Monitoring CUI

AGENDA

1. iSensPro CUI solution
2. Some Use cases
3. Future developments
4. Questions

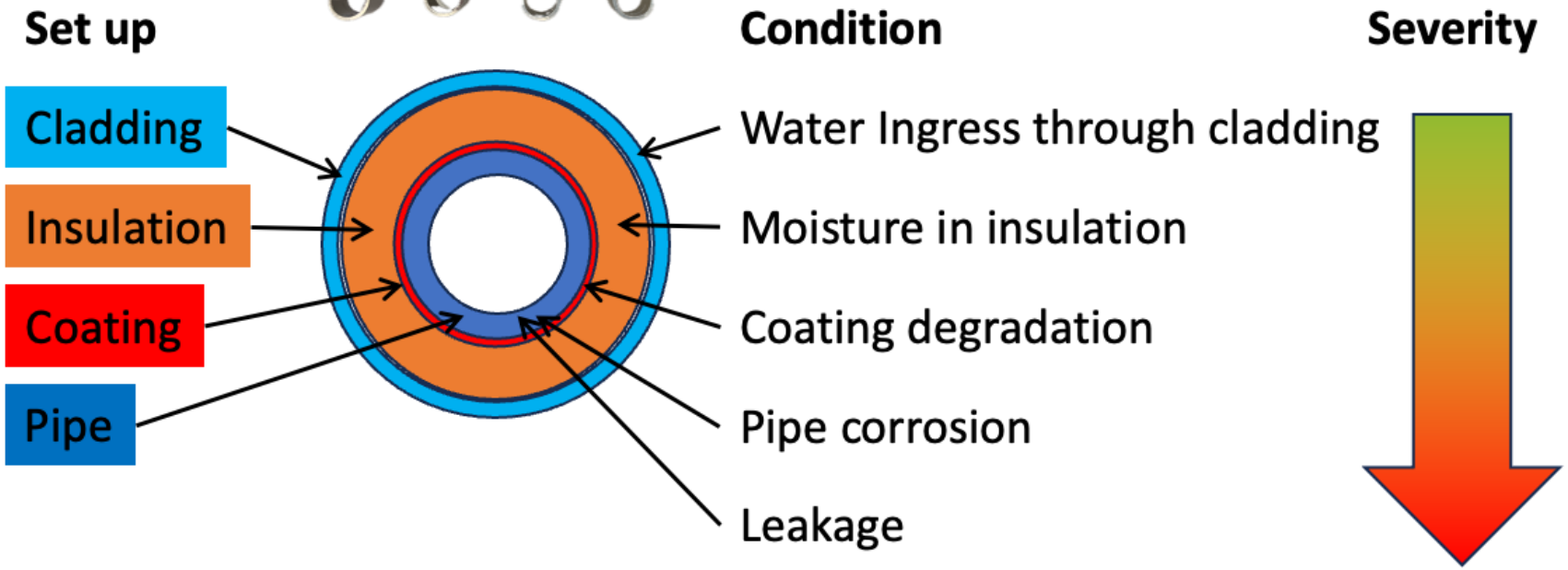
iSensPro CUI Solution

Founded in 2019, iSensPro is on a mission to tackle the challenges of Corrosion Under Insulation (CUI) in industrial installations.

Our cutting-edge corrosion detecting technologies, which are non-intrusive and ATEX-certified, are revolutionizing the industry bringing end to end solutions for a more efficient asset management optimizing the use of resources.

Yves Desmet – Dirk De Keukeleere - Maurice Mergeay

Monitoring evolution of assets towards CUI



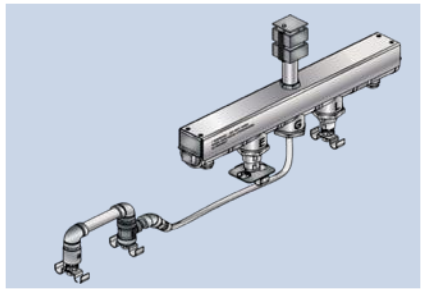
iSensPro monitors remotely active corrosion on insulated assets up to 1 km with a single sensor

Non-intrusive, w/o removing insulation

Moisture- & CUI- sensors for new & existing insulated pipes

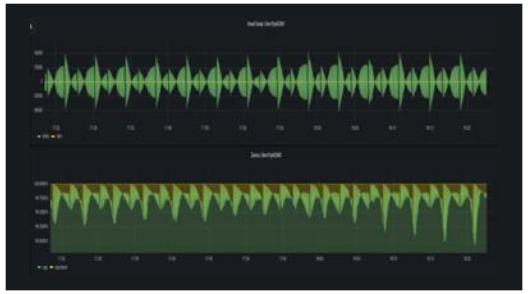
Complete 360° detection

Monitoring complete segments all around the insulated pipes



Continuous monitoring

Continuous data from wireless battery-fed LORA-sensors



Inspection & localization

Handheld sensor as a tool for condition inspection and localization.

Staged alarms

Detection of potential hazards allowing data-based risk mgmt.

- Water ingress
- Coating
- Corrosion
- Leakage

The **Emerging Technology Award** went to iSensPro for its iSens-SDS ATEX moisture and CUI-sensor. *The judges said that this technology could well be a game changer for the maintenance of insulated tanks and that it offered lots of opportunities to save time and money*.

www.isenspro.com

A handheld sensor giving immediately information on the conditions of your insulated asset

Allows quick inspection to decide on stripping avoiding unnecessary maintenance actions and costs

- **A completely self-contained and easy-to-use tool that can be used in the laboratory or in the field to quickly inspect insulated assets. Position it on a segmented pipeline and it will instantly take a measurement and give you information on the condition of your insulated asset. The screen will tell you if the insulation is wet, if the coating is deteriorating or if the pipe is corroding.**
- **This allows you to target maintenance activities prior to a plant shutdown, focusing on those segments that require action to maintain asset integrity and avoiding the removal of intact insulation systems. This not only reduces costs and the use of material resources, but also reduces the risk of corrosion, giving you peace of mind.**

Benefits

- Allows inspection of insulated assets, giving immediate and local feedback on asset conditions
- Detects accurately critical CUI conditions in pipe segments
- Portable and easy to reposition for inspection of multiple pipe segments before reconditioning
- Evaluation of the proper functioning of insulation systems avoiding removal of good insulation

Features

- Stand-alone system with sensing, data storage, data analytics and visualization Integrated in one unit.
- Touch screen to adjust parameters and visual output for accurate measurements.
- Low weight, small dimensions, battery powered, wireless communication and pluggable electrodes
- Indication of status insulation system: dry, wet, coating degraded, corrosion

A non-ATEX sensor monitoring continuously the conditions of your insulated asset

Generates immediate alarms when conditions change to trigger preventive and cost-effective maintenance actions

- **A wireless and battery fed sensor which can be easily installed in the field to continuously monitor the conditions of insulated assets. Once placed on top of the cladding of a segmented pipeline, it will measure at regular predefined intervals and give you information on how the conditions of your insulated asset are evolving. Alarms will be generated when the insulation becomes wet, when the coating is degrading or when the pipe starts to corrode.**
- **This allows you to plan preventive maintenance activities in function of changes in the asset conditions to maintain the integrity of critical assets. This reduces maintenance costs and operational issues; it also reduces the risks of CUI thereby avoiding incidents and unforeseen shutdowns giving you peace of mind.**

Benefits

- Allows monitoring of insulated assets, giving immediate feedback on asset conditions and changes in conditions.
- Detects accurately critical CUI conditions in pipe segments.
- Monitors the conditions of insulated asset without putting personnel in unsafe circumstances.
- Provides information for targeted inspection and maintenance actions when and where required.

