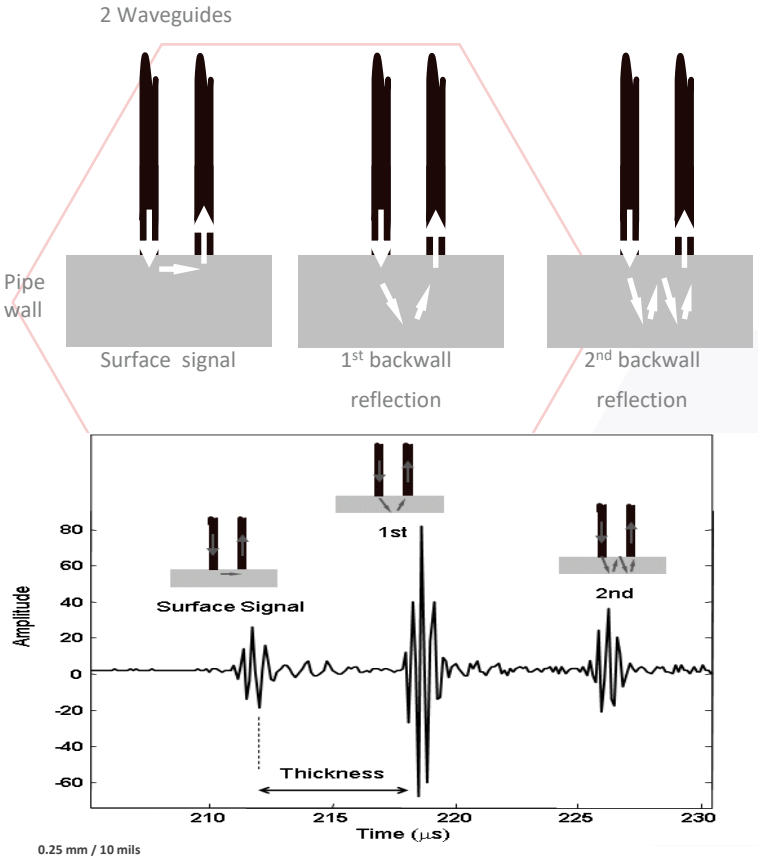
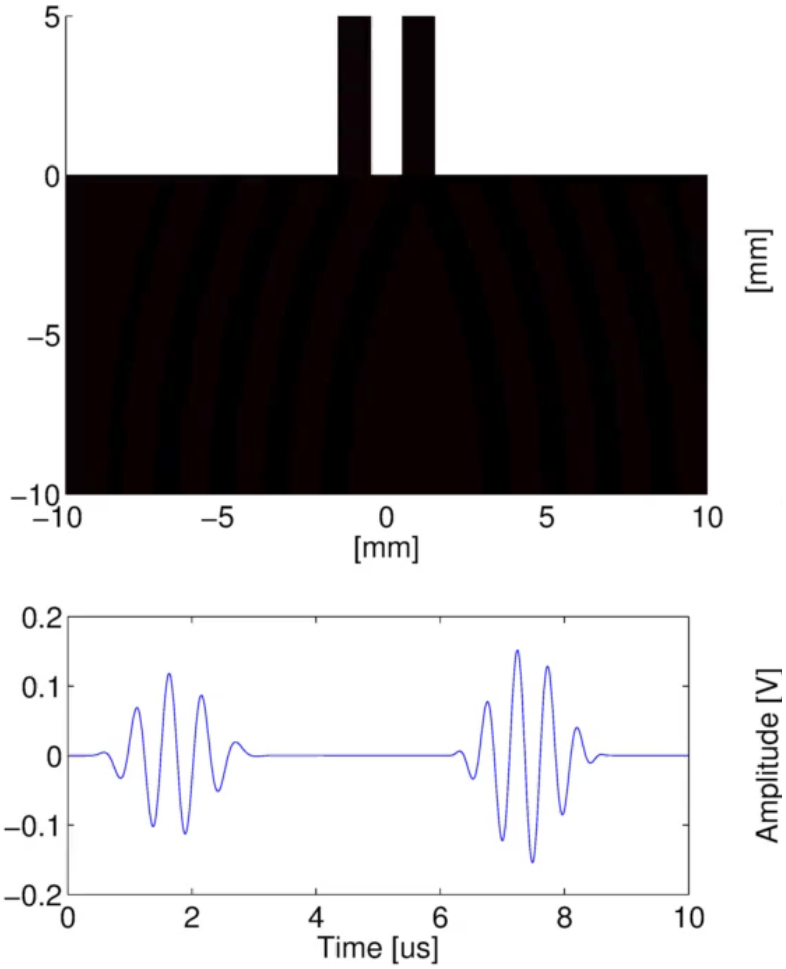
The Building Blocks of Digitalization



