Whitepaper

Introduction to the Ferro One sensor system

A brief explanation of how the Ferro One sensor system is used to permanently detect crack growth in steel structures

VILLARI

Fatigue cracks and manual inspections

Heavily loaded steel structures such as large highway bridges, overhead travelling cranes, or ship to shore cranes will risk fatigue cracking when they reach end-of life. This occurs due to cyclical heavy loading patterns over the course of their design life. To keep these vital assets safe, inspections are performed frequently to ensure crack growth is occurring within the acceptable rate. If unacceptable crack growth is detected, inspection intensity may be temporarily increased until repairs can be made to prevent further dangerous material fracture.

Detecting cracks on steel structures has, until now, been a matter of manual labor. It requires highly skilled personnel that is equipped with specific crack detection equipment. These types of inspections are referred to as Non-Destructive Testing or NDT.

Examples of popular NDT methods are magnetic particle inspection, die penetrant inspection, and ultrasonic testing. They are technologies based on different physical principles (capillary action, magnetism, and sound waves respectively) that provide a snapshot of cracks in the material at a specific point in time. By returning for a follow-up inspection at a later point in time the asset owner is informed of the development -or absence of- crack growth.
The critical areas that require inspection are often hard to reach and frequently require the use of aerial platforms or rope-access to be inspected. This substantially increases the complexity of the inspection operation leading to longer asset downtimes, more personnel on-site, and overall increasing inspection expenditure.

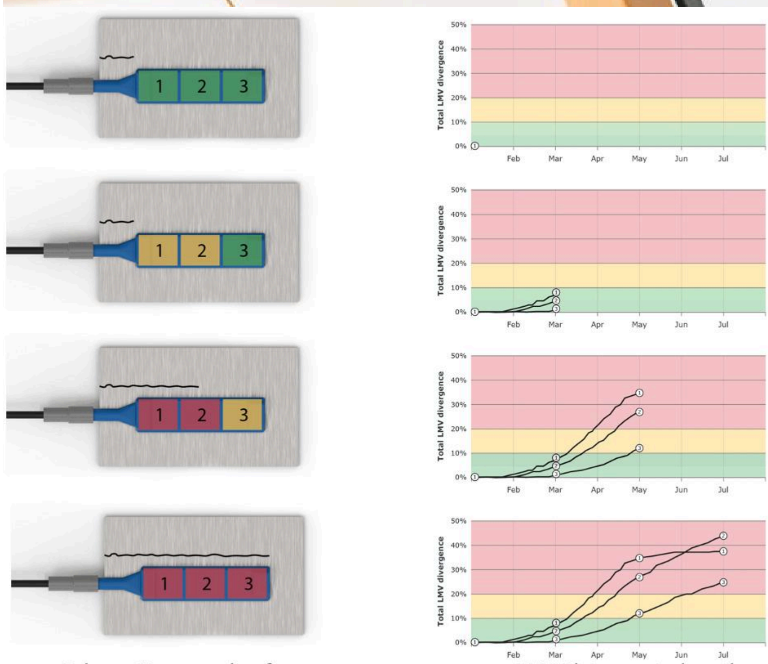

Figure 1 Inspection using Non-Destructive Testing (left), and hard to reach locations often require an aerial platform (right).

Ferro One System

Ferro One sensor system is a highly-advanced monitoring system for detecting local crack growth in steel structures with permanently installed sensor probes. They allow assets to be monitored continuously without human intervention. The key system characteristics are summarised below:

- LoRaWAN Wireless Module
- IP66, UV-resistant, built for harsh environments
- Operates from -40C to +80C
- 5-min probe installation
- Supports 20 probes per unit
- 6–96 measurements/day
- 5-year battery life
- Globally deployable

The sensor system consists of two parts: the transmitter which contains the batteries, a wireless communication module, and a processor. The transmitter is attached away from the crack detection area using magnets at the bottom of the unit and additional fastening straps. The control unit powers on every few hours to obtain crack detection measurements from the sensor probes, send these wirelessly to our office, and go back to sleep mode afterwards. The sensor probes consist of an array of magnetometers that collect magnetic field data at distinct points in time. Variations in this magnetic field data are picked up by our extensively tested algorithms and reported back to the customer as potential crack growth.

Due the fact that measurements are taken multiple times per day, cracks can be detected in a much earlier stage than with conventional methods, making it a very suitable warning system capable of flagging potential crack growth long before it becomes problematic.

Sensor probes are available in two options: a rigid 70 mm sensor probe and a flexible 500 mm sensor strip used to cover more distance and cover a longer surface. A maximum of twenty sensor probes can be attached to a single control unit. The data is securely transmitted using LoRaWAN, which is a protocol ideal for long-lasting and low-power monitoring applications such as the Ferro One System. More on LoRa can be found in the following link: https://www.actility.com/what-is-lora-and-lorawan/. Ferro One System can be deployed globally.

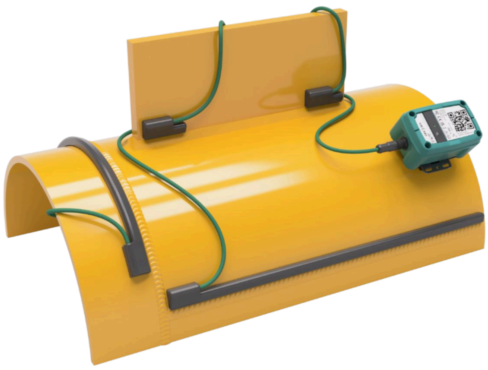

Figure 2 Transmitter and rigid and flexible sensor probes.