Features

- Measures continuously moisture & corrosion in/under insulation.
- Battery-fed sensor with wireless (LORA) communication for easy installation.
- Non-intrusive, placed on top of the cladding.
- Weather proof, durable and low power for long time in field monitoring.
- Evolution of condition insulation system: moisture content, coating degradation and corrosion.

An ATEX sensor monitoring continuously the conditions of your insulated asset

Generates immediate alarms when conditions change to trigger preventive and cost-effective maintenance actions

- **A wireless and battery fed sensor which can be easily installed in the field to continuously monitor the conditions of insulated assets under explosive environments. Once placed on top of the cladding of a segmented pipeline, it will measure at regular predefined intervals and give you information on how the conditions of your insulated asset are evolving. Alarms will be generated when the insulation becomes wet, when the coating is degrading or when the pipe starts to corrode.**
- **This allows you to plan preventive maintenance activities in function of changes in the asset conditions to maintain the integrity of critical assets. This reduces maintenance costs and operational issues; it also reduces the risks of CUI thereby avoiding incidents and unforeseen shutdowns giving you peace of mind.**

Benefits

- Allows monitoring of insulated assets, giving immediate feedback on asset conditions and changes in conditions.
- Detects accurately critical CUI conditions in pipe segments.
- Monitors the conditions of insulated assets without putting personnel in unsafe circumstances.
- Provides information for targeted inspection and maintenance actions when and where required.

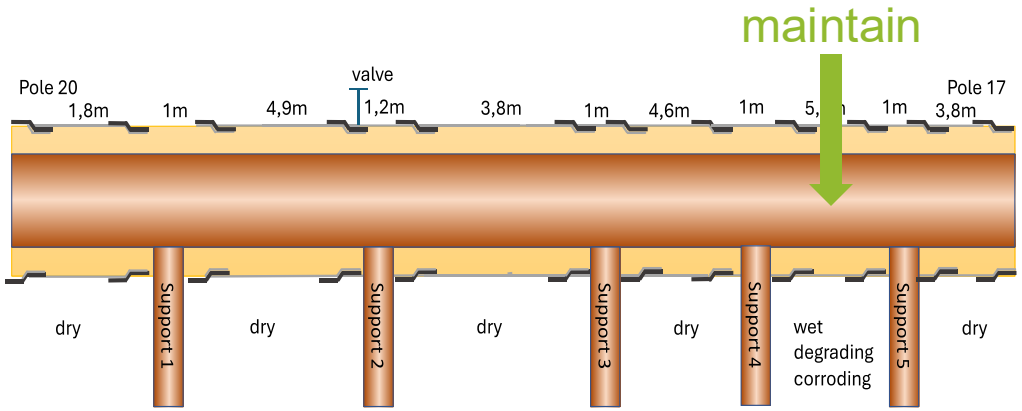
Features

- Measures continuously moisture & corrosion in/under insulation.
- Battery-fed sensor with wireless (LORA) communication for easy installation.
- Non-intrusive, placed on top of the cladding.
- Intrinsically safe, CE-certified to be used in explosive zones 2, 1 and 0.
- Weather proof, durable and low power for long time in field monitoring.
- Evolution of condition insulation system: moisture content, coating degradation and corrosion.

Some use cases

How to apply our corrosion detecting solutions

- **Asset Classification :**
  - Measuring current conditions of specific segments
    - To scope activities before a maintenance stop
    - To nourish Risk Based Inspection with actual data



- ❼ Up-to-date asset condition overview for budget allocation (CAPEX-OPEX).
- ❼ Reduces maintenance costs (better targeted scope)
- ❼ Reduces waste (no refurbishment of good insulation)
- ❼ Reduces risk levels (lower uncertainty)
- ❼ Reduces inspection frequency

RISK ANALYSIS

LIKELIHOOD \ CONSEQUENCE	1. INSIGNIFICANT Dealt with by in house first aid	2. MINOR Treated by medical professionals, hospital out patients	3. MODERATE Significant non permanent injury overnight hospital stay	4. MAJOR Extensive permanent injury eg. Loss of fingers, extended hospital stay	5. CATASTROPHIC Death, permanent disabling injury eg. Loss of hand, quadriplegia
A. Almost certain to occur in most circumstances	MEDIUM 8	HIGH 16	HIGH 18	CRITICAL 23	CRITICAL 25
B. Likely to occur frequently	MEDIUM 7	MEDIUM 10	HIGH 17	[illegible]	CRITICAL 24
C. Possibly and likely to occur at sometime	LOW 3	MEDIUM 9	MEDIUM 12	HIGH 19	HIGH 22
D. Unlikely to occur but could happen	LOW 2	LOW 5	MEDIUM 11	MEDIUM 14	HIGH 21
E. May occur but only in rare circumstances	LOW 1	LOW 4	LOW 6	MEDIUM 13	MEDIUM 15

Inspection insulated pipes before replacement (1/2)

Case: 5 outdoor insulated pipes at several heights (up to 15,8m) in industrial plant.
Time bound replacement of insulation.
➔ Measuring moisture and corrosion before dismantling to check need for new insulation

Technical implementation:

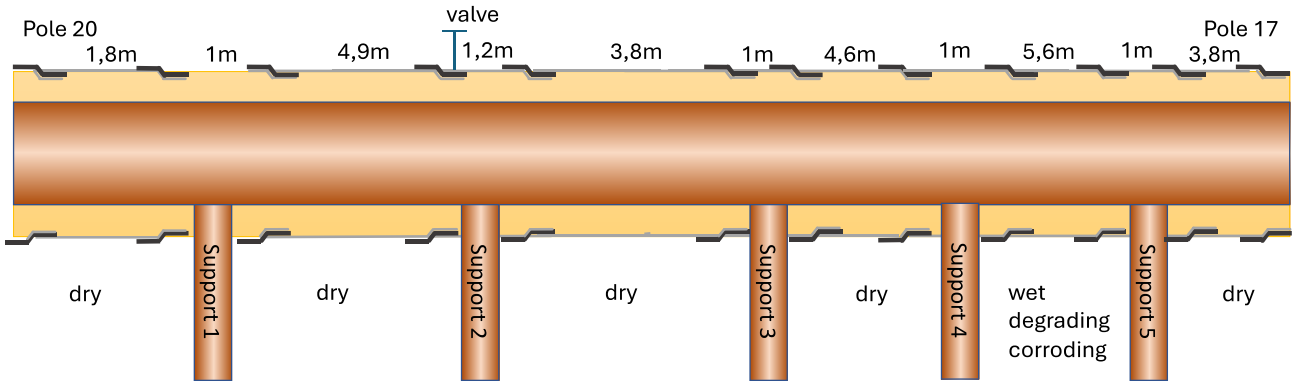
Measurement with handheld sensor on different segments in between 2 supports to check moisture content and corrosion.

Segmentation carried out by repositioning shielding.