Sensor Operation: WT210 (Waveguide)

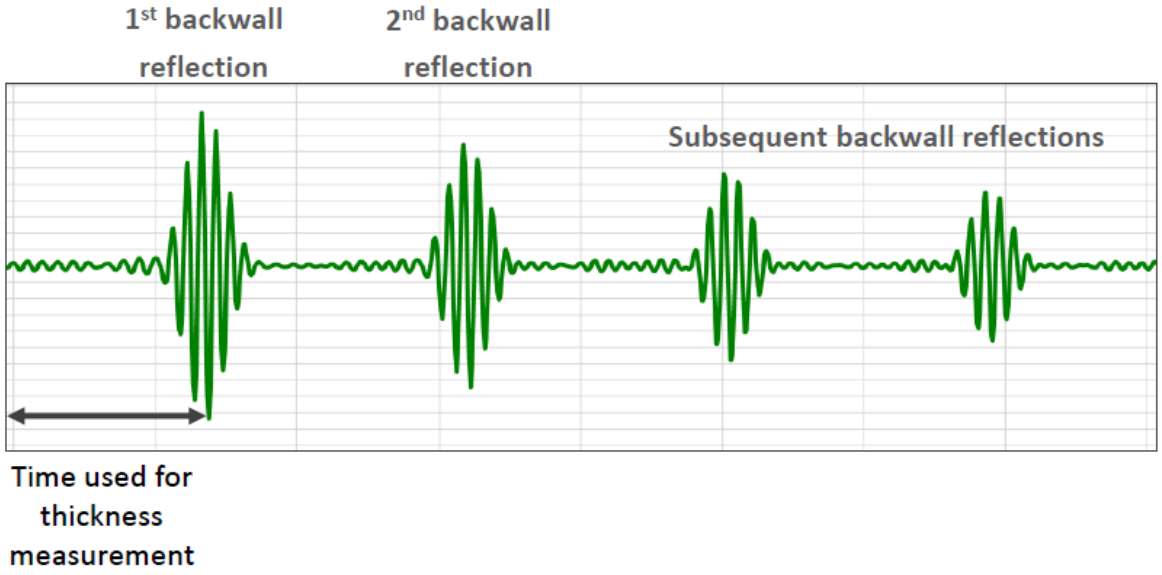


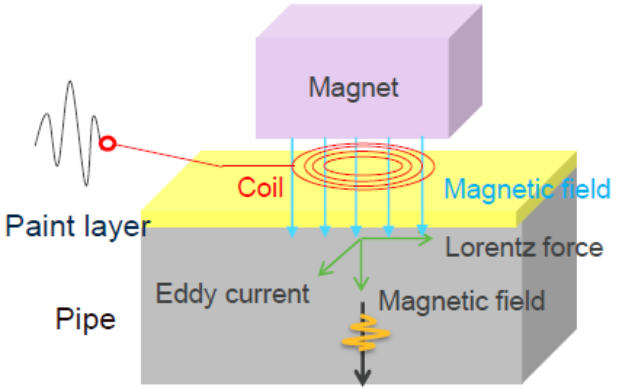
- Input signal sent into pipe wall
- Signal reflects off inner surface
- Reflection received by the sensor
- Sensor measures ultrasonic amplitude over time
- From this the time of flight can be measured
- As velocity is known, the distance (thickness) can be calculated from time of flight
- Distance = Speed * Time



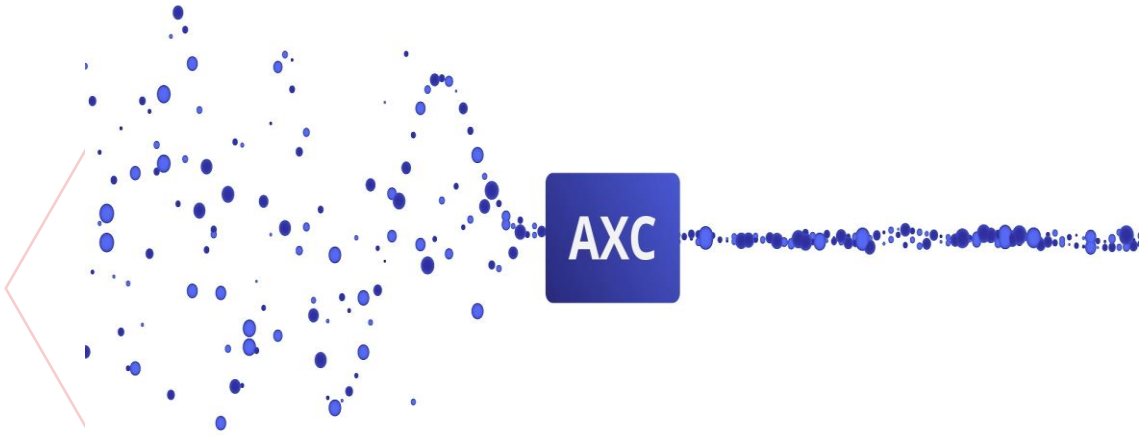
Sensor Operation: ET sensors

- ET sensors have a simpler installation process that WT210 sensors
- Installed onto painted or unpainted surfaces (up to 1mm coating)
- EMAT technology generates the sound in the pipe and does not have a surface wave
- We can calculate a thickness from just 1 backwall reflection with this sensor





