



# MCMS

## Malux CUI Monitoring System

A complete solution for monitoring CUI risk.

**Malux**  
*solutions*

## DOCUMENT PROPERTIES

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## TERMS AND DEFINITIONS

<b>3GPP</b>	3rd Generation Partnership Project, an umbrella term for a number of standards organizations which develop protocols for mobile telecommunications
<b>ATEX</b>	Appareils destinés à être utilisés en ATmosphères EXplosibles, EU directives describing safety requirements for workplaces and equipment used in explosive atmospheres
<b>CirruSense</b>	Trisense's Industrial IoT cloud platform
<b>CUI</b>	Corrosion Under Insulation
<b>DNV-RP-G109</b>	Recommended practice for risk-based management of CUI
<b>Firmware</b>	Software embedded in physical devices
<b>Fusion</b>	Trisense's sensor product range
<b>IECEX</b>	International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres, international system for equipment used in explosive atmospheres
<b>IoT</b>	Internet of Things
<b>LTE-M</b>	Cellular wireless protocol optimized for low-power IoT
<b>MQTT</b>	MQTT is a lightweight, publish-subscribe network protocol that transports messages between devices.
<b>NB-IoT</b>	Cellular wireless protocol optimized for low-power IoT
<b>PoF</b>	Probability of Failure, defined by DNV-RP-G109 standard for risk based CUI maintenance
<b>REST API</b>	Representational State Transfer Application Programming Interface, a client/server architectural style typically used to connect components in microservices architectures
<b>SIM</b>	Subscriber Identity Module, used to identify and authenticate cellular network users

## CORROSION UNDER INSULATION

Corrosion under insulation (CUI) poses large economical, health and safety risks as unmitigated, it may cause catastrophic failures in insulated process piping. Vast resources are used to strip, inspect and re-insulate the piping periodically, with the assumption that the piping might have been exposed to water and hence under risk of CUI.

### CUI RISK MONITORING

Various inspection methods are employed to ensure that insulated piping is not compromised by corrosion. Some use complex and expensive measurement equipment. Others involve visual inspection, which require destructive removal and replacement of insulation. Certain sensor types need to be installed inside the insulation, hence can only be installed in greenfield or after removing insulation.



## THE TRISENSE CUI MONITORING SOLUTION

Trisense has developed a complete solution for monitoring CUI risk, consisting of the Fusion 310 CUI sensor and the CirruSense CUI cloud solution. Sensor data is transmitted using the 4G/5G cellular network, and the entire solution is offered on a subscription based (OPEX) model. The Fusion 310 CUI sensors can easily be installed in greenfield or brownfield deployments.

By using the solution to continuously monitor the piping, it is possible to determine whether water is present in the insulation, which is a prerequisite for corrosion to develop. The sensors and cloud solution collects and presents the current and historical states to give full insights on different aggregation levels.



The insights provided by continuous CUI risk monitoring can be used in several ways, leading to vast cost savings and safety improvements.

<b>Maintenance and inspection optimization</b>	Re-insulate and inspect only high risk assets
<b>Proactive maintenance</b>	Avoid corrosion by early detection and repair, confirm successful mitigations
<b>Improving and learning</b>	Correlate cladding damages to work operations, understand water propagation behavior

## UNIQUE BENEFITS

### CUI RISK MONITORING

- No extra communication or power infrastructure needed
- Efficient mounting by self-drilling bits or integrated fixation device
- 10+ years of battery life
- Automatic configuration, rapid deployment
- Subscription covering sensors, connectivity, analysis, and sensor health monitoring

### POWERFUL

- Powerful and intuitive data analysis and presentation
- Intelligent sensors with state-of-the-art processors
- Secure communications and solutions
- Connectivity solution supporting dense population of sensors

### TIME SAVING

- Full insights from cloud solution
- Probability of Failure analysis aggregated on asset level
- Automated reports of CUI risk overview (future)
- E-mail alerts on events such as new water intrusion or change in Probability of Failure level (future)

## FUSION 310 CUI SENSOR

The sensor continuously monitors humidity and water presence inside the cladding of insulated piping using a relative humidity and temperature sensor element, in addition to a separate capacitive direct water presence detector. By combining two detection methods and having a battery life of above 10 years, the sensors give confidence in understanding the current and historic state of the piping. The sensor is Ex-certified zone 0 for hazardous areas.

### MOUNTING AND INSTALLATION

Sensors are configured and connected to the cloud from factory. Installation is done in three simple steps, and the order may be adapted if needed.

1. Define assets and measurement points in CirruSense cloud
2. Mount sensor in pre-drilled hole or using integrated drilling and fixation device
3. Scan QR code with app to associate sensor with measurement point


Sensors will be installed along piping stretches to be monitored, with a typical sensor distance of 1 meter or more, according to piping complexity and risk.

The sensors come with an integrated fixation device, and the only requirement is a pre-drilled hole of Ø12-Ø15 mm for ease of installation. Later editions of the sensor may come with an integrated drilling and fixation device, prepared for semi-automatic or robotic installation. This will save on installation costs.



