# INSIGHTS INTO INSPECTION

**ANDREAS BOENISCH, INNOSPECTION LIMITED, UK, INTRODUCES NEW DEVELOPMENTS IN FLEXIBLE RISER INSPECTION TECHNOLOGY.**

Flexible risers and flexible pipes are by nature complicated in design with their various layers and types of material. The complex multi-layered structures with contra-wound tensile armour wire layers equate to challenges in the inspection and integrity evaluation of these pipes. Anticipated concerns of flexible pipe operators are defects such as cracking, corrosion, erosion and fatigue in the different wire layers under various tensional stress levels.

While typical inspection techniques are able to inspect only the near side armour layers for wire disruptions, the far side armour layers remain uninspected. Corrosion or cracks which are not complete breaks could fail to be detected. Ultrasonic technologies require the flooding of the annulus with a couplant for the inspection to be performed, which presents a potential risk of damage especially to the inner layers of the flexible risers.

The market showed a clear demand for an inspection technology capable of delivering an external fast screening of flexible risers in-situ at offshore installations, providing visibility of multiple wire layers but without the risk of damage from the annulus flooding. To meet this

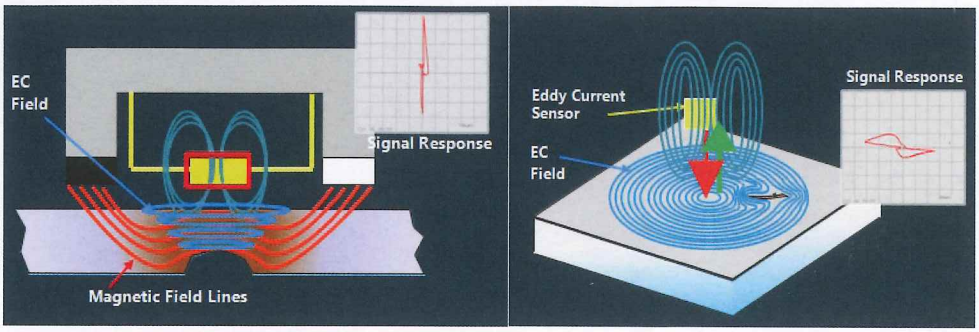


**Figure 1.** *Detection of far side defects (left) and near side defects (right).*

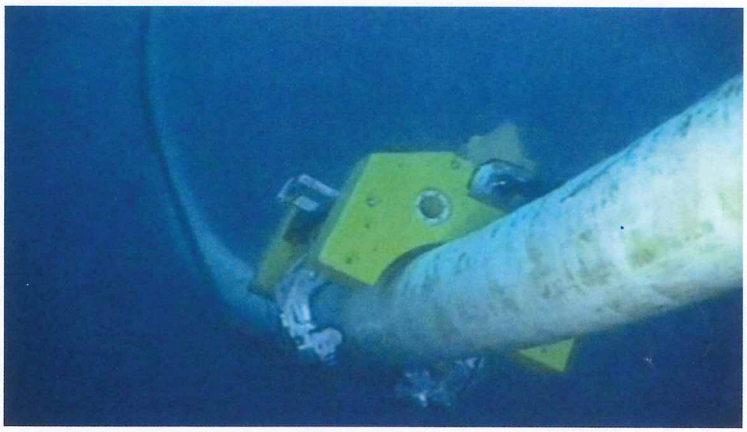

**Figure 2.** *MEC-Hug Crawler inspecting through the sag bend of the flexible riser.*

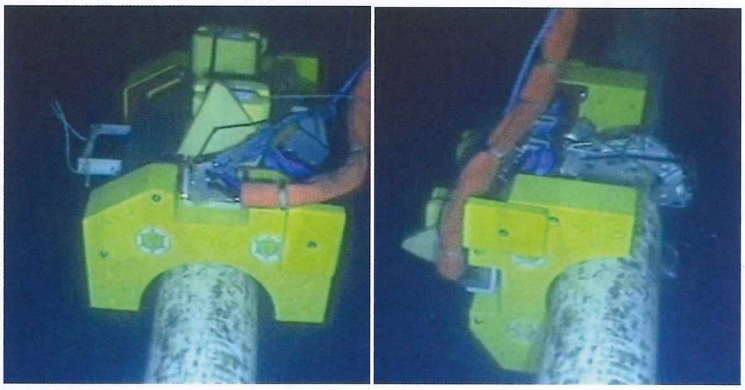

**Figure 3.** *Circumferential scanning of the flexible riser.*

demand, Innospection developed MEC-FIT™ – an enhanced flexible riser inspection technique.

