

IOW Analysis with Installed UT Sensors: How Process Changes Impact Corrosion Rates

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ABSTRACT

Installed UT sensors can provide better visibility around how, when, and why corrosion is happening in assets and allows people to track and monitor with extremely high precision (.001"). Owner operators can then overlay corrosion rate data with process data to analyze Integrity Operating Windows (IOWs) and help them better understand how to most efficiently and safely operate their assets and either remediate or extend their useful life, thus moving from a time-based maintenance interval to that of a predictive based interval. This paper will cover a real-life example of how an owner operator has used permanent or temporarily installed wireless UT sensors to monitor problematic areas, track remediation tactics, and verify the ramification of operational changes.

Key words: Corrosion, Ultrasound, Permanently Installed Monitoring Systems (PIMS), Wireless Sensors, Ultrasonic Thickness (UT), Monitoring, Asset Integrity, Internet of Things (IOT).

INTRODUCTION

Many asset owners struggle to identify the root cause of fluctuating corrosion rates due to unreliable inspection data. Facilities worldwide are tasked with monitoring thousands of Condition Monitoring Locations (CMLs) with established NDE techniques such as manual ultrasonic testing and radiography. While these techniques can provide valuable "snapshots" of the condition of particular locations, limitations and inherent errors can compound leading to ill-advised decision making. Manually taken thickness data can vary greatly and result in unwarranted complacency or excessive and costly inspections. Utilizing long range wireless continuous monitoring systems have drastically improved operators understanding of how process changes influence corrosion rates. Installed UT sensors provide

near real-time data with a 0.001" accuracy. This influx of data provides a trend line whereas with manually taken data, sometimes only taken a few times a year, only provides a few points on a graph. Asset owners have realized they can use this wealth of new information to validate and discover the effects of operational changes on corrosion rates.

Remote systems supplement piping inspection programs by providing accurate, repeatable data. After locating areas of interest with other established inspection techniques such as manual UT or AUT, remote systems can be used to confirm corrosion rates and help make well informed decisions about the remaining life of stationary equipment. When these systems confirm the absence of corrosion activity at a particular CML, inspection resources can be reallocated to higher risk locations. By helping locate areas of higher and lower likelihoods of corrosion, inspection resources can be optimized while simultaneously decreasing the overall risk of unexpected equipment failure within a unit.

Another way that facilities are improving reliability is by using installed UT sensors in combination with Integrity Operating Windows (IOWs). These operating windows are meant to act as boundaries in which operating parameters can be controlled to minimize equipment damage. Usually, these targets or limits are set according to industry best practice. However, these industry guidelines are often based off laboratory studies that do not always have a directly correlate to field experience. Installed UT sensors can help bridge this gap by correlating unit specific process data to real-time corrosion data. With this knowledge, unnecessary unit constraints can be avoided and replaced with realistic operating windows.

Installed Ultrasonic Sensors

Similar to manual ultrasonic thickness gauging, installed UT sensors utilize the same ultrasonic principals. Ultrasonic waves are sent through the material, given the time it takes to travel through the material and the material velocity, the distance (thickness) can be determined.

(1)

$$\text{Equation: } T = V \times t/2$$

Where

T = Thickness

V = Material Velocity

t = Time

However, the technique is fundamentally different in that the transducers and instrumentation are deployed permanently or semi-permanently with automatic data backhaul. This addresses several of the shortcomings of existing manually deployed solutions. Some of the major differences are as follows:

Instrumentation and probes are deployed on the asset in a permanent or semi-permanent fashion and can be accessed remotely, thus the cost of access is reduced over time and operators are not deployed to the point of the inspection. Once the instrumentation is deployed, data can be remotely accessed via the Internet or on-site server.

Due to the fixed transducer position and instrumentation, operator-to-operator, probe-to-probe, and instrument-to-instrument variability is eliminated. This removes significant sources of error and allows for improved measurement resolution, precision, and accuracy which is particularly important for corrosion-rate trending and asset management.

Data can be collected on a more frequent basis (>1X per day) for automated systems. This allows for more accurate corrosion-rate trending through statistical data analysis of varying operational parameters such as temperature fluctuations, feed change, transient conditions, etc.

The system can be deployed with an integrated temperature measurement device so that changes in material acoustic velocity due to temperature variation can be automatically removed from the measurement, thus eliminating another significant source of error.

The data is easily accessible. Wireless installed sensor systems can make use of various forms of data backhaul including the plant's wired or wireless intranet, industrial wireless networks, satellite, or cellular networks for remote collection points, allowing real-time data/asset health availability.

The data is more easily managed. While most historians are not set up to handle the amount of data that installed UT sensors provide, most come with proprietary software that provides corrosion rate trending and analysis, either on the web or locally.

Sensors can be installed while operations are live, even on high temperature piping, therefore avoiding costly downtime. The sensors are usually attached using stainless steel clamps, magnetic bases, or welded studs.

Installed sensors are intrinsically safe and can handle extremely corrosive and harsh environments such as offshore platforms.