## SPECIFICATIONS

A summary of typical values are stated below. Please refer to separate datasheet for most detailed and up to date specifications.

<b>Calibration and configuration</b>	From factory, no user intervention required
<b>Communication</b>	Cellular IoT (4G/5G LTE-M and NB-IoT)
<b>Operating temperature range</b>	-40 to 120 °C
<b>ATEX/IECEX temperature range</b>	-40 to 80 °C
<b>Relative humidity range</b>	0 to 100% RH
<b>Relative humidity accuracy</b>	± 5% RH
<b>Temperature accuracy</b>	± 0.5 °C
<b>Humidity response time</b>	10 s (t @ 63% - valid at 25 °C and 1 m/s airflow)
<b>Temperature response time</b>	15 s (t @ 63%).
<b>Expected battery life</b>	Above 10 years. Cellular coverage, ambient temperature, physical environment, and configuration may affect the actual battery life.
<b>Certifications</b>	Atex/IECEX:  II 2G Ex ia IIC T4 Gb -40°C≤Ta≤+80°C Presafe 20ATEX77641X IECEX PRE 20.0093X








## CIRRUSENSE CLOUD PLATFORM

Every measurement is gathered in the CirruSense cloud platform, for long-term storage and analysis, as well as real-time presentation. Multiple sensors are grouped by the asset they monitor, typically a piping section. Assets can be organized into different locations. The data is presented by different perspectives and detail levels as shown below.

Enterprise integration may be provided through industry standard protocols such as MQTT or REST APIs.

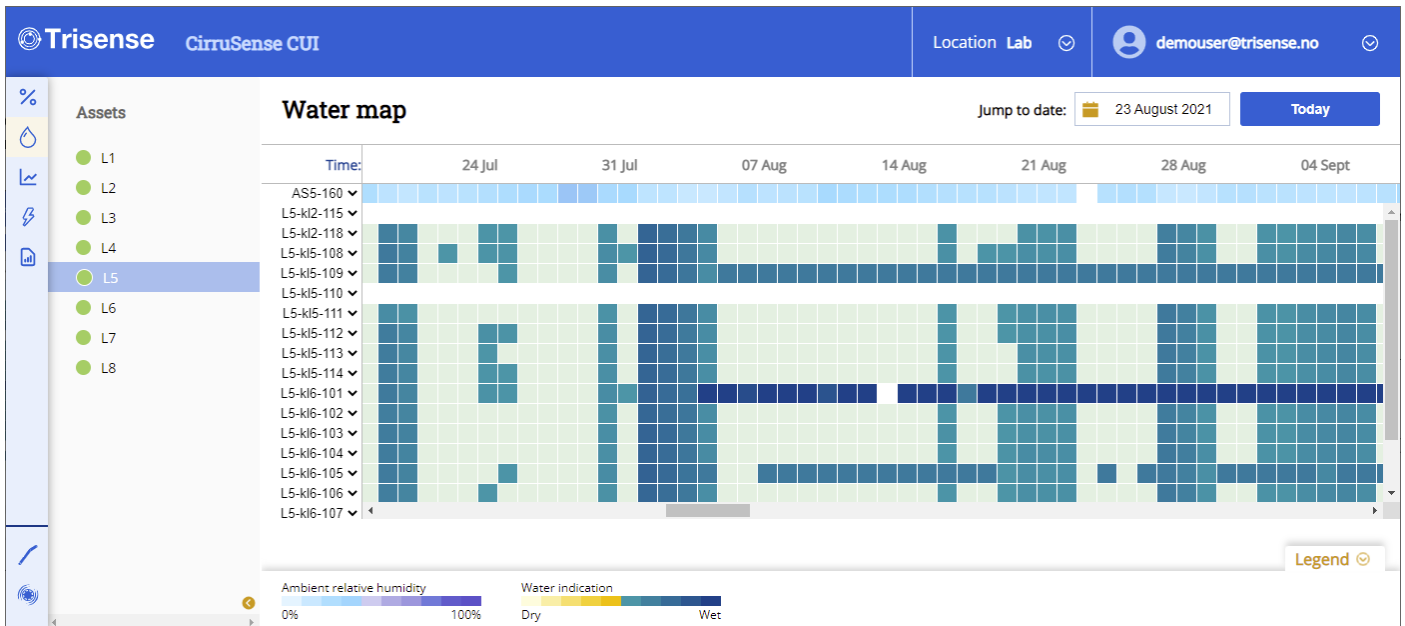
### PROBABILITY OF FAILURE

The top level view is an aggregated Probability of Failure (PoF) due to water wetting per asset. The individual PoFs for every measurement point (sensor) can be shown in the next level. A color bar shows the historical changes. It is possible to drill down to the water map from here.

