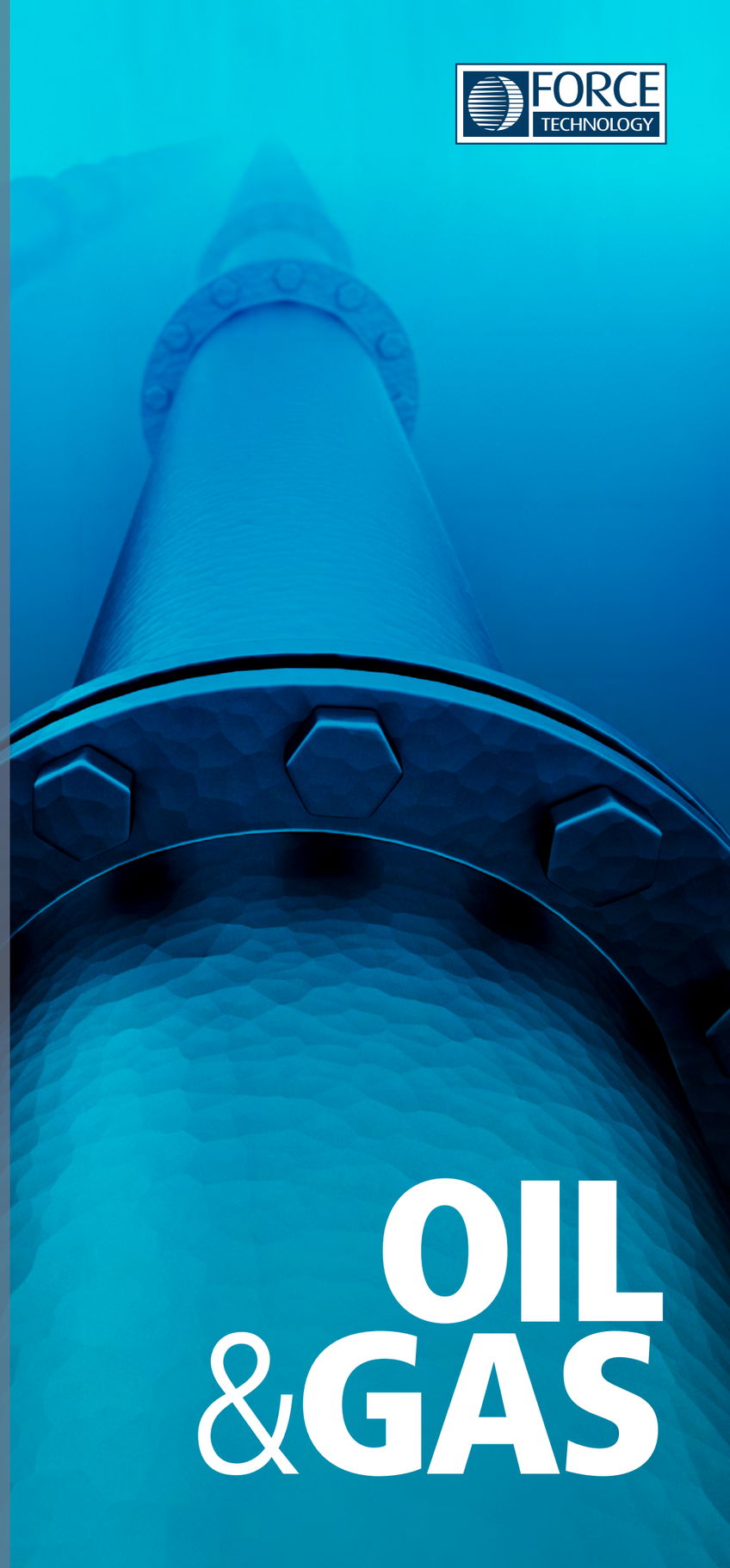
FORCE Technology Norway
Headquarters
Nye Vakås vei 32
1395 Hvalstad
Norway
Tel. +47 64 00 35 00
info@force.no
www.forcetechnology.no

SUBSEA SERVICES



OIL &GAS

PIPELINE INTEGRITY MANAGEMENT

Pipelines represent a very important part of the energy infrastructure. Proper operation is crucial to a company's export capabilities. We ensure safe, continuous and economical product transportation.