Placement of sensors on pipeline with textile belts

Verification of observations after dismantling of insulation

Inspection insulated pipes before replacement (2/2)



		length (m)	length (m)	theor. cap. (pF)	meas. cap (pF)
Section 1	Section 2	1,8	4,9	109	720,3
Section 2	Support 2	4,9	1,2	407	1400,4
Support 2	Section 3	1,2	3,8	316	787,5
Section 3	Support 3	3,8	1	316	646,7
Support 3	Section 4	1	4,6	382	653,6
Section 4	Support 4	4,6	1	382	1185,2
Support 4	Section 5	1	5,6	466	1384,1
Section 5	Support 5	4,7	1	391	NaN
	tion 6	1	3,8	316	548,4

Observations :

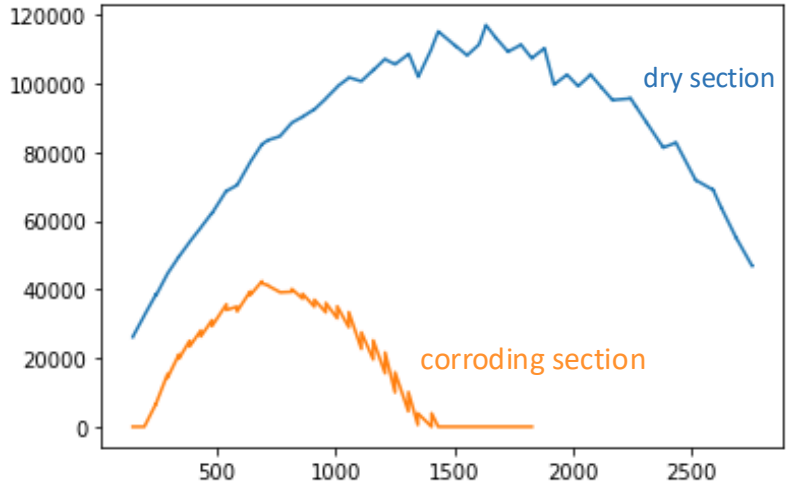
Individual measurement takes around 10 minutes for preparation and 5 minutes for measurement.

Supports must be segmented due to contact with shielding.

According to measurements most segments were dry with capacitances close to the theoretical dry capacitance and with no indications of corrosion.

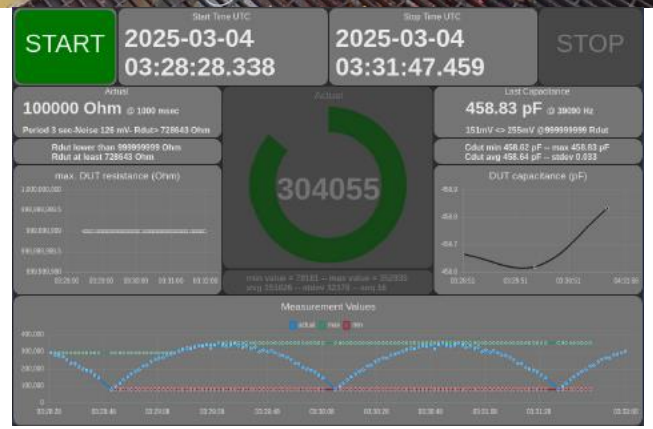
Some segments were however wet and gave indications of corrosion.

➔ In the future unnecessary dismantling and costs can be avoided



Inspection insulated pipelines in humid climate

Case: 3 outdoor insulated pipes at several heights in industrial plant in humid climate.
Replacement is expensive activity. High corrosion risks
➔ Measuring moisture and corrosion before dismantling to check need for new insulation and/or recoating.



Technical implementation:

Measurement with handheld sensor of 16 segments on 3 different pipelines over total length of 53 m

Measurements on Calcium silicate and wired meshed wool

single as well as mutual capacitive measurements were carried out

Observations:

- Inspection technique can cover different geometries and different insulation materials (wool and calcium silicate).
- According measurements all 3 pipelines were dry and did not have corrosion, which was confirmed by visual inspection.
- Importance of correct segmentation and good isolation between shielding and supports for correct interpretation of results.

Inspection of pipes in harsh environment (1/2)

Case: Extensive test program to validate iSensPro technology and methods for CUI-inspection in the company.
19 pipe set ups with

- different lengths (1-100 m),
- different diameters (28-356 mm),
- different insulation thicknesses (20-100 mm)
- different insulation types (wool, wool with wire mesh, calcium silicate, foam glass)
- different operating temperatures (-70°C till 200°C)

➔ Measuring moisture and corrosion before dismantling to evaluate inspection procedure.

Technical implementation:

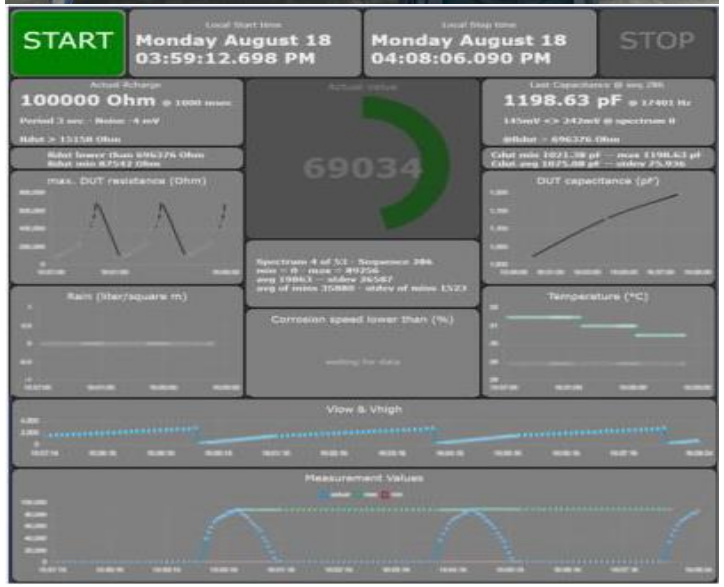
- Inspected with 1 handheld rugged sensor
- Supported by local insulation company for the segmentation
- Training of local partner for future inspections

Inspection of pipes in harsh environment (2/2)

Conclusions:

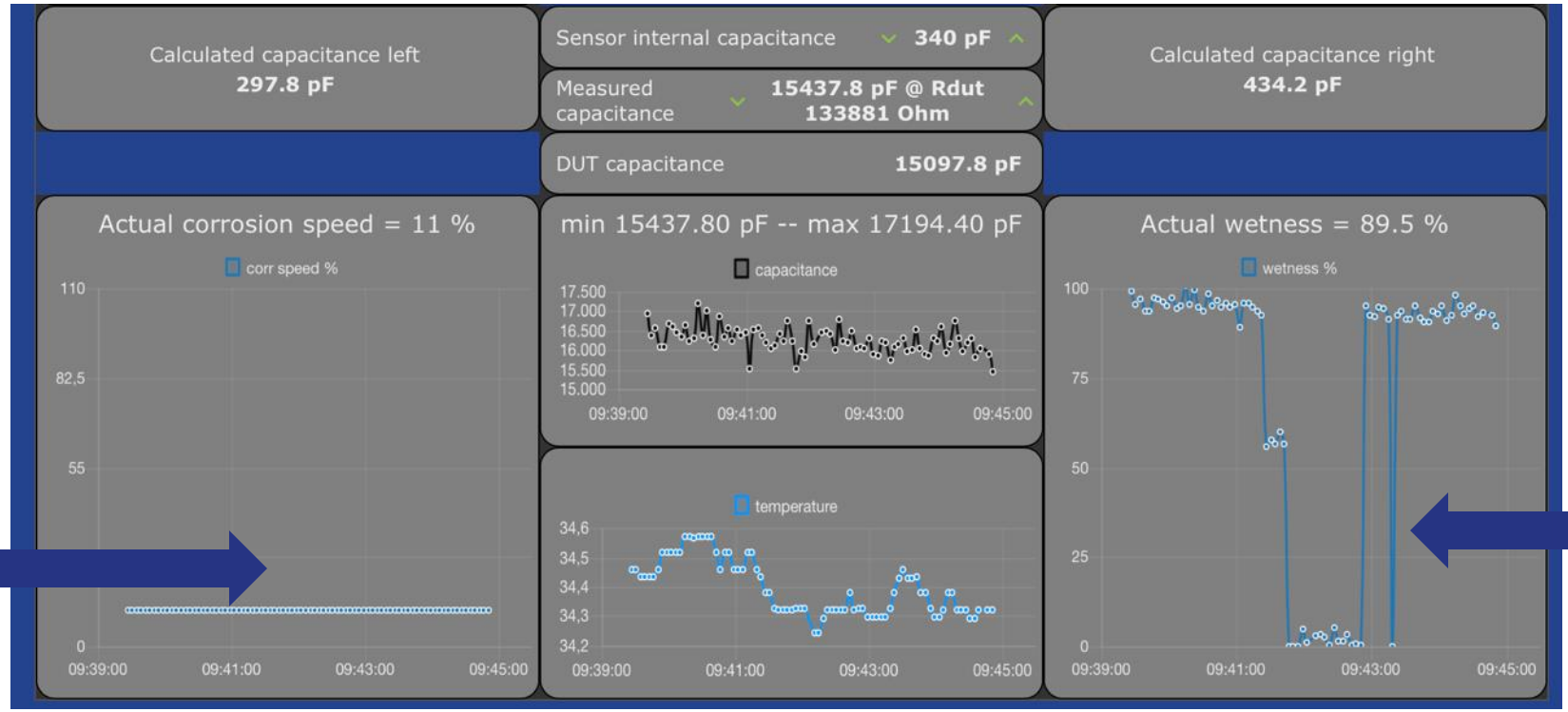
- 68 measurements (including segmentation) were carried out in 5 days
  - Above expectation of customer, more pipelines were inspected
  - Timing was crucial
- All test results were confirmed by visual inspection after dismantling
  - No false positives
  - No missed negatives
- Test were carried out without interruption of operation
- Repeatability tests on same segment over 4 days:
  - moisture content variation 10%
- Branching method for pipe rack inspection successfully applied
- Effective training local partner working together with our inspector