Our Adaptive Cross Correlation (AXC) is a **Patented Signal Processing Technique**



Improves measurement accuracy by eliminating the effects of ultrasonic noise

- **Effectively overcomes thickness trend anomalies** caused by waveform distortion induced by back wall geometry by **using historical trend analysis** to improve peak detection.
- This results in **more stable UT measurements**, even when dealing with internal pipe roughness.
- **<10µm (0.0004”) Repeatability in field conditions**, across entire ultrasonic portfolio

Good quality sensor data is the foundation of any corrosion management

Software Enabled Solutions To Deliver Real-Time Asset Insight To Desk

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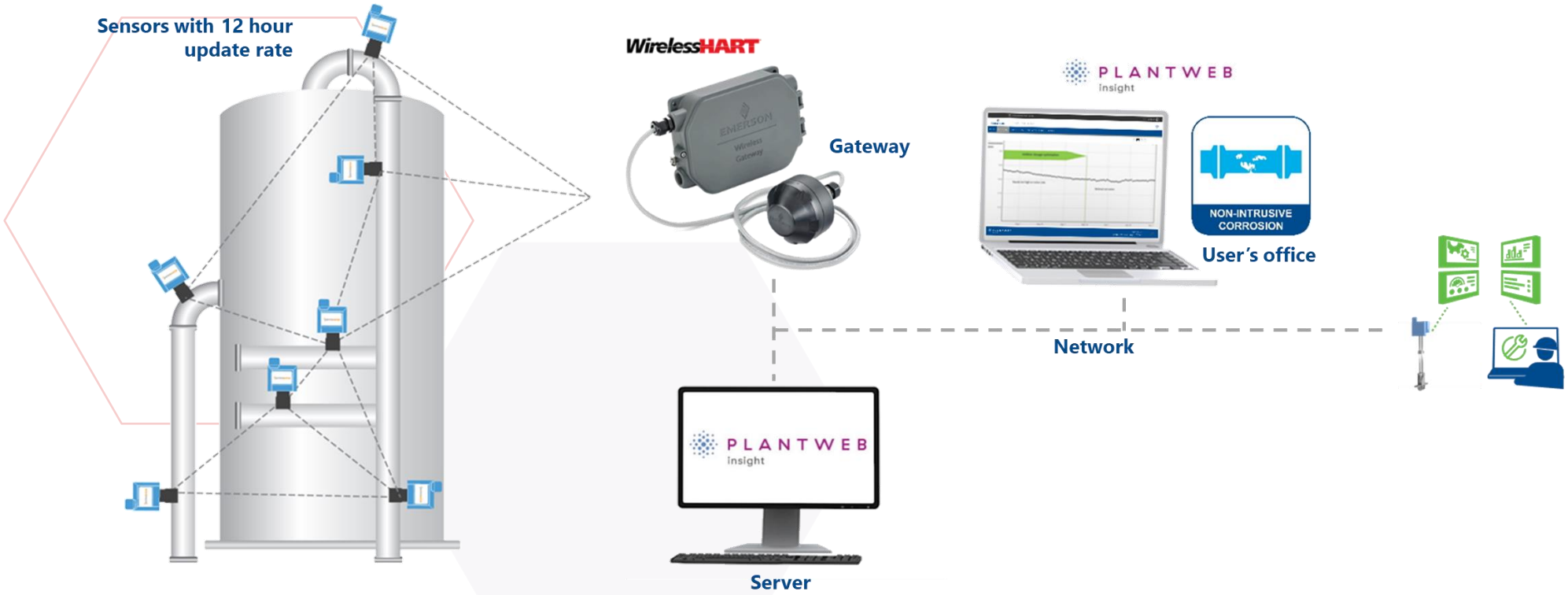
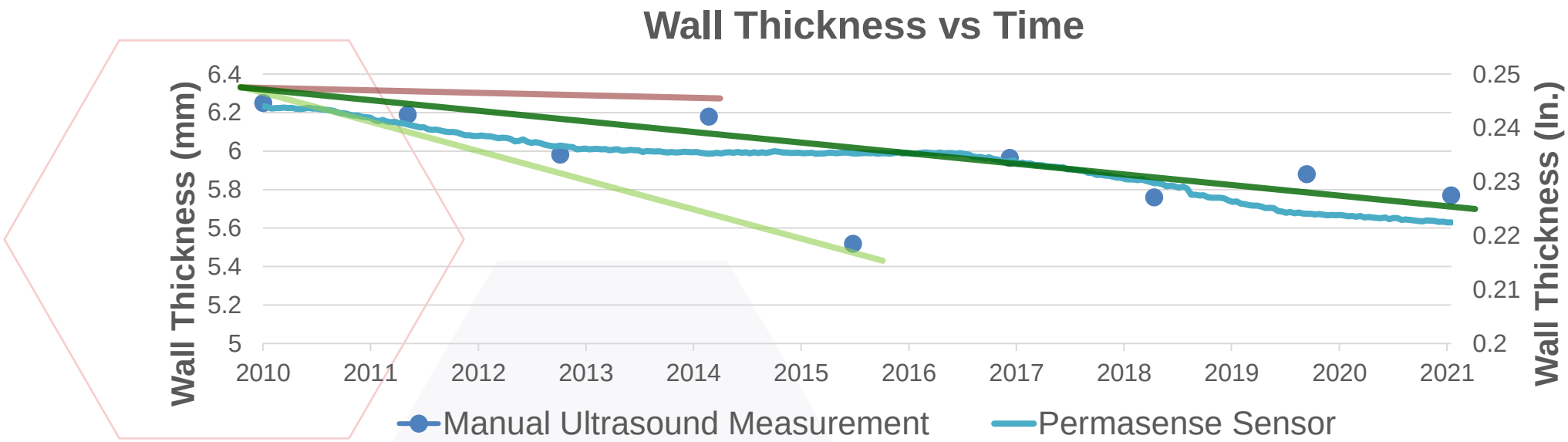
Continuous Integrity Monitoring Delivers Real Time Asset Health Data Directly to Desk