An essential aspect of pipeline integrity management is identifying locations along the pipeline that are most vulnerable to corrosion. Another important aspect is forecasting corrosion over a period of time in order to predict the possibility of pipeline failure (corrosion rate versus time to failure).

We hold years of experience in maintaining and securing pipeline integrity on a large number of offshore and onshore assets.

We ensure:

- Continuous production
- Identification of high risk areas for corrosion
- Effective use of mitigation, monitoring and inspection resources
- Improved public health, safety and environmental protection

3 categories of pipeline integrity management

Direct assessment: Internal and external conditions assessment, pipeline risk ranking, flow modelling, corrosion rate and profile calculation.

Integrity plan: Definition of operations and procedural manuals, corrosion mitigation, corrosion monitoring, maintenance and inspection.

Project Management: Data management, burst pressure calculations, fit for service calculation, third party verification, corrosion management audits.

Inspection management circle

FORCE Technology software & tools

CorPos-AD™

Software tool developed to assess the corrosion profiles for entire pipelines. It combines modelling with monitoring and inspection data in an integrated approach for increased safety control.

CorPos-AD provides and stores data on:

- Actual corrosion risk situation
- Risk status (maximum corrosion depth vs. acceptable corrosion depth)
- Remaining service life (e.g. re-qualification / life extension of the pipeline)
- Optimum time to next inspection
- Requirements for chemical treatment (inhibition) and other Key Performance Indicators (KPIs)
- "What-If" situations

Field Gradient Sensor (FiGS®)

Inspection tool developed to perform cathodic protection surveys with electric field gradient measurements in order to evaluate current density values on structures and pipelines. It detects coating damages on exposed and buried pipelines and accurately measures anode performance.

A wide area of application, including (but not limited to):

- Measurement of current output from anodes
- Measurement of current density on pipelines and structures (bare steel, coated steel and concrete)
- Detection of coating defects on pipelines, including buried pipelines
- Measurement of current drain to buried structures, such as piles and wells

Risk based inspection planning

FORCE Technology uses Risk Based Inspection (RBI) planning, which is a method for identifying the probability and consequence of components failure. By this systematic approach, the optimum inspection schemes are determined and detailed inspection plans are furnished, based on these schemes.

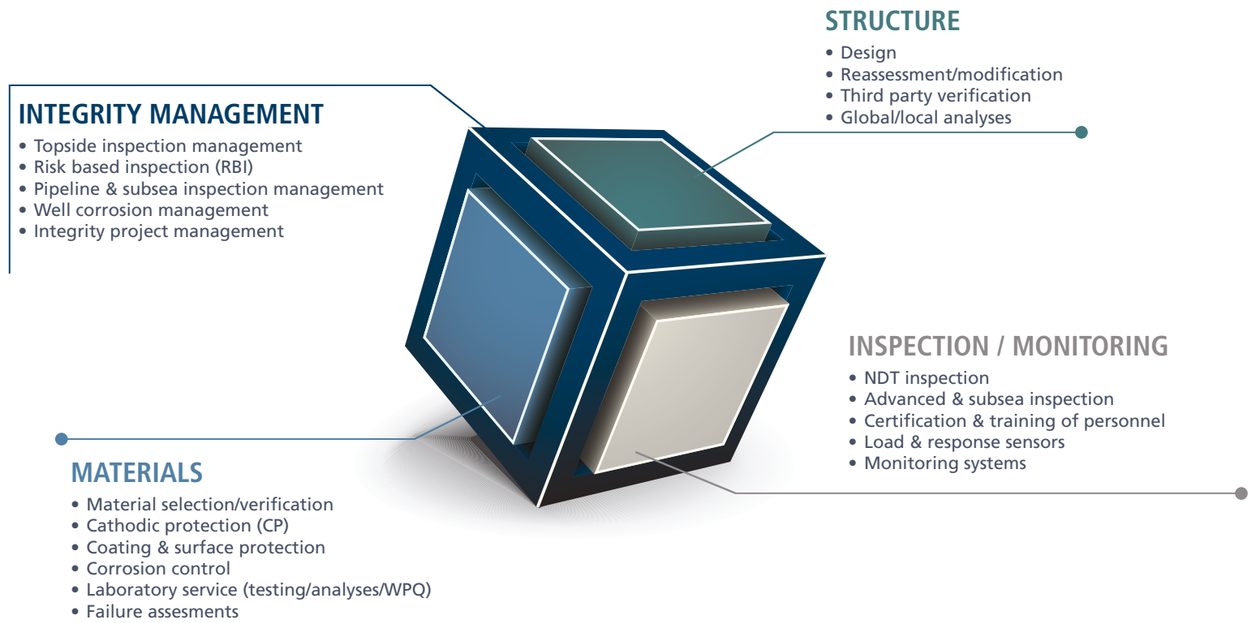
Inspection planning encompasses various activities performed in order to optimise the use of inspection resources (cost effective), while at the same time ensuring the technical integrity of the asset. By targeting areas strategically based on an RBI, you acquire an inspection programme that is both safe and cost-effective.