➔ Successful step in technology certification process



Measurement inspection

Inspection provides immediate output indicating the actual corrosion speed and the actual wetness



Corrosion speed

Moisture content

How to apply our corrosion detecting solutions

- **General Condition Monitoring :**
  - Permanent sensors **continuously monitoring** long segments (up to 1 km/sensor)
  - If the **condition is normal, no further action is required**
  - **Alarms initiating actions when moisture, coating degradation or corrosion is detected**
  - Additional inspections with handheld **to pinpoint the issue**

⇗ No need for regular inspections requiring expensive access (e.g. scaffolding)

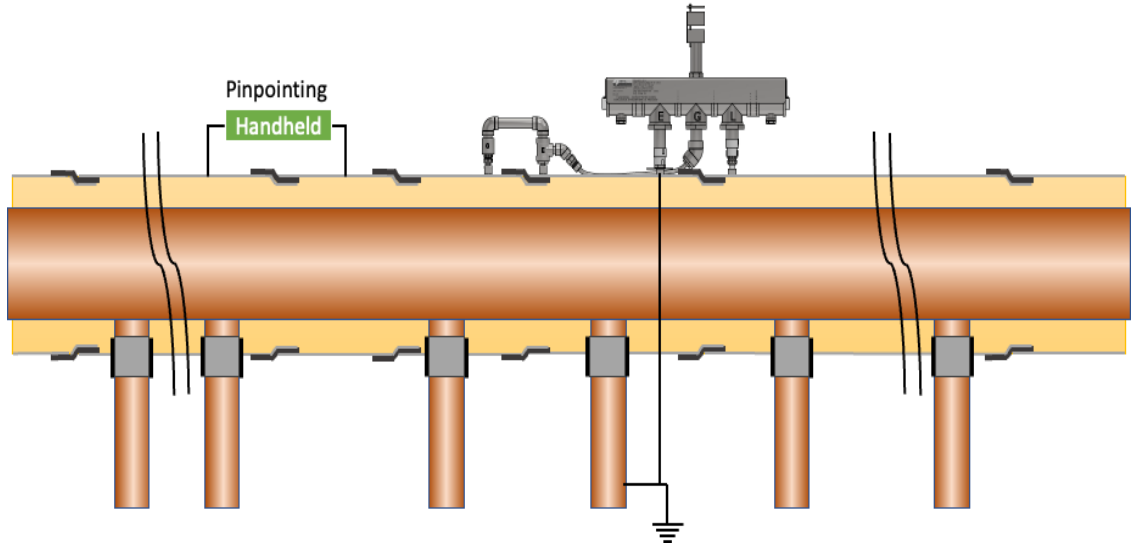
⇗ Targeted and planned maintenance actions

⇗ Better allocation of resources

⇗ Less waste

⇗ Reduced reconditioning costs

⇗ Reduced inspection and maintenance costs



Monitoring pipelines in a chemical plant

Case: 2 different pipelines (>30 m; one horizontal; one vertical) at different temperatures insulated with mineral wool must be monitored to verify their conditions in function of the time and provide alarms when conditions changes.

➔ Continuous monitoring of moisture content and corrosion speed

Technical implementation:

Monitoring with 2 wireless sensors (battery fed) communicating (LORA) with gateway in office.

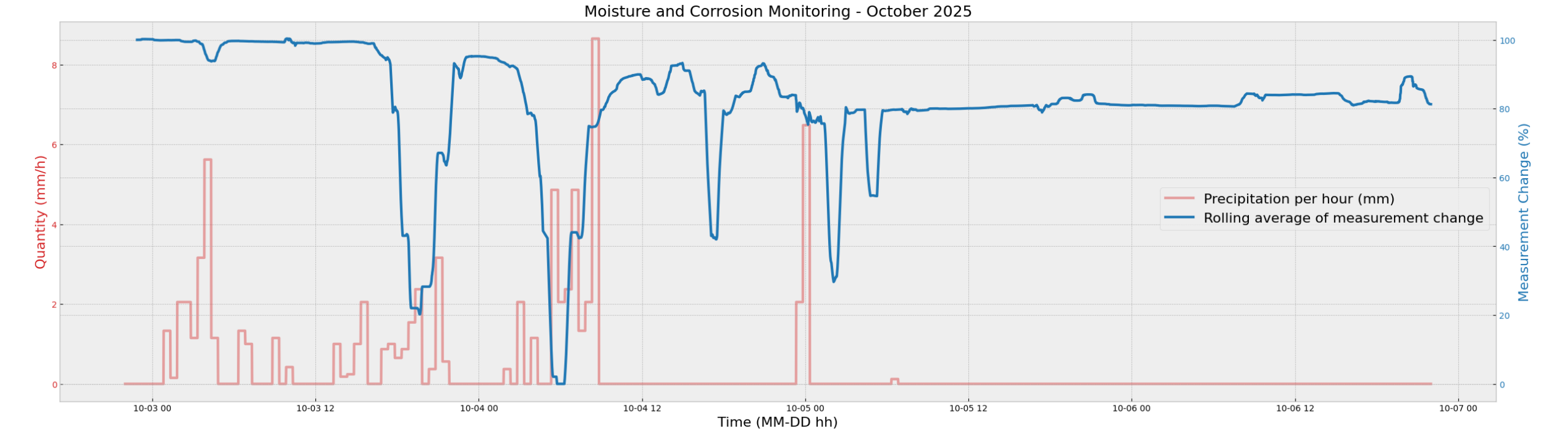
Observations:

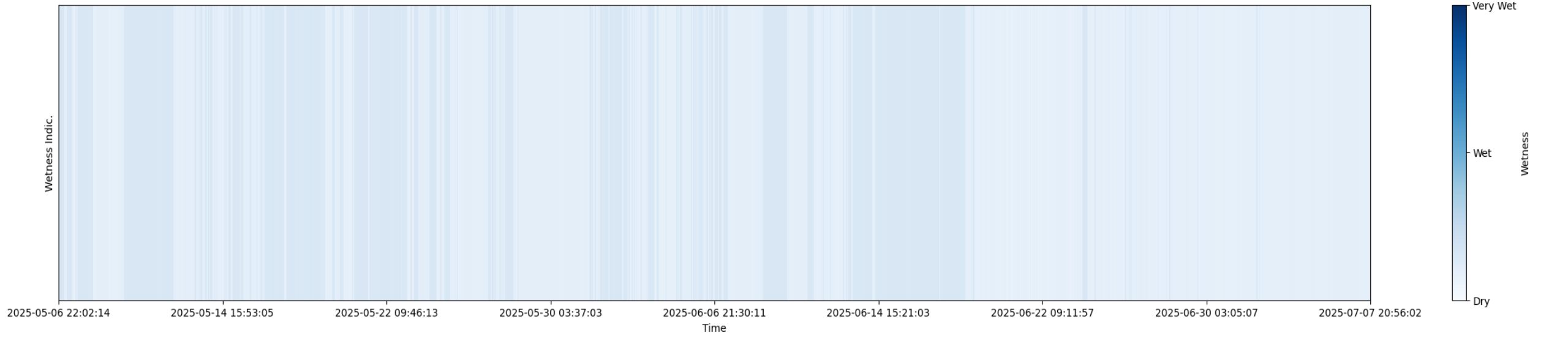
Communication is running properly, even with a gateway installed inside building.

