System guide

Introduction to the Villari sensor system

A guide explaining how the Villari sensor system detects and measures crack growth in steel structures

VILLARI

The traditional way of measuring fatigue in steel structures

Heavily loaded steel structures such as large highway bridges, overhead travelling cranes, or ship to shore cranes will **risk fatigue cracking** when they approach their end-of-life or just by being exposed to varying load cycles for extended periods of time.

To keep these vital assets safe, **periodic inspections are performed.** In case these inspections find signs of fatigue, for instance cracks, **inspection frequency may be temporarily increased until repairs** can be made to ensure the safety of users and prevent further dangerous fractures.

Detecting cracks on steel structures has, until now, been **a labor intensive process**. 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** include magnetic particle inspection, dye penetrant inspection, and ultrasonic testing**.** These 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.** During a follow-up inspection, the asset owner is informed of the development or absence of crack growth.

It is important to note that most **critical areas that require inspection** (and are most exposed to fatigue) **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** process leading to longer asset downtime, more personnel on-site, and higher inspection costs.

The Villari system

The Villari sensor system leverages an advanced method for detecting local crack growth in steel structures by monitoring passive magnetic flux leakage and plastic deformation (the "Villari effect"). Using the LoRaWAN network, the information becomes accessible via a safe, online dashboard and gets translated into actionable insights.

System components:
The Villari system consists of 3 key components:

1. Wireless sensor system
2. Intelligent algorithms
3. User-friendly dashboard

1. Wireless sensor system

At the heart of the Villari solution lies the wireless sensor system. Each unit consists of **a compact transmitter and** a maximum of 20 **sensor probes** connected per transmitter**.** These together form a durable, and zero-maintenance monitoring setup, that can **last for at least five years** without any human intervention.

Figure 1 The Villari wireless sensor system

The transmitter houses the batteries, wireless communication module, and processor, and is easily mounted using magnetic bases and fastening straps. It **activates periodically to collect data** from the sensor probes, **transmits the measurements** securely to Villari's cloud environment **via the LoRaWAN network**, and then switches back to low-power sleep mode thereby ensuring long battery life.

The sensor probes, available as either a rigid 75 mm probe or a flexible 500 mm sensor probe, **measure changes in the magnetic field** at the most critical points of the steel surface. Variations in this magnetic field data are picked up by our extensively tested algorithms and reported back to you if it can be an area of concern. Because measurements are taken several times a day, the system provides an early warning long before issues become critical.

Crack detection area

Villari's sensor probes can detect crack growth at a very early stage, comparable only to the most advanced NDT technologies available today. **Each probe detects crack growth in a three-dimensional region** with a radius of approximately 15 mm, referred to as the *crack detection area*. Within this zone, a single probe can detect crack growth near one weld toe, at the opposite weld toe, and even from the weld root (sub-surface). This capability is illustrated schematically in the figure below. Crack length increase of more than 5 mm is approved as detectable by the Villari sensor probes, placing their performance on par with Phased Array Ultrasonic Testing (PAUT) and Time-of-Flight Diffraction (TOFD) methods. **Outside the defined detection area, cracks can still be identified,** typically at a slightly later stage than those within the detection zone or with slightly less precision.

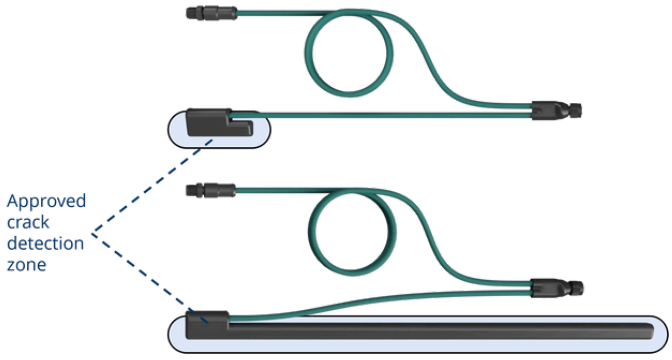


Figure 2 A rigid sensor probe with a detection area of 75 mm (above), and a flexible sensor probe with a detection area of 500 mm (below), used to cover a larger area. Typically when the sensor probe is placed close to a fillet weld.

Key system characteristics:

- LoRaWAN wireless module
- IP66, UV-resistant, built for harsh environments
- Operates within a temperature range of -40 °C to +80 °C
- A transmitter supports 20 sensor probes
- The system collects 6–96 measurements/day
- Installation per sensor takes less than 5 minutes
- 5-year battery life
- DNV type approved

2. Intelligent algorithms

Our **intelligent algorithms** are tailored to your specific use case, **analyzing variations in the magnetic field response** of steel structures to detect the earliest signs of fatigue and crack growth.

Meticulously tested and approved, they bring a level of precision traditionally reserved for periodic inspections with advanced ultrasonic methods into a continuous monitoring service, which is capable of identifying structural changes well before they result in failure.

With this shift from schedule-based to condition-based monitoring, you gain not only earlier warning but also **actionable insight to plan repairs** when they're needed and thereby avoid over-maintenance and unscheduled downtime.

Figure 3 Algorithms analyzing the magnetic field response

3. User-friendly dashboard

T**he Villari dashboard gives you a continuous view of crack growth**, making complex structural data easy to understand and act on.

The user-friendly interface links **sensor data, trend analysis and automated alerts,** enabling stakeholders to visualize fatigue progression, prioritize interventions and integrate findings with existing reports.

Using a **traffic light color-coding system, customers are informed about potential crack growth activity** at each monitoring location. A green status indicates no signs of crack growth near the sensor strip, yellow signals an increasing likelihood of crack development, and red alerts the user to a significant probability of active crack growth in the monitored area.

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

Summary

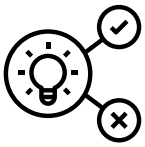
Villari's wireless sensor system continuously monitors steel structures for fatigue and crack growth, turning inspection from a manual, periodic task into a fully data-driven process. **Using magnetic field analysis**, intelligent algorithms, and an intuitive online dashboard, **it provides early warnings long before issues become critical.**

With continuous insights instead of periodic snapshots, asset owners can:

Increase uptime

Optimize repair and maintenance planning

Improve inspection accuracy



Extend asset lifetime

Reduce environmental impact

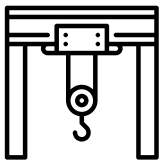
Together with our partners, we operate in industries as diverse as ports and terminals, steel manufacturing, infrastructure, offshore, wind energy, and even entertainment.

From reducing downtime on cranes to extending the life of bridges or monitoring unique steel structures, Villari's technology adapts to any environment. Ultimately, if it's made of steel, we can monitor it, no matter the industry.

Proven and deployable globally.

Ports

Oil & Gas



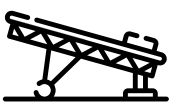
Manufacturing

Infrastructure

Offshore

Energy & Utilities

Entertainment



Mining

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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?