Pipeline & subsea inspection management

Pipelines and subsea equipment represent a very important part of the energy infrastructure. Proper management of the pipelines and subsea equipment is critical to a company's ability to maintain continuous production, identification of high risk areas for corrosion, effective use of mitigation, monitoring and inspection resources, improved public health, safety and environmental protection. We offer several solutions for these types of challenges. We offer several solutions for these types of challenges.

This includes among others:

- Inspection planning
- Data analysis (e.g. pipeline degradation)
- Corrosion modelling (e.g. remaining life estimations, softwares)
- Recommendations regarding corrosion and materials
- Cathodic protection inspection (FiGS), modelling and analysis
- Advanced inspection/monitoring for subsea (e.g. vibration, field gradient sensor)
- Operational support



CATHODIC PROTECTION (CP)

In order to prevent corrosion from damaging and tearing down valuable assets, cathodic protection systems are installed. We have more than 35 years of experience within cathodic protection and offer various types of solutions.

We provide a wide range of cathodic protection (CP) services and solutions that prevent and control corrosion as a part of integrity management of fixed platforms, including:

- CP modelling
- CP design
- CP inspection
- CP management and consulting

Many of these services draw from our own computer software, SeaCorr™, which is designed to simulate CP systems. We also provide solutions for stainless steels, which in many cases are in fact prone to corrosion.

Our combination of practical and theoretical approaches provides more accurate results, which is important when considering inspection intervals and life extension studies.

CP modelling

We provide cathodic protection modelling of all types of structures and pipelines. Our experts have developed a powerful software solution for this purpose, SeaCorr™, which can be used to simulate a wide range of structures. The main objective of CP modelling is to demonstrate the actual performance of a CP system.

We simulate CP performance throughout its service life on structures with or without coating, using sacrificial anodes, impressed current as well as hybrid systems. SeaCorr™ is an excellent tool to use when considering anode retrofit and life extension, as it utilises our unique database with real life data in order to simulate the exact amount of retrofit anodes needed.

This comprehensive approach gives us a competitive edge with regard to the quality and reliability of our CP modelling results and we can demonstrate large savings by using real life current densities as opposed to conservative design codes. We can also of course verify CP designs, using design code values.

Typical cases evaluated by CP modelling:

- Current shadow effects, current drain and anode distribution issues
- Uneven anode consumption
- Over or under protection
- Protection in confined areas, small annuluses, etc.
- Galvanic corrosion
- Anode interference
- Interaction between connected structures
- Pipeline attenuation

With CP modelling, you can try out different scenarios in order to ensure the optimal protection of your asset.

CP design

When designing a structure, whether it's a new one, a retrofit modification or a life extension, it is important to ensure full cathodic protection throughout its entire design life. This is achieved through a proper cathodic protection design, where the required amounts of anodes are calculated, and anode placement is determined.

We hold a large team of experts, with experience from deep waters to onshore facilities, and from case studies to research and development. We provide CP design and evaluations of jackets, subsea structures, pipelines, FPSOs, semi submersibles, wind turbine foundations, caissons and other confined areas, chain connectors and more.