Traditional Corrosion Monitoring Does Not Provide the Granularity Required for Informed Decision Making



With Manual Ultrasound Measurements

With Permasense Sensors Installed

Continuous measurements with high repeatability and accuracy

Corrosion rate calculation accessible continuously

Granular data readings allow unrivalled insight into plant health

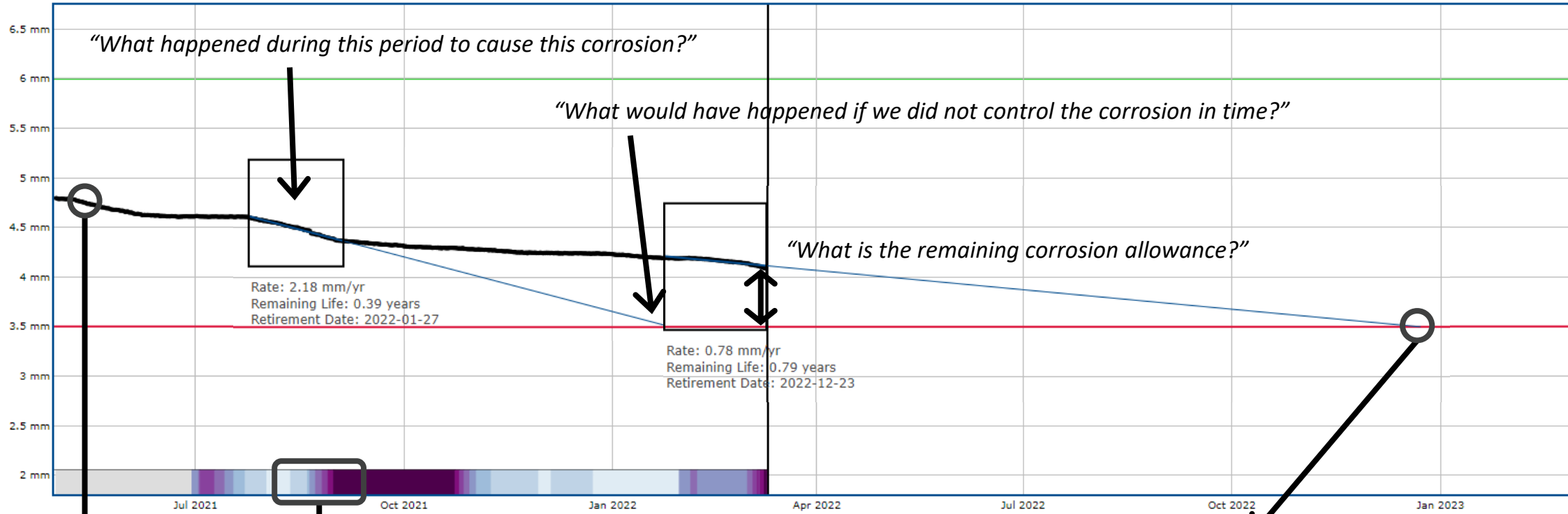
Our Sensor Portfolio is Broad and Capable for Any Application - All Sensors Send Wall Thickness Data Twice per Day With 9 Year Battery Life

