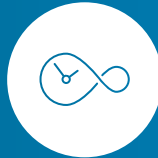


Flexible Pipe Inspection

Assessing the Integrity and Remnant Life of Flexibles



Cost-efficient inspection by operational pigging during normal operation



Lifetime extension by providing enhanced integrity information on flexible pipes



Preventing carcass damage with tested inspection tools

Deep water, harsh environments, long distances, extreme temperatures – these are a few of our favorite things. When extreme operating conditions come together, the ROSEN Group steps up to the challenge. An experienced team of offshore experts offers flexible, multi-purpose, and future-proof solutions in the areas of planning, inspection, maintenance, and monitoring. The competence we possess in all components of asset management is what makes us the industry leader we are today, and the right team to turn to for expertise in the offshore arena.



Challenges

Whether it is a rigid or a flexible pipe, the need for routine inspection and reliable analysis remains the same. Subsea pipelines and risers never stand still. The offshore environment in which a flexible pipe exists – from subsea structures up to and beyond the sea surface – exacerbates the difficulty and cost associated with the repair, refurbishment and replacement of these assets. We address these problems with our expertise and experience in testing and inspecting flexible pipes.

Various types of defects in the carcass and pressure armour of the flexible pipeline can have an impact on its integrity, which makes it difficult to assess the exact condition of the asset. With multi-layered products consisting of both metallic materials and polymers threats come from many different directions. In addition, there are no uniform standards for flexible piping, i.e. the pipes are typically manufactured according to individual customer requirements, so that each inspection requires individual solutions.

| Defect Type | Flexible Layers |
|--|--|
| Breakage | <ul style="list-style-type: none"> • Outer tensile armour layer • Inner tensile armour layer • Pressure armour • Carcass |
| Crack like defect (not complete breakage) | <ul style="list-style-type: none"> • Outer tensile armour layer • Inner tensile armour layer • Pressure armour • Carcass |
| Wear/corrosion/metal loss | <ul style="list-style-type: none"> • Outer tensile armour layer • Inner tensile armour layer • Pressure armour • Carcass |
| Detection of water flooding (annulus) | All (top side annulus) |
| Geometrical disarrangement | <ul style="list-style-type: none"> • Outer tensile armour layer • Inner tensile armour layer • Pressure armour • Carcass |

Solution

It is recommended to implement an integrity management strategy and program of inspection as early as practicable and to record results at regular intervals throughout an asset's operational lifecycle.

The more data available, the greater the confidence that it can be applied to any assessment of remnant life and integrity status of an asset.

ROSEN's approach applies internationally accepted codes of practice and follows industry regulations and guidelines. It includes:

- Specialized Finite Element Analysis (FEA),
- Free volume annulus testing, and,
- Tailored in-line inspection routines.



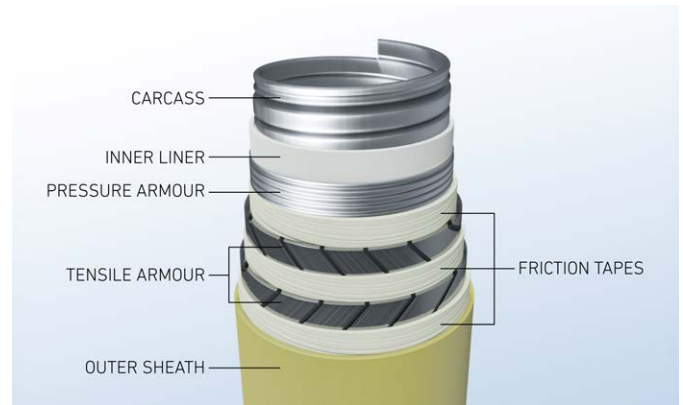
Annulus testing

Planning

ROSEN's integrity experts possess decades of experience in managing the integrity status of offshore assets. The inspection and assessment projects that we have performed around the world with various operators give us unique insights into what works and what does not. ROSEN can audit existing systems to identify gaps in order to help define and implement a best practice which enables any operator to achieve effective and sustainable asset management.



Example of a RoCorr MFL-A tool suitable for the inspection of flexible riser pipes to avoid damage to the inner pipe



Layer setup of flexible piping

Pre-ILI Cleaning

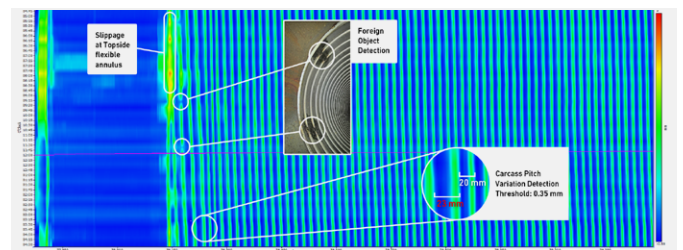
A clean pipeline inner surface significantly increases first run success and data quality and enables accurate integrity assessments. This reduces operational risk and can result in significant cost savings by avoiding a second run.