Our design and modelling experience combined with on-site inspection allows us to keep CP retrofit cost at a minimum, as well as ensuring optimal operation.

Our services within CP design include:

- Traditional CP design with both impressed current and sacrificial anodes
- CP design verification
- CP retrofit design
- Anode protection range and attenuation calculations
- CP design of stainless steels (see RCP further down)
- Material compatibility with cathodic protection systems

RCP anodes.

Resistor controlled cathodic protection (RCP)

Resistor controlled cathodic protection (RCP) prevents internal corrosion of stainless steels. It is highly applicable in chlorinated seawater and produced water systems that are likely to experience severe corrosion, which in turn may increase service cost. The system is based on sacrificial anodes with resistors that control the anode output. This enables very low current densities, allowing for significantly extended protection ranges from individual anodes. RCP anodes are easily installed and extend the service life of existing piping systems.

By using RCP, you are able to improve the first time investment costs (CAPEX) with the addition of a smaller replacement cost during the operational phase and allow for the use of inexpensive, low alloyed, stainless steels as an alternative to expensive components. RCP can also be used to prevent galvanic corrosion in couplings between materials and corrosion of various highly alloyed steel components in sea water systems.

Our clients have experienced large savings by using RCP, thereby avoiding the use of costly materials, like titanium. More than 6000 anodes have been supplied and our list of satisfied clients is steadily increasing.

CP management

Proper CP management is important and necessary to stay in control of your cathodic protection system. Staying in control may result in improved cost efficiency with regard to inspection intervals and prevention of otherwise unforeseen corrosion damages and breakdowns.
We offer full management of cathodic protection systems and RCP installations, including site inspection and inspection management, data analyses and reporting as well as various assessments of CP and RCP systems.

CATHODIC PROTECTION (CP) INSPECTION

As subsea infrastructure is ageing, the need for detection of coating damages and the performance of the CP systems gets increasingly important. FORCE Technology Norway has developed a highly sensitive Field Gradient Sensor (FiGS) to give our clients new accurate insight into the integrity of their buried infrastructures as well as exposed.

FiGS

The FiGS® sensor measures both the strength and direction of electric fields in seawater, enabling us to assess the overall status of the CP system, pinpoint anodes, coating damages and other areas of interest, as well as measuring the real life current density of the system.

Unlike conventional periodic monitoring of the potential, the data from our FiGS® sensor gives information on how much current is drawn from the CP system. This information enables us to e.g. predict the remaining life of a CP system, providing our clients with a greatly increased confidence level.

The unique high sensitivity of FiGS® enables inspection of buried structures and pipelines without possibly having to go for costly excavation.

FIGS® combined with CP computer modelling

FiGS® provides information on the distribution of the electric field, enabling the use of FiGS data in subsequent computer simulations. The FiGS® data is used to e.g. map the real life current density distribution, which is often significantly lower than design values. This provides a foundation for large savings when retrofitting the CP system in order to achieve a life extension of the infrastructure.

ROV and AIV / AUV

FiGS® can be fitted to Remotely Operated Vehicles (ROV) tagging it on to e.g. traditional GVI (general visual) inspections campaigns. Being a non-contact measurement method, it is also perfectly suited for use by Autonomous Underwater Vehicles (AUV / AIV).

	Exposed structures & pipelines		*Buried structures & pipelines*	
	Twin Cell	**FiGS**	**Twin Cell**	**FiGS**
Anode current	Possible, with some constraints*	☑	☒	☑
Cathodic current density	Possible, with some constraints**	☑	☒	☑
Calculated anode wastage	Possible, with some constraints*	☑	☒	☑
Calculated potentials	☒	☑	☒	☑
Detection of coating damages	Possible, with some constraints***	☑	☒	☑
Accurate current drain to eg. piles, wells & substructures	☒	☑	☒	☑
Detection of damage to flexible pipes outer sheath	☒	☑	☒	☑

**Fly-by measurements and stab measurements (lower sensitivity)*
***Stab measurements (lower sensitivity)*
**** Larger damages*

FiGS compared to Twin Cell inspection. Table is based on FORCE Technology experience.