## The Magnetic Eddy Current (MEC) principle

MEC-FIT is based on the Magnetic Eddy Current (MEC) technique which is the next generation and a further development of the industry proven fast corrosion screening Saturation Low Frequency Eddy Current (SLOFEC™) technique.

The principle of the MEC technique is that by superimposing direct current magnetisation with an Eddy Current field, the depth of penetration is increased to such an extent that the internal defects, such as corrosion, cracks and pitting, can be detected from the external surface. The field line changes caused by the defects are analysed as signal phase, amplitude and pattern against a calibration.

The MEC technique operates on magnetic field controlled high frequency Eddy Current and uses specifically developed Eddy Current sensors able to generate a higher density field for increased defect detection sensitivity. By analysing and controlling the magnetic field strength to operate at the retentivity point of the hysteresis curve while combining it with higher operating frequencies, the MEC technique is capable of detecting defects at a higher wall thickness and stand-off (coating) range.

By applying the electromagnetic MEC principle to the MEC-FIT technique, the method offers the following capabilities and advantages over existing flexible riser inspection techniques:

- Deeper penetration of inspection to three armour wire layers.
- Detection of cracks, pitting corrosion and general corrosion in the single and multiple wires.
- Detection of wire misalignment and wire gaps.
- Fast external scanning in both axial (for for wire angle setup of < 35˚) and circumferential direction (for a wire angle setup of > 35˚).
- Delivery of inspection data without the flooding of the riser annulus.
- Inspection signals are shown for the different layers, defect types and wire gaps.

It still proves challenging to inspect under the bend stiffener of the flexible risers and this represents the future development of the MEC-FIT technique.

## Successful deployments

The MEC-FIT technique for flexible riser inspection has matured following the completion of several verification tests with major operators and deployments to the field. Two deployments are illustrated below.

### Inspection of flexible riser

Due to the absence of a pressure armour layer, a 13 in. oil export flexible riser in the North Sea is susceptible to stress corrosion cracking (SCC) and possibly hydrogen induced cracking (HIC) in both armour layers. The inspection challenge for this flexible riser was its tight 55˚ wire angle structure in both the outer and inner armour layer and the presence of a thick outer sheath of 15.3 mm with an anti-wear tape of 2.5 mm between the two armour layers.

To ensure that the technique was capable of inspecting the 55˚ wire angle structure and the thick outer sheath, blind tests were successfully performed on a simulated test sample with EDM cracks in 45˚ and 90˚ angle and various flaw types established by placing wires at different locations and wire layer positions to simulate the different armour layers.

The MEC-FIT technique was adapted onto the MEC-Hug Crawler tool which was rebuilt to enable the circumferential scanning to accommodate the scan requirement of the 55˚ flexible wire angle structure. At the same time, the MEC-Hug Crawler tool was also customised for deployment by an inspection-class ROV from the installation. This represented a substantial cost saving in comparison to the deployment by a work-class ROV from the vessel.

Completed in Q4 of 2015, the operator was not only satisfied with the successful inspection operation and the substantial cost saving due to the deployment by the inspection-class ROV, but more importantly that the riser operation could be continued safely.

### Flexible pipe wire gap monitoring

Flexible pipe sections stacked in the masts of the turret drag chain on the FPSOs are often subjected to external tensile armour wire disorganisation.

Gamma radiation with images being captured on a film has been the traditional method of inspecting these flexible pipes and although this technique is widely used throughout the industry, it poses several issues.

Radiography could not be performed in the direction of the FPSO's nucleonic detectors as this would trip the vessel's high-integrity pressure protection system (HIPPS), causing an unplanned production outage. The entire turret area has also to be shut off to personnel during the inspection as radiography poses a significant danger to health and this prevents routine operations from taking place in the vicinity. In the case of a North Sea operator, radiography could only achieve around 50% of the required work despite the inspection being performed for over nine months of the year.

Hence, the aim of the inspection was to investigate a better way of inspecting the 6 in. and 10 in. flexible pipes on the FPSO's turret to identify, monitor and measure the increasing wire gaps of the flexible pipes.

As the inspection requirement differed from the intended inspection capability of the MEC-FIT technique for the detection of cracks, pitting and general corrosion in the single and multiple wires, the technique was redeveloped to enable the detection of the signals from the surface and its repeatability in determining the individual wire gaps of the flexible pipes.