ET210	ET310	ET310C	ET410	WT210
120°C / 250°F Limit	160°C / 320°F Limit		270°C / 520°F Limit	600°C / 1100°F Limit
Magnetic EMAT, strap mounted				Stud or clamp mounted
Measures through coatings		Measures on all metals	Measures through coatings	Measures on all metals
<10µm (0.0004”) Repeatability & 1µm (0.00004”) Resolution				
Class 1 Div 1 / Zone 0 with WirelessHART Data Retrieval				
Embedded Temperature and Material Compensation				

Root Cause Analysis

Today

Predictive Maintenance



"What happened during this period to cause this corrosion?"

"What would have happened if we did not control the corrosion in time?"

"What is the remaining corrosion allowance?"

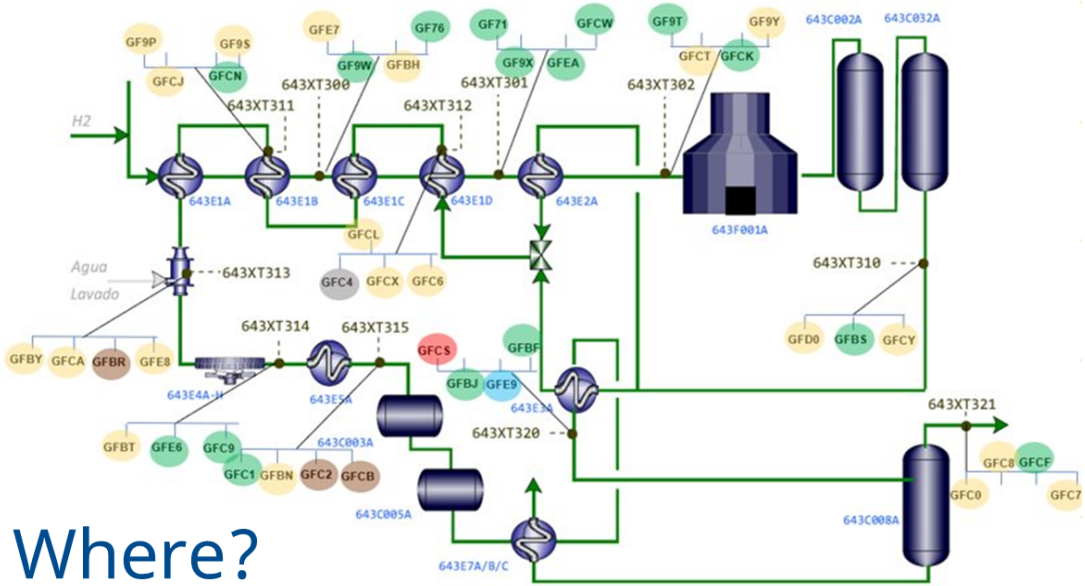
"How is the inside surface of my pipe changing over time?"

"What was my wall thickness in March last year?"

"When will I reach retirement thickness on my pipe?"

"Will I reach the next planned turnaround?"

Customized Analysis to Answer Specific Questions



Where?

Custom Corrosion Rate (mm/yr)

	02/03/2022 to 21/05/2022	22/05/2022 to 16/07/2022	17/07/2022 to 21/07/2022	21/07/2022 to 25/07/2022	25/07/2022 to 30/01/2023
Average	0.07	0.02	0.00	0.00	0.00
Max	0.19	0.08	0.00	0.00	0.00

When?

Corrosion/ Erosion Data Analysis: Estimated Life Span of Pipe < 20 years

Address	Identifier	Sensor MAC	Final Thickness (mm)	Retirement Thickness (mm)	3 Month Corrosion Rate (mm/yr)	Estimated Pipe Remaining Life (yrs) based on 3 Month Corrosion Rate	1 Month Corrosion Rate (mm/yr)	Estimated Pipe Remaining Life (yrs) based on 1 Month Corrosion Rate
NB 10" MF Top CR Draw 2nd Bend 6 O'clock	#00017	GGJA	11.55	6.27	0.34	15.5	0.00	< 20 Years
NB 24" MF Overhead 4th Bend 10 O"clock	#00022	GGHF	12.92	6.52	0.29	22.0	0.45	14.2
NB 24" MF Overhead 4th Bend 12 O"clock	#00021	GGGD	11.50	6.52	0.08	62.2	0.25	19.9
NB 6" MF Top CR Return 3rd Bend 12 O"clock	#00023	GGHW	5.41	4.11	0.01	130.0	0.14	9.2

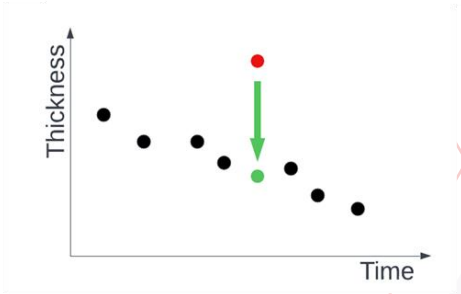
2 locations with similar Address (MF Overhead 4th Bend) are reporting estimated pipe remaining life of less than 20 years based on 1 Month Corrosion Rate.