CASES

» Weight coated buried pipeline

The line was inspected to determine the current density and anode performance of a 35 year old buried weight coated pipeline as input to a CP retrofit design. We found the current density to be 45% less than design code, reducing our clients CP retrofit need by 45%.

» Inspection of flange under concrete mattress

Traditionally the mattresses had to be removed by deploying divers prior to inspection, but FiGS® could easily measure the covered flange and its anodes. The flange was found to be well protected and the anodes to last a minimum of 80 years. The client reduced the HSSE risk involved and claimed themselves to have saved GBP 250 000 on the base case cost of the diving operation.

» Jacket

The jacket was inspected to establish the current density to find the actual requirements for cathodic protection. The Client claimed themselves to have saved USD 7,75M, nearly 65% of the original estimate using our processed data, combined with CP modelling instead of design code.

» Xmas Tree

FiGS® found significant amounts of current flowing out from the X-mas tree down towards the well casing, indicating that protection of the well casing was offered by the anodes of the X-mas tree. We were able to quantify the current drain to the well casing, enabling us to calculate remaining life of the CP system.

» Buried infield flowlines

Three newly laid flowlines buried in the same trench were inspected. FiGS® was able to separate the lines and associated anodes even though the lines were backfilled, rock dumped and lying right next to each other.

We found the status of the CP system to be as expected. The anodes are mainly protecting adjacent structures, something which requires close follow-up of the anode consumption in the future.

» Flexible pipeline

FiGS® was able to detect a minor tear in the outer shield. By combining data with CP modelling we were also able to estimate the size of the damage.

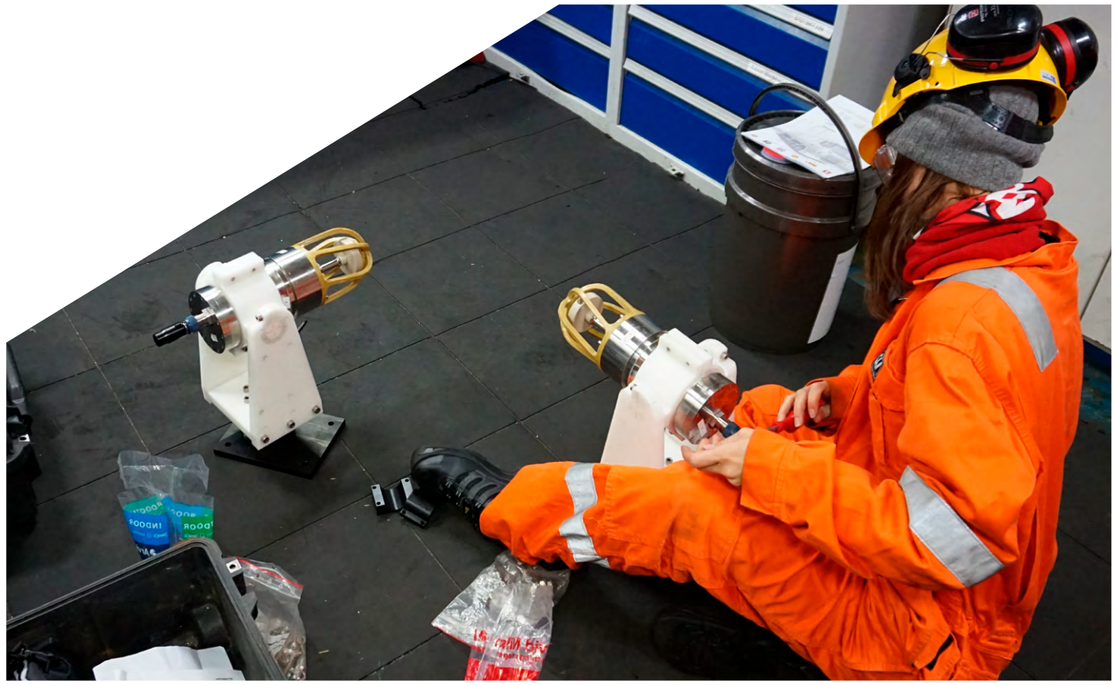
We also offer traditional CP inspection equipment

- Dropcell (proximity potential measurement)
- Stab Probe (potential contact measurement)
- Remote Cell (continuous potential measurement)

ADDED VALUE

- Steel current densities: remaining service life evaluation and retrofit savings
- Anode current outputs: anode wastage and remaining service life evaluation
- Coating defect detection (also for buried pipelines and structures): defect sizes will also be calculated
- Calculation of CP values and profiles by non-contact readings

Prepping FiGS® for survey.