Crack detection area

Villari's sensor probes are capable of detecting crack growth at an early stage, comparable with some of the most advanced NDT technologies currently in the market. This holds true for a three-dimensional region around the probe with a radius of 15 mm which we define as the crack detection area.

This crack detection area enables a single probe to detect crack growth near one weld toe, while simultaneously detecting crack growth at the opposite weld toe and detecting crack growth from the root of the weld (sub-surface). This is schematically drawn in the figure below.

Crack length increase of more than 5 mm is certified detectable with our sensor probes, comparing us with Phased Array Ultrasonic Testing and Time-of-Flight Diffraction in terms of detection capabilities. Outside of the crack detection zone, cracks can be detected at a slightly later stage than within the zone. More information on crack detection capabilities can be provided upon request.

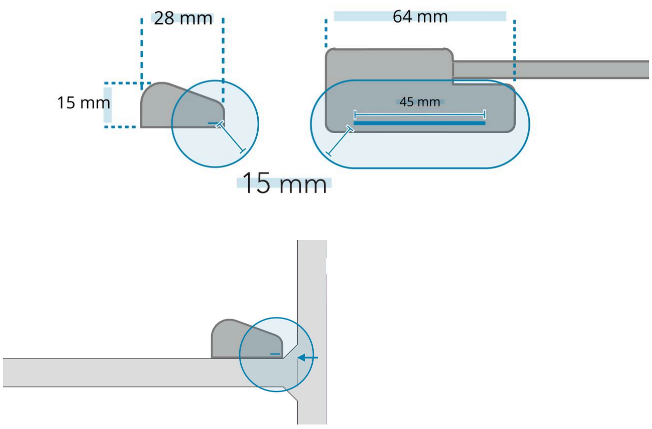

Figure 3 A rigid sensor probe with a detection area of 75mm (left), and a flexible sensor probe with a detection area of 500mm (right), used to cover a larger area. Sensor probe placed close to a fillet weld (bottom).

Disclosure of analysis results

The crack detection algorithm output for each sensor probe is automatically updated into an online dashboard environment which can be accessed from anywhere with an internet connection.

From a clear overview page, a technical drawing of the assets shows the locations of the installed sensor strips. With a traffic light color coding system the customer is informed of potential crack growth activity occurring at each monitoring location. Green zones indicate an absence of crack growth activity near the strip, yellow zones indicate an increasing likelihood of crack growth, and red zones tell the customer that there is a significant chance of crack growth occurring near the strip. The analysis outcome of all strips on an entire asset is shown, which provides a direct insight into the status of crack growth activity on the entire asset in a quick overview

Examples of installed sensors, analysis output, and how trends over time are analyzed to detect potential crack growth or indicate an absence of crack growth on a variety of different assets and structural details is available upon request.

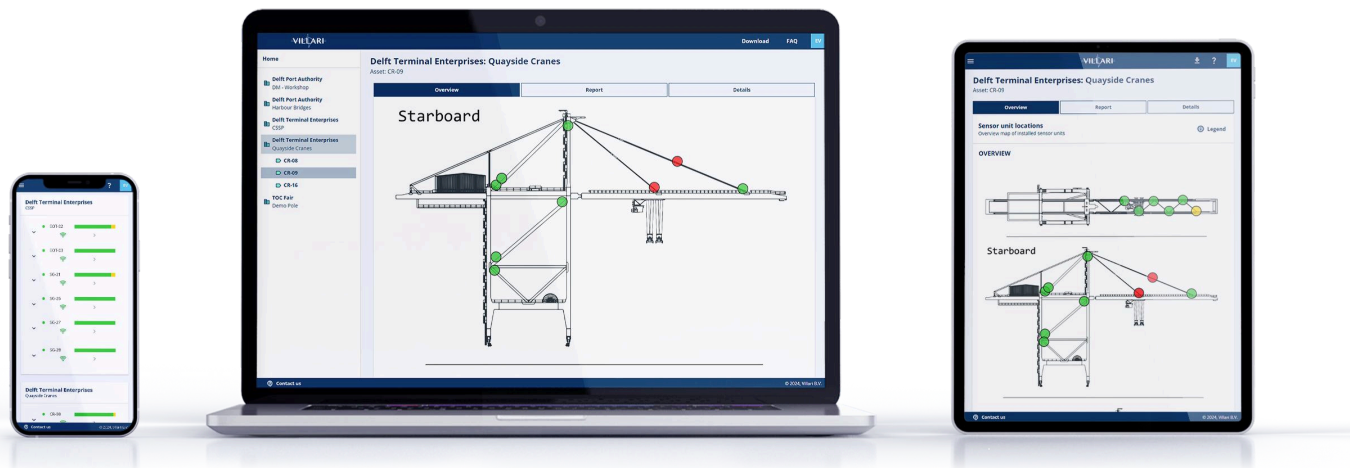

Figure 4 The Villari dashboard provides insights into crack growth from any device.

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Talk to one of our experts today

Are you ready to take your asset management and maintenance strategy to the next level?

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