How long?

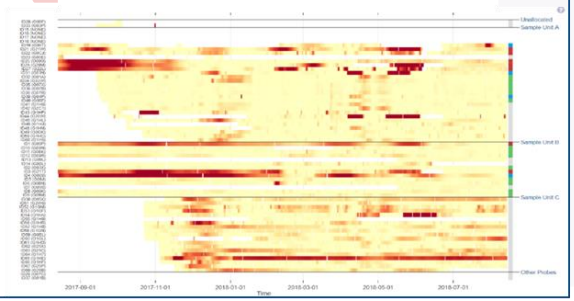
Software Provides Context and Insight From High Quality Sensor Data

Gain Value from More Sensors

Improved data quality to ease review



At-a-glance view of hundreds of sensors



Enables More Applications

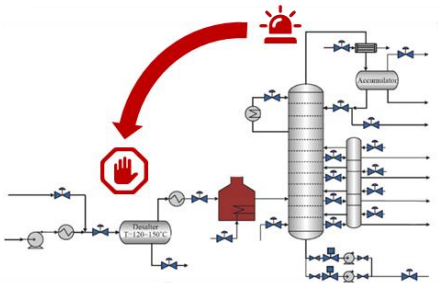
Measure internal scale layers

Chemical Industry

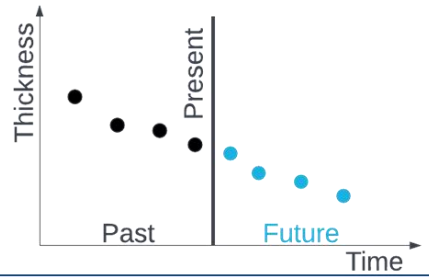
Rosemount ET310C

Integrate with Process Optimization

Root cause analysis with actions



Simulate and predict future damage



The Future -Intelligent Corrosion Management

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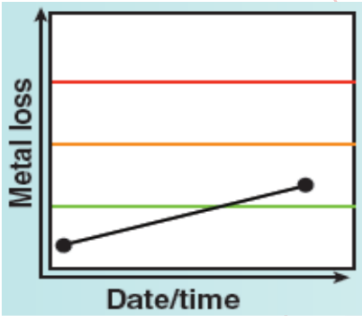
Going Forward – Intelligent Corrosion Management

Inspection / Offline Monitoring

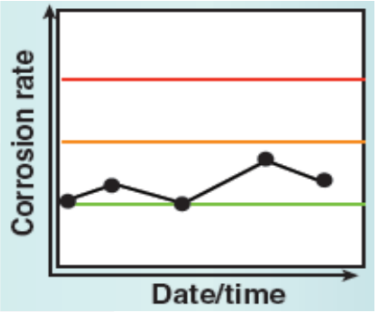
- Offline
- Historical



- Mostly manual techniques
  - *Visual Inspection*
  - *Manual UT*
  - *Off-line Probes*
  - *Coupon*
- Time frame too long for process correlation
- See only cumulative damage

Online Monitoring

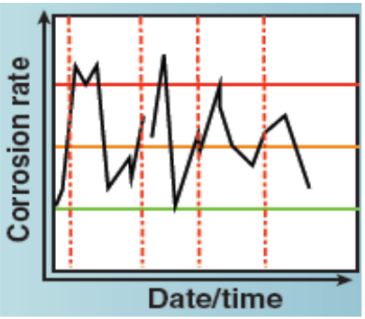
- Online
- Real-time



- Intrusive & Non-intrusive sensors
  - *ER/LPR Probes*
  - *Online UT*
  - *FSM*
  - *Others*
- See cumulative and **past damage**
- Slow for process optimization

Intelligent Corrosion Management

- Online + Integration
- Realtime + Future



- Integrate into automation & control strategies
- Manage & optimize system productivity
- Condition management strategy
- “See” future damage