Correct segmentation ensuring isolation between shielding and supports requiring proper training.

Influence of rain on moisture content is visible (short and longer term)

No corrosion detected in first months.





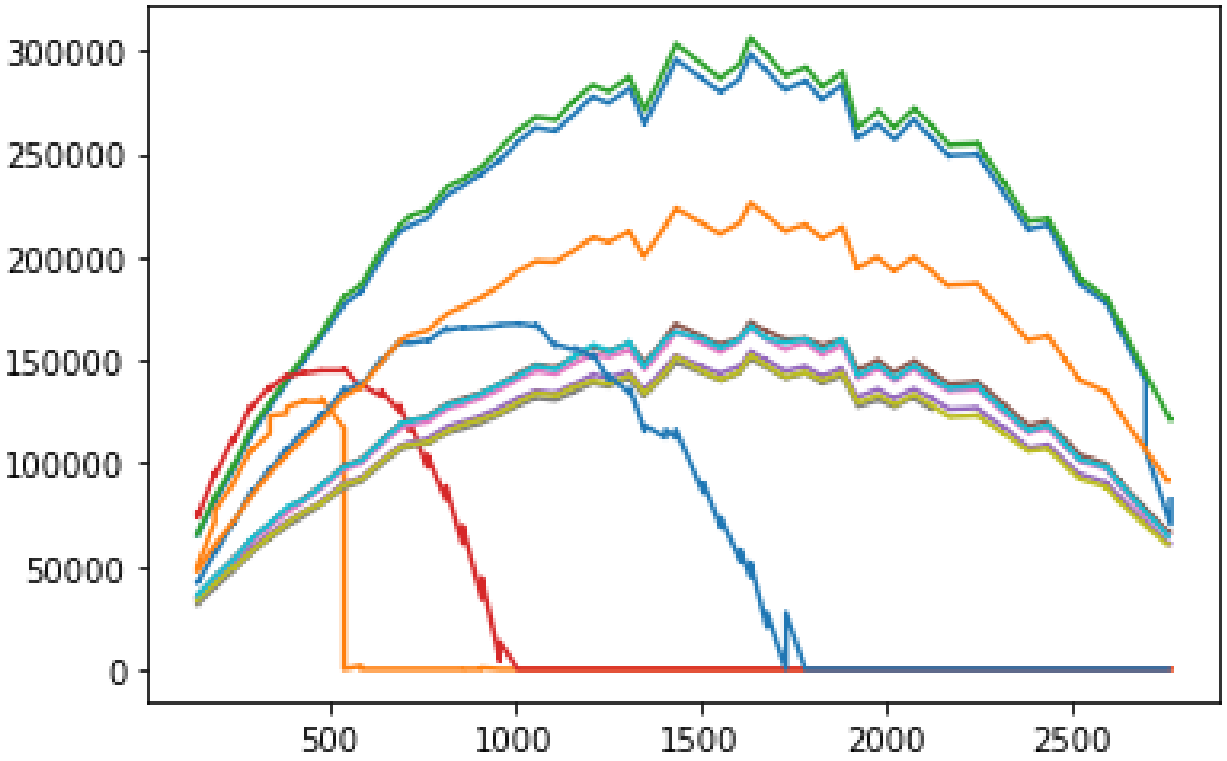
How to apply our corrosion detecting solutions

- **Critical Assets Monitoring :**
  - Continuous follow-up of CUI-critical assets with permanent sensors
  - Small segments around critical points for targeted follow up
  - Alarms provided when condition changes

- ❼ Generating insights in evolution of asset conditions
- ❼ Initiating low-cost preventive actions before high-cost failure
- ❼ Reducing costs from frequent inspection
- ❼ Optimizing use of inspection personnel
- ❼ Reducing unexpected curative maintenance resources

Alarms generated over time

- Evolving from dry insulation to wet insulation
- Degrading coating
- Increasing corrosion speed



Future developments

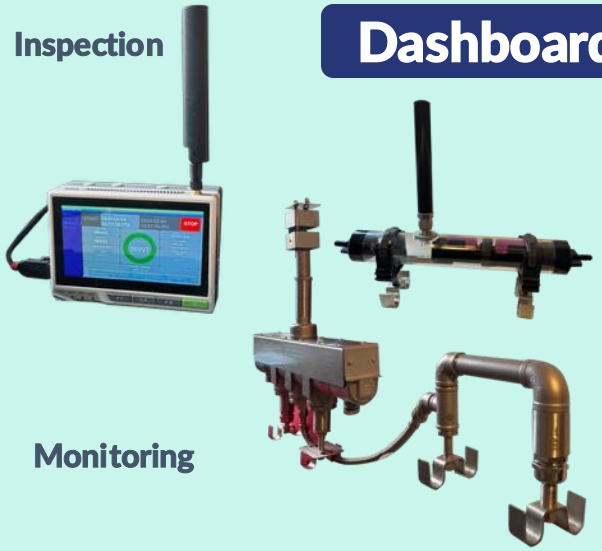
iSensPro provides an end-to-end solution using Coria©