Trisense CirruSense CUI					Location Lab	demouser@trisense.no
Probability of Failure						
Asset: L5						
Measurement point	PoF	Wet days	Age	Search	Clear All	
Measurement point	Probability of Failure (water wetting)	Wet days	Age (days)	PoF over time	Water map	
L5-kl10-117	Very high	304	418		Water map	
L5-kl10-120	Very high	133	418		Water map	
L5-kl2-118	Very high	112	418		Water map	
L5-kl5-108	Very high	243	418		Water map	
L5-kl5-109	Very high	279	418		Water map	
L5-kl5-111	Very high	214	418		Water map	
L5-kl5-112	Very high	242	418		Water map	

## WATER MAP

The water map shows development of water wetting both in time and space. Colors indicate normal dry conditions (light green), or wet conditions (blue). This gives great insights on how water propagates. The next level of drill-down is graphs of measurement time series.



## GRAPHS

For the most detailed view, graphs of every measurements are available.



## SENSOR MANAGEMENT

Every sensor's health metrics such as connectivity parameters, battery life, and errors are reported to the cloud. Parameters can be remotely changed to optimize battery life and performance. Sensor operation and management is included in the subscription.

## CELLULAR IOT COMMUNICATIONS

LTE-M and NB-IoT are cellular IoT (cloT) protocols optimized for large-scale IoT applications with long battery life. The protocols are developed by 3GPP as part of the 4G and 5G standards. Cellular connectivity gives tremendous benefits for industrial IoT applications, as described in the sections below.

### NO LOCAL INFRASTRUCTURE

Instead of deploying gateways requiring power and connectivity infrastructure, every sensor is directly connected to a cellular base station. This greatly simplifies deployment, and moves the burden of maintaining infrastructure to the cellular operator.

### POWERFUL

Bidirectional communication in Megabit range fulfils today's expectations of capabilities such as remote firmware upgrades and configuration.

### SCALABLE

The cloT technologies are designed to support hundreds of thousands to millions of devices per km<sup>2</sup> in order to be recognized as 5G capable. Alternative wireless communications may experience large issues with contention and interference on much less dense deployments.

### LOW POWER

cloT has been designed to use as little power as possible, and allows sensors to stay offline until they decide to transmit.

### RELIABLE

cloT uses licensed frequency spectra, where unauthorized use is subject to prosecution. Every sensor adheres to the frequency and time slots allocated by the base station. By deploying sensors using unlicensed bands such as Bluetooth, LoRaWAN or proprietary solutions (e. g. on 868 MHz), the frequency planning becomes the responsibility of the plant operator, and there is always a risk of new wireless equipment blocking communication of existing equipment.

### FUTURE PROOF

As NB-IoT and LTE-M are already accepted into the 5G technology family, they will be maintained and supported in the future.

### SCATTERED

Long range and deep coverage enables monitoring of equipment in remote and difficult locations.

### FLEXIBLE

Sensors can connect to regular base stations, enabling connectivity out of the box. However, it is also possible to deploy private 5G infrastructure in various combinations with public infrastructure, or completely isolated if required.

## CYBER SECURITY AND ROBUSTNESS

Security has been a key element in all development activities of the Fusion sensor range and CirruSense cloud platform. Third party security expertise has guided and reviewed the process, and threat modelling and assessments have been performed to discover and mitigate any weaknesses.

The sensors are designed to be inherently secure, so they can connect to public base stations. Every sensor has a unique encryption key to ensure authenticity and confidentiality in all communications. Firmware updates need to be cryptographically signed in order to be accepted by the sensors.

Although it is not deemed necessary, mobile operators can optionally provide additional private solutions where the network is isolated between the sensors and cloud platform, as an extra layer of security.

## SUBSCRIPTION MODEL AND PLANS

Trisense offers our Industrial IoT solutions on a subscription model adapted to the process industry. This business model eliminates expensive capital expenditures (CAPEX) costs from the end customer balance sheet and transitions it into a much more manageable and predictable operational expense (OPEX).

Our subscription plans are adapted to the customer's needs and includes everything needed for hassle-free operations during the subscription period.

### CIRRUSENSE BASIC

CirruSense Basic is the base plan, providing monitoring as a service, as well as basic storage and visualization.

- Sensor hardware subscription
- Cellular connectivity
- Measurement storage (three months with full detail, entire history with aggregated data)
- User interface with time-series graphs
- CSV export of time series (future)
- Sensor health monitoring (Trisense monitors and proactively initiates corrective actions)

### CIRRUSENSE CUI

CirruSense CUI adds domain specific analysis and presentation, giving the best insights on your assets.

- Includes everything in CirruSense Basic
- Measurement storage (full detail in entire history)
- Water wetting estimation, presented in Water map
- Probability of Failure due to water wetting estimation (DNV-RP-G109)
- Downloadable reports (future)
- Event detection and alerts (future)
- Plant map (future)

### ENTERPRISE INTEGRATION

Enterprise integration enables automatic transfer of measurements and analyzed data to the customer's own platform.

- Integration via MQTT/REST API
- All domain specific analysis in addition to raw values can be exported