Applications and Case Study

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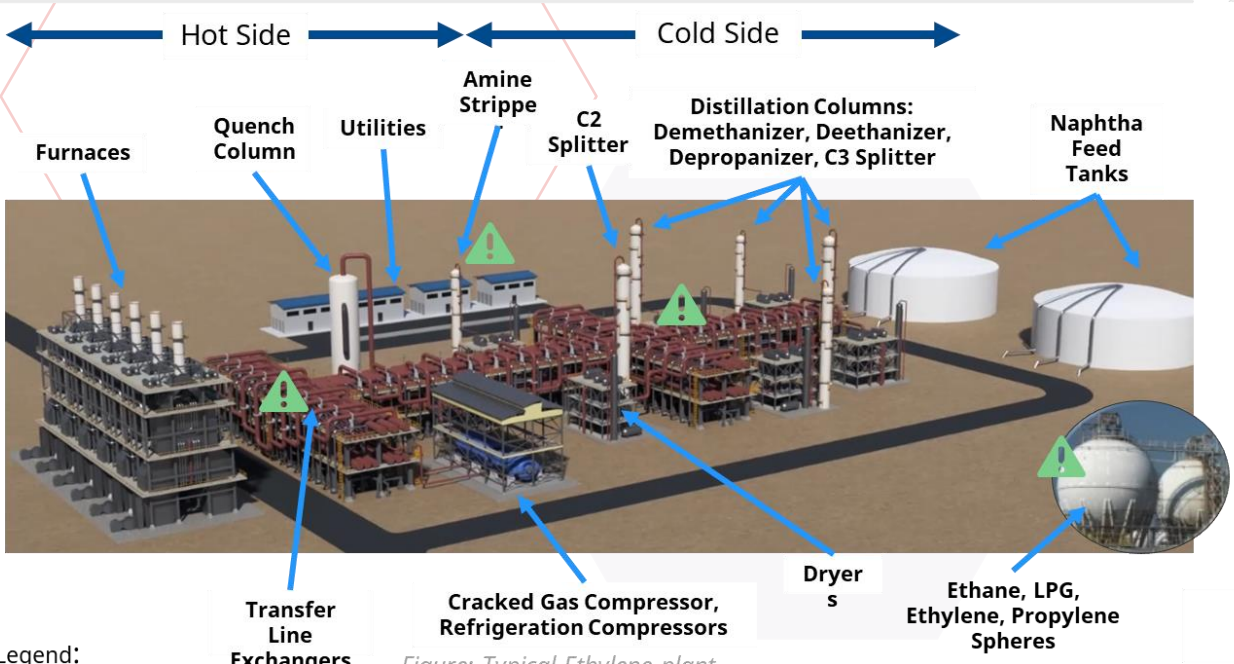
Ethylene Plants - Customer Challenges & Solution – ROI within 4 Months

Ethylene Plants

Olefin crackers are the workhorses of the petrochemical industry, producing mainly ethylene, propylene, and butadiene.

They consist of three main areas:

- a hot section;
- a compressor section
- A distillation (recovery) section



Legend:

⚠ - Elevated Corrosion Risk

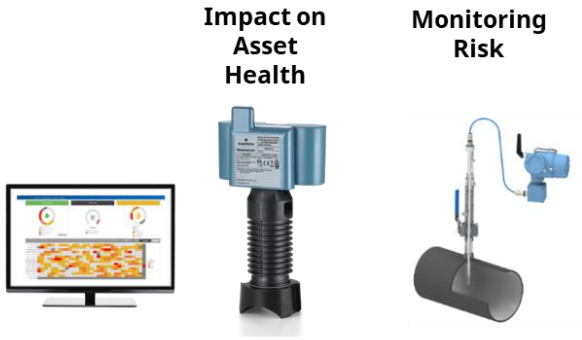
Figure: Typical Ethylene plant

Link to Application pack - Ethylene

Corrosion customer challenges

- TLE boiler feed water requires tight quality control to prevent corrosion
- Acid gas remaining in cracked gas can cause corrosion downstream in piping and caustic scrubber
- Furnace tubes, amine stripper overhead, cracked gas compressor inter-cooler vessels, dilution steam drums, de-ethanizer overhead system

Emerson Solution



Ethylene	~30 – 50	~3

$1M in return per year delivers ROI within 4 months

Styrene Plant Monitoring

Challenges

- Large styrene complexes spend millions annually on corrosion abatement
- Some output lines from the Chloride Alky process (HCl present) are in Carbon Steel and customers require to replace them every 3 years
- Strong CO2 corrosion within the OFFGAS lines due to increased content on CO2 and sections with condensate conditions
- **Key Areas of concern:**
  - After-reactor coolers
  - Overhead condensers
  - Process water stripper overhead
  - Vent gas compressor after cooler area
  - Superheated steam areas

Value Enabler

Continuous Corrosion Monitoring:
Ensures asset integrity and optimization of process conditions

- Online sensors to measure corrosion and erosion in real-time
- Non-intrusive pipe thickness wireless sensors
- Wired or wireless corrosion probes
- Online analytics package to show trends and visualize results

- Lower risk of corrosion-related incident
- Ability to monitor known problem areas
- Reduced outages caused by corrosion
- Operating conditions optimized based on the feedback from the sensors