Artificial Intelligence for Industrial Assets

iSens CUI Detection

Inspection

Dashboard



Monitoring

Technology y

Dashboard

Technology x

Dashboard

Raw Data

iCollect Asset Data

AI based Search engine

Dashboards database

Information Asset conditions

iLearn Asset Learning

Reinforced Learning

AI based Learning engine

Process Optimalisation

Alarms Actions & Feedback

Asset Owner Workflow

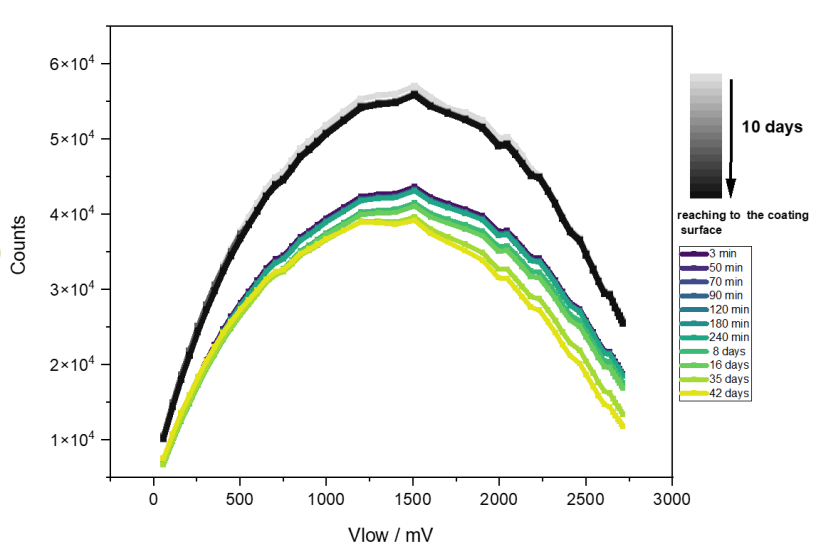
iKnow Asset Knowledge & Reporting

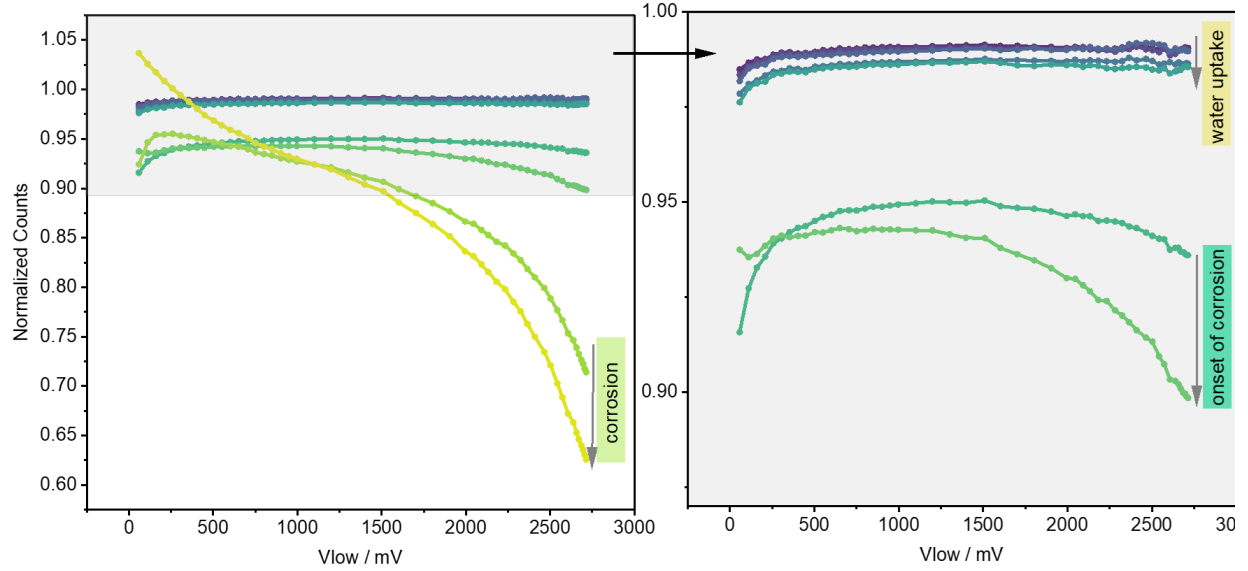
Finance | Safety | Sustainability | Operations | Planning | Purchase | Resource

Asset Owner BI

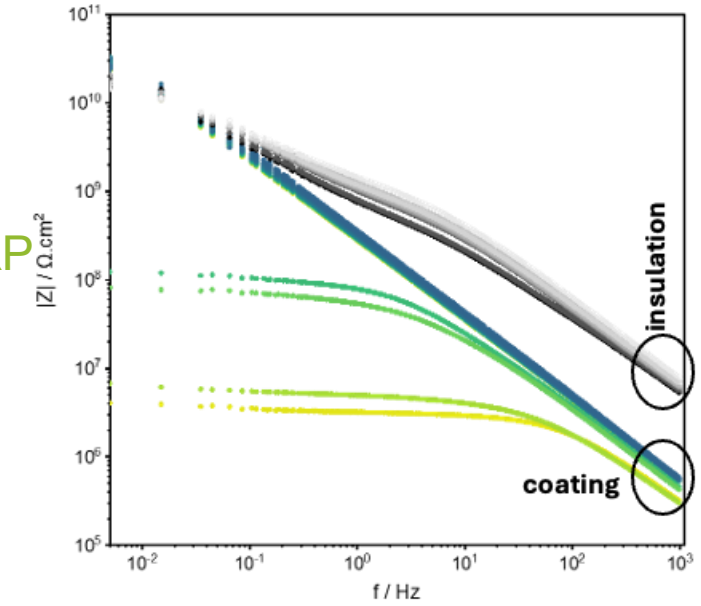
Evolution of insulation and coating

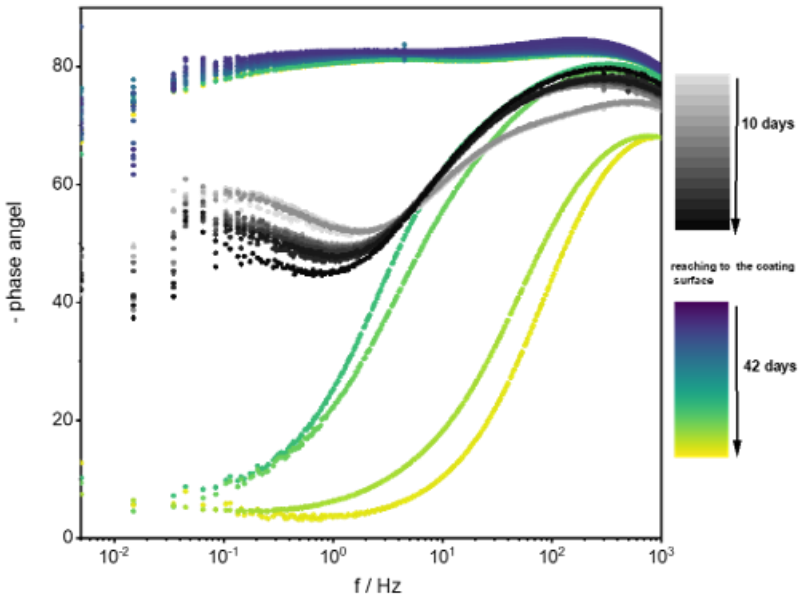
iSensPro





EIS-ORP





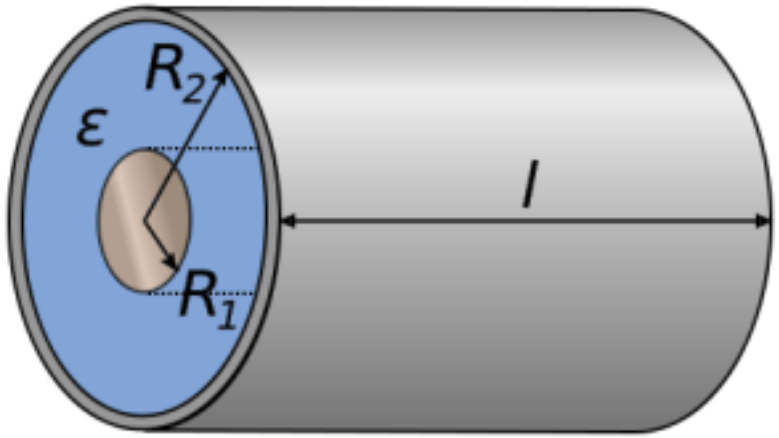
Comparison iSensPro – EIS ORP

➔ Differentiating conditions of insulation and coating in line with EIS

Performed by VUB-SURF

Any questions?