Taking into account the requirements for careful cleaning of flexible pipelines, the ROSEN Group offers a wide range of pipeline cleaning services. Non-abrasive plastic brushes ensure that the sensitive carcass is not damaged.

Annulus Riser and Flexible Testing

ROSEN has established the capability of performing different types of annulus testing to meet market needs. These deploy vacuum or positive pressure testing and will always use innovative methods, processes and technologies. Getting reliable, repeatable data from annulus testing is the key to evaluating remaining life, as subtle changes in the annulus will occur over time.

ROSEN has developed and laboratory-tested purpose-built equipment to improve the accuracy of annulus and flexibles testing, supported by a robust process. In practice, ROSEN supplies a highly experienced team performing annulus testing anywhere in the world. Technicians will be quickly mobilized to site with compact, state-of-the-art equipment, supported around the clock by principal engineers.



Example of a high-resolution data set from a flexible pipe inspection: topside end fitting (left) and the inner carcass (right)

In-line Inspection

In-line inspections using magnetic, ultrasonic, eddy current and mechanical technologies provide accurate and reliable data on metal loss, cracks, geometric anomalies and leaks in steel pipelines without damaging the inside carcass. The collected data can also be utilized to identify possible anomalies like carcass collapse, excessive bending, end-fitting irregularities, loss-of-buoyancy modules, operational configuration and other information that can contribute to an understanding of the condition of the flexible. For the best possible inspection solutions, we take into account the individual characteristics of the flexible pipeline and offer tailored solutions with customized tool specifications. In addition to this, ROSEN has developed a special sensor technology to address the carcass integrity with high-resolution eddy current and magnetic sensors. Defects in the carcass like axial and circumferential cracks as well as metal loss and erosion can be detected and the system has the capability to measure the carcass pitch with submillimeter accuracy (+/-0.35 mm) as shown in the data example above. In case of non-magnetic carcass materials the new technology has the potential to collect data from the underlying pressure armor layer.

Specialist Analysis and Verification

A flexible pipe is subjected to variations in loads, which cause fatigue of the internal armor layers. With aging assets achieving longer and longer useful life, operators are striving to understand fatigue life to more robustly predict safe remaining life.

ROSEN has the capability of performing the specialist analysis and verification needed to address these different types of stress and fatigue phenomena and associated failure modes. Our principal deliverable provides an indication of flexible pipe stress and fatigue condition, assesses remaining fatigue life and gives specialist advice for flexible pipe integrity management.

Ageing and Life Extension

Life extension assessments are critical to maximizing the operational life of a flexible pipe. Whether initiated early or later in the operational life, the assessment allows for the fullest potential of a pipe to be realized. All types of assets are increasingly being re-evaluated to operate well beyond their original design life. To achieve this, operators may need to go through a procedural restructure if their current arrangements cannot effectively handle

the amount of data generated by proper inspection. Following the requirements set out by safety regulators, additional challenges to the operators' process may occur. ROSEN can support with significant experience in developing a structured process to facilitate life extension for flexibles. We also deliver forward guidance on remedial actions that may be required at the same time, addressing future management challenges.

Benefits

- Cost-efficient inspection through operational pigging service during normal operation
- Avoiding damage and wear to the carcass by deploying tested inspection tools with well-proven designs
- Supporting asset lifetime extension by providing enhanced integrity information on flexible pipes
- Independent verification and consulting services
- Tailor-made services according to customer requirements
- High reliability and minimized risk based on more than 30 years of experience in offshore ILI projects, including several hundred kilometers of inspected flexible pipes
- As an API 1163 certified supplier, ROSEN offers a high quality service, delivered by ASNT-qualified personnel, according to the highest safety standards with certified equipment (CE, ATEX on request)

Service Options

- Cleaning – operational and pre-inspection
- Inspection of flexible pipes from 6" - 14"
- Free-swimming, tethered and bidirectional services - system friendly application for pipelines with different requirements for launching and receiving
- Subsea launching and receiving as well as vertical launching and receiving
- Multi-diameter – pipelines with varying diameter
- Combined Diagnostics – multiple inspection technologies in one run
- Post-ILI – data alignment and combined evaluation
- Integrity Assessments – RBI, FFP, CGA
- Reporting Software – reporting and data management
- NIMA – versatile cloud-based integrity software

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