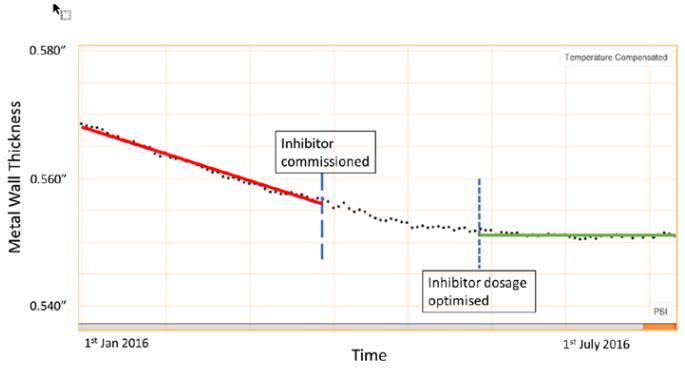


Figure 4: Plot of data received from Permasense sensors

Summary: Monitoring Drives Top Quartile Performance

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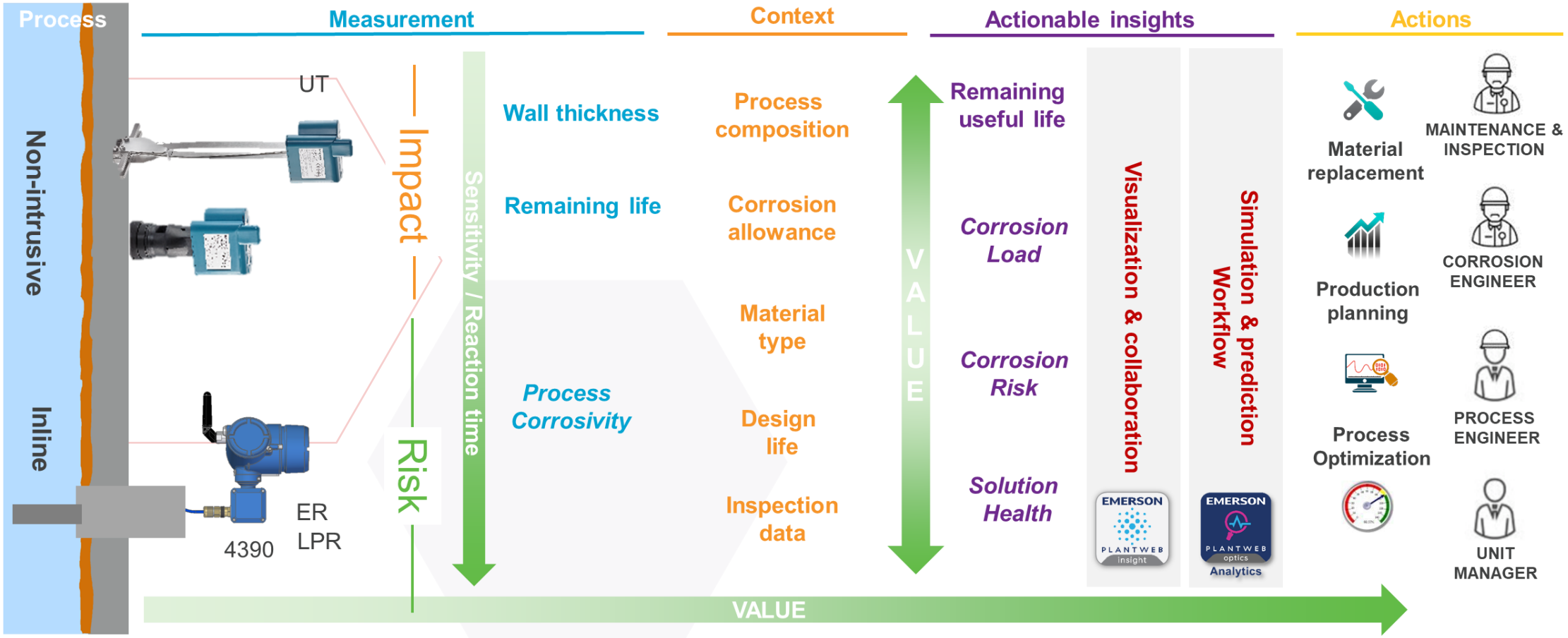
Data driven decisions unlocks value



Summary

- Corrosion and/or Erosion are **ever-present threats**
- Corrosion and/or Erosion **vary across the asset and over time**
- **Manual inspection is not frequent enough** to understand asset health or corrosion rates
- Monitoring of both **corrosion and erosion risk and their impact on the asset health is essential**
- **Emerson's *Wireless*HART® capability** delivers best-in-class data to your desk
- **Use the data** to better-operate your process plant, ensuring the asset is driven to its maximum capability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Thank you