Internal checks are performed at every reading cycle ensuring the validity of the measuring circuitry. Furthermore, the majority of error associated with ultrasonic thickness measurement is the wear and or acoustic change of the measuring transducer. Because installed UT sensors are permanently affixed and use acoustically stable materials over the specified temperature ranges, measurement errors associated with the transducer fall well within the specified measuring error.

Current temperature limitations for installed sensors ranges from -40 degrees C/F up to 1,100 degrees F (593 degrees C).



Figure 1: Wireless UT Sensors Installed on Refinery Assets

LoRaWAN Wireless Communication

LoRaWAN (Long Range Wide-Area Network) is a wireless technology based on the LoRa standard and governed by the LoRa Alliance. The advantage of LoRa is primarily in the technologies long range and

low-power capability. A single gateway can handle thousands of sensors over an area of several square miles. Both LoRa-compliant and proprietary LoRa-based technologies are available in the market for the purpose of connecting end devices to the Internet of Things (IoT).¹

For corrosion/erosion monitoring in facilities, this technology has the primary advantage of being able to deploy thousands of battery powered sensors, covering thickness monitoring locations (TMLs) over a mile in industrial settings from a gateway and antenna. Due to the multi-directional technology and lower frequency the sensors do not need to have line of sight to the gateways, meaning multiple process units, and sometimes the entire facility can be covered by a single gateway. Furthermore, the STAR network topology allows for predictable, long battery life because the individual sensor nodes are not required to relay sensor data, in contrast to MESH network technologies such as Wi-HART and ISA100. Because the gateway is capable of connecting to and using available third-party cellular networks, it avoids the problems associated with installing hardware on the plant IT infrastructure. Overall, this allows for an easy and low-cost installation of the technology with a wide deployment footprint. Thus, allowing asset owners to realize the economic scalability in deploying not just a handful of sensors, but sensors by the hundreds or thousands and thereby moving from a manual time-based maintenance interval to that of an automated predictive-based model.

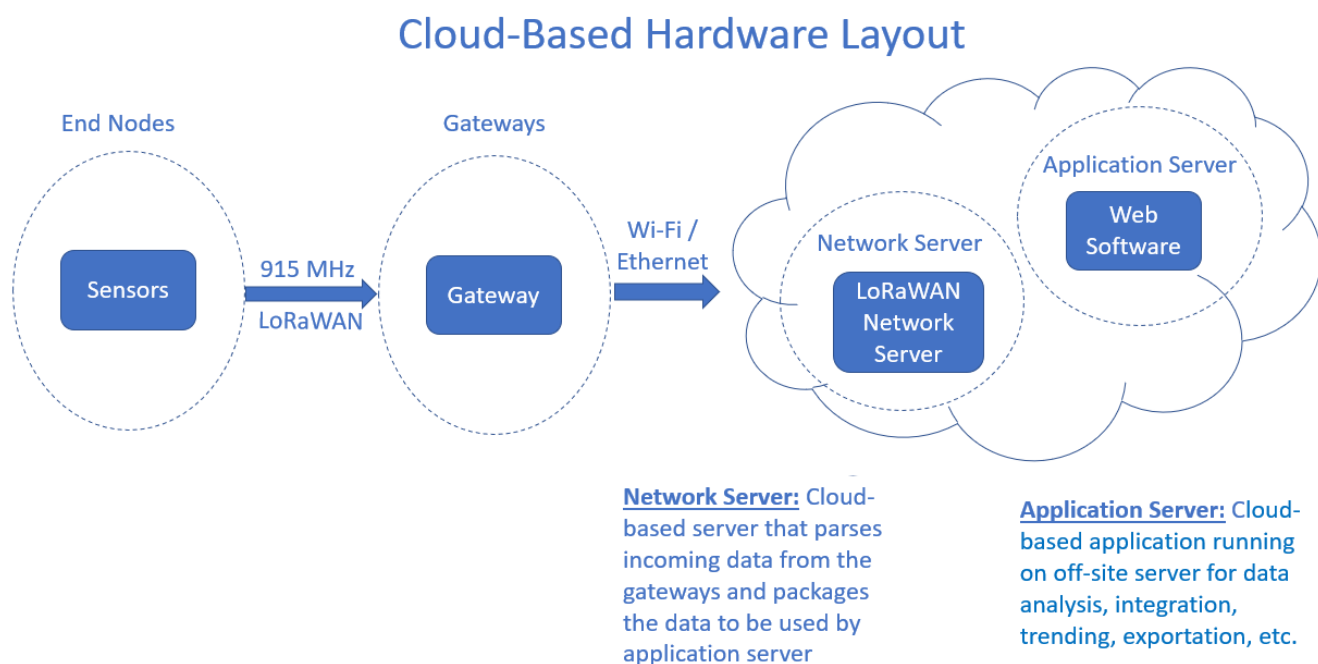


Figure 2: Cloud-based layout of LoRaWAN network

In contrast to the cloud-based application there is also the option of an on-premise solution which keeps all data inside the fence. Due to strict IT policies some customers prefer this option which provides improved security. This layout utilizes the same sensor-to-gateway infrastructure, but the data is then sent to a local server via Wi-Fi or Ethernet and can be viewed on a locally installed web browser.