Capacitive measurement



Basic measurement principle
Pipe-Insulation-Cladding is considered as an electrical capacitor

ELECTRICAL CAPACITIVE MEASUREMENT

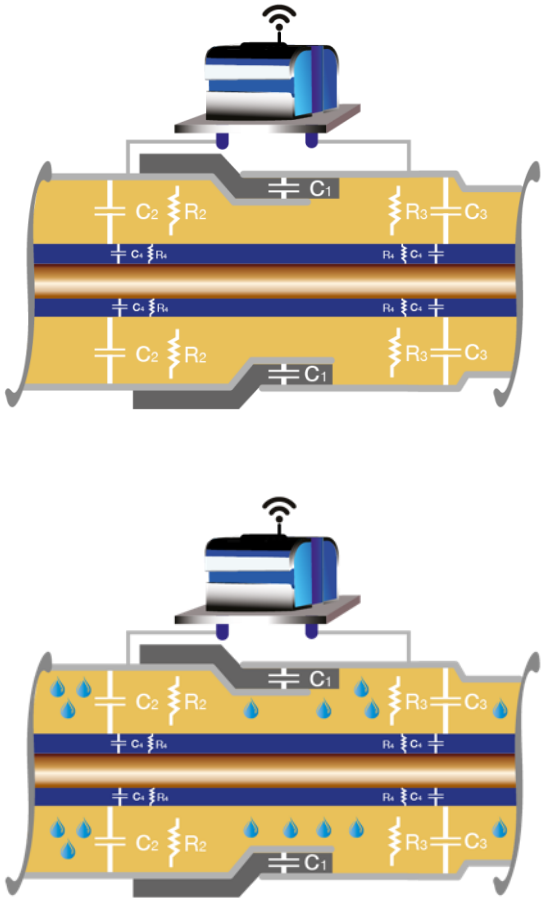
pipe	= electrode 1
insulation	= dielectricum
cladding	= electrode 2

$$C = \frac{2\pi\epsilon_0\epsilon_r L}{\log_e\left(\frac{R_2}{R_1}\right)} F$$

ε_r air	= 1
ε_r water	= 80

The capacitance value is influenced by presence of water

Mutual Capacitive Measurement



Practical set-up to avoid intrusion of cladding or insulation

MUTUAL CAPACITIVE MEASUREMENT

Cladding will be segmented (= electric disconnection)

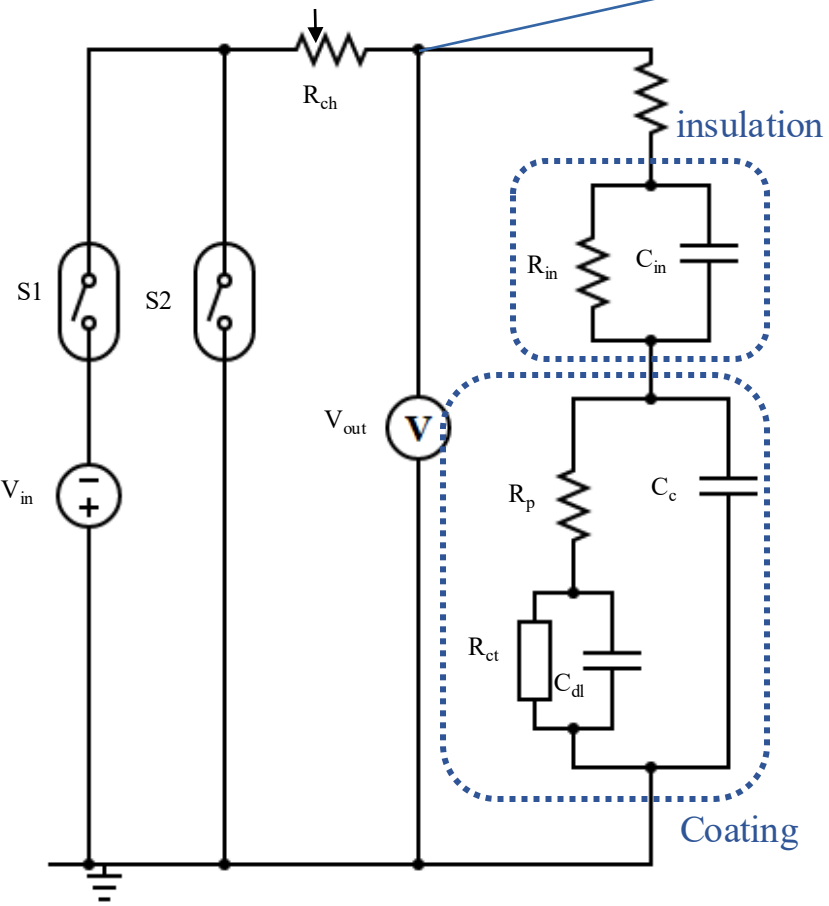
Capacitance is measured from left cladding segment over the pipe to the right cladding segment

The sensor will detect **moisture** when the insulation resistance is high
The sensor will detect **corrosion** when the total resistance is small

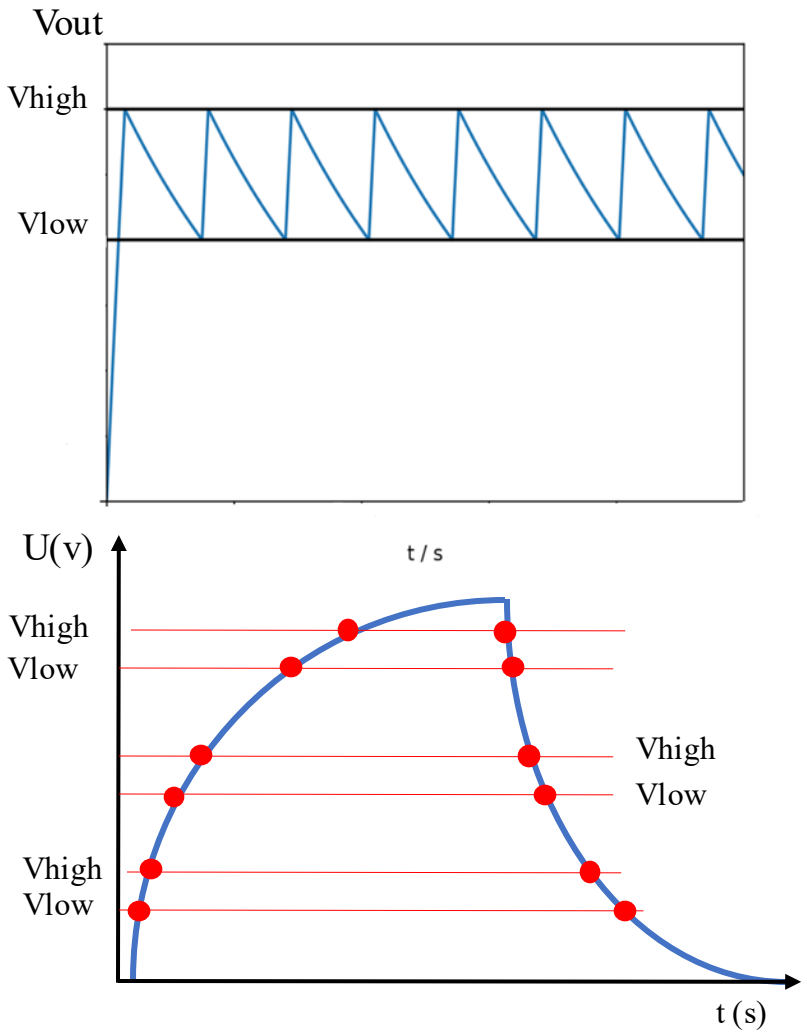
No dismantling of insulation is required