The flat MEC-P7 Scanner having a customised high resolution encoded drive for precise definition of the edges and distance to the neighbouring pipe was also designed and developed to accommodate the tight space of 150 mm gaps between the flexible pipes where the inspection tool had to fit in.

Completed in Q4 of 2015, all the 6 in. flexible hoses that made up 40% of the turret system were scanned in just two weeks. In addition to better coverage whilst maintaining image quality, the MEC technique removed the radiation risk posed to personnel. Just two fortnightly trips are now required instead of multiple trips to complete the required inspection, resulting substantial cost savings.

## A flexible riser integrity management programme

In a strategic alliance between INTECSEA and Innospection, FlexIQ which is a complete offering in the arena of flexible riser integrity management was launched in June 2016.

This partnership aims to redefine the approach to flexible riser integrity management by offering inspection and computational simulation techniques as part of an overall integrity management framework. In turn, this leads to a significant improvement in understanding of operational risk and enables a fully integrated service for inspection, analysis, and data management.

Central to the value and distinctiveness of FlexIQ are the enhanced inspection capabilities of MEC-FIT from Innospection and the numerical simulation capabilities of FLEXAS™ from INTECSEA. By combining these capabilities with annulus testing and a formal risk-based approach to flexible riser risk assessment and life extension, FlexIQ delivers all aspects of flexible integrity management through a single provider.

The first part of this flexible riser integrity management programme is annulus testing, which is a critical benchmarking tool to understand the current performance of fundamental integrity related components within the flexible pipe design. It is critical to know if there is a breach to the outer shield and also, ideally, where it is located. It is also important to determine if vent ports are open with annulus gases being vented to the flare system and to identify the constituents of the flared gases. The annulus test kit incorporates the components required to implement an offshore annulus test, which allows the risk assessment to be carried out with real information and trending analysis, leading to enhanced integrity understanding.

This is followed by MEC-FIT inspection which combines DC magnetic and Eddy Current fields to detect single or multiple wire damage in up to three metallic layers, including cracking, pitting, general corrosion as well as wire misalignment and gaps.

FLEXAS is the multi-body nonlinear dynamic sub-structuring solver which conquers the computational limitations of other industry simulation software through advanced computational methodologies. The computational efficiencies provided by this solver enable the direct inclusion of high fidelity 3D finite element models into the large scale, nonlinear dynamic simulations with long duration irregular wave inputs. This results in a high resolution fatigue spectra and accurate fatigue life predictions. Furthermore, this framework allows detailed inspection data (damage, flooding, corrosion) to be captured in the 3D models and incorporated into the simulations, enabling a comprehensive risk-based strategy to be developed for integrity management.

The software has been qualified by DeepStar and ExxonMobil in independent validations against numerical and experimental benchmarks.

The final part of the programme consists of workshop integrity assessment and inspection planning. By adopting a workshop integrity assessment of the flexible risers, it enables the risk to be quantified and mitigation measures to be justified using common terminology and industry standard approaches. A range of inspection techniques can be considered to ensure valuable data is collected that can be fed back into the integrity assessment. In summary, this flexible riser integrity management programme is capable of providing insight as well as data.

**Figure 4.** *Flexible riser sections in the turret drag chain on the FPSO.*

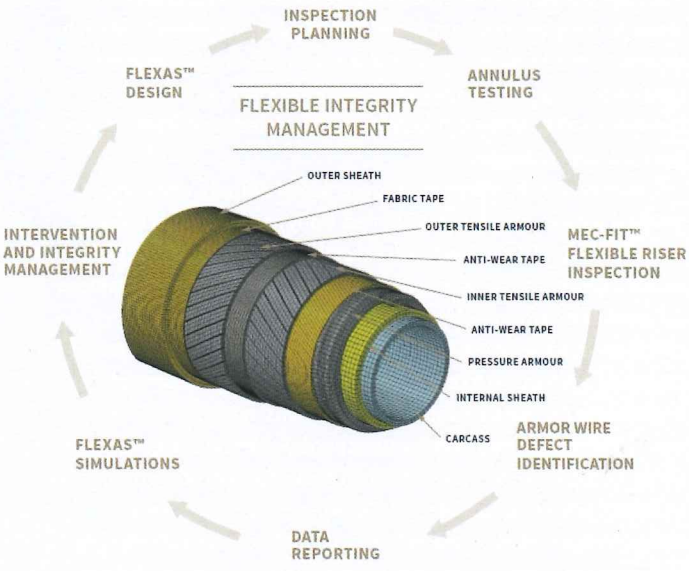


**Figure 5.** *FlexIQ – redefining flexible riser integrity management.*