Theory of Sensor

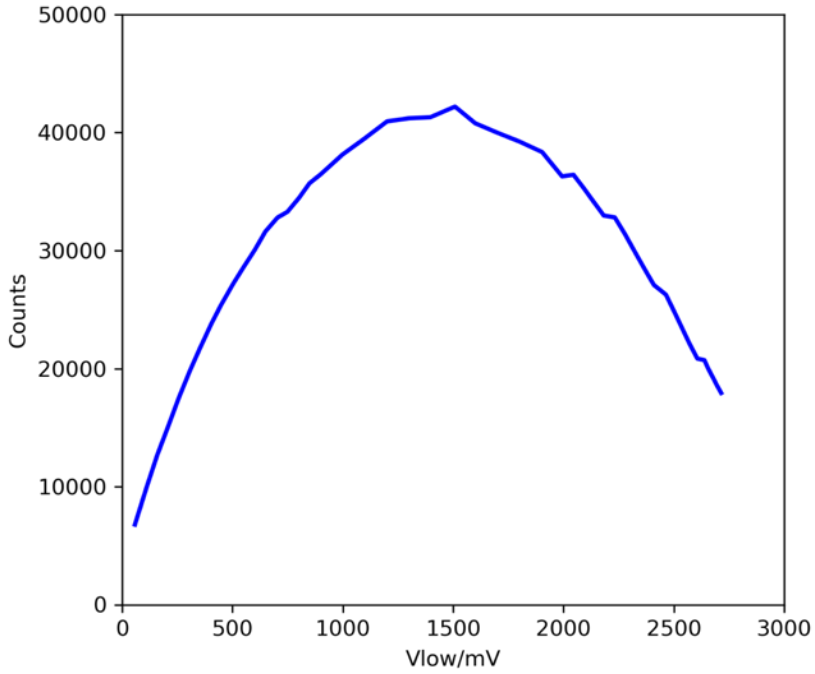
Sensor's electrical circuit



Measured signal



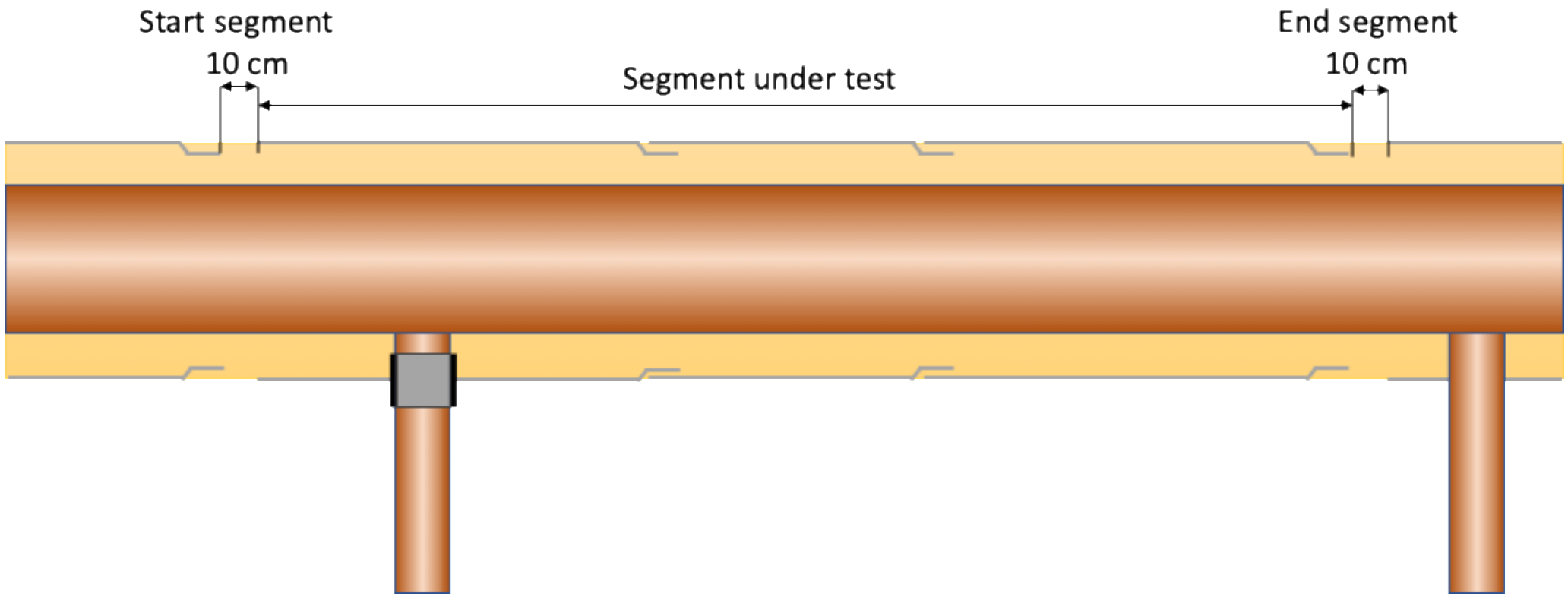
Sensor's output



Counts : Number of charging-discharging of capacitor as a function of Vlow during measurement time

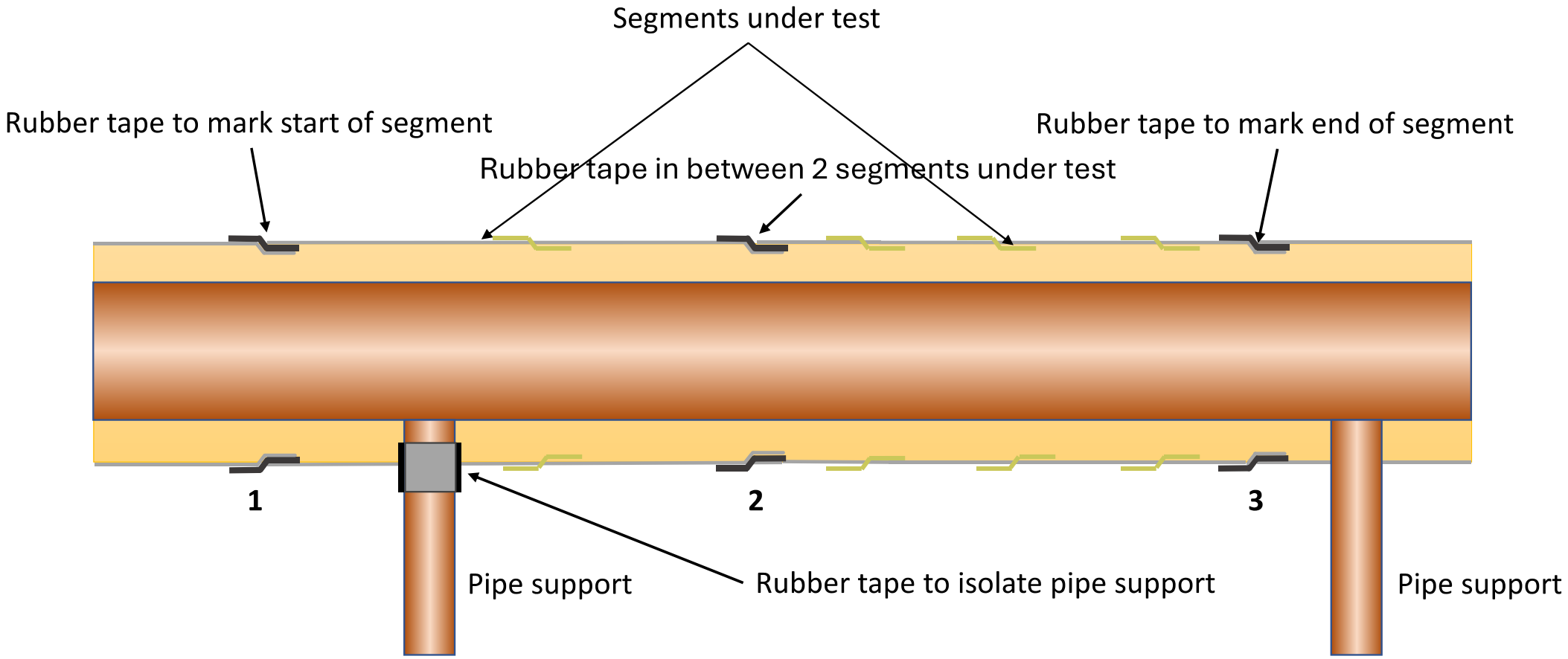
Segmentation for an inspection

Single segment measurement



Applying an open space between cladding elements (10 cm) to separate segments to be inspected from rest of installation.

Segmentation for a mutual segments' measurement



Applying a rubber tape between cladding elements to separate segments to be inspected from rest of installation.