INSPECTION & TESTING

For whatever purpose your material may have, it is important to ensure that is in good shape and that it is suited for its purpose. This may prevent unexpected failures and reduce the likelihood of an abbreviated service life. We offer both non-destructve (NDT) and destructive testing - onshore, offshore and subsea.

Non-destrucive testing (NDT)

NDT is fundamental in ensuring the safety of assets for personnel, environment and investors, because it allows for safe and complete testing without damaging or otherwise altering the test object.

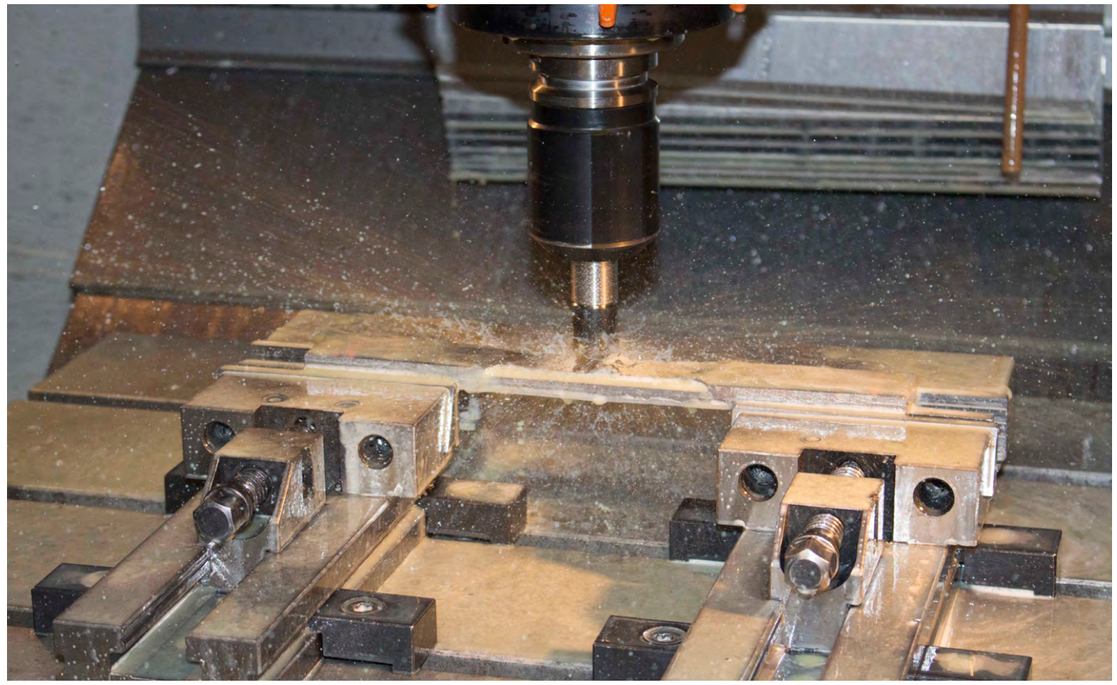
Failure of a component, structure or weld can cause significant hazard to the environment and often leads to significant costs. Ensure safe, continuous and cost effective performance of your asset, basing decisions on reliable NDT- data on the assets condition.

For decades, we have delivered high quality NDT services to all industries manufacturing and utilising steel structures, including offshore installations, power plants, pressure vessel pipelines, storage tanks and much more. We perform NDT during fabrication, in-service as well as during shut downs and maintenance.

Our NDT Techniques:

- Visual Testing
- Radiography
- Ultrasonic
- Eddy Current
- Liquid Penetrant
- Magnetic Particle
- Plus a variety of leak testing methods.

Furthermore, we supply Phased Array, Digital Radiography, P-Scan, ToFD and 3D MFL (Magnetic Flux Leakage).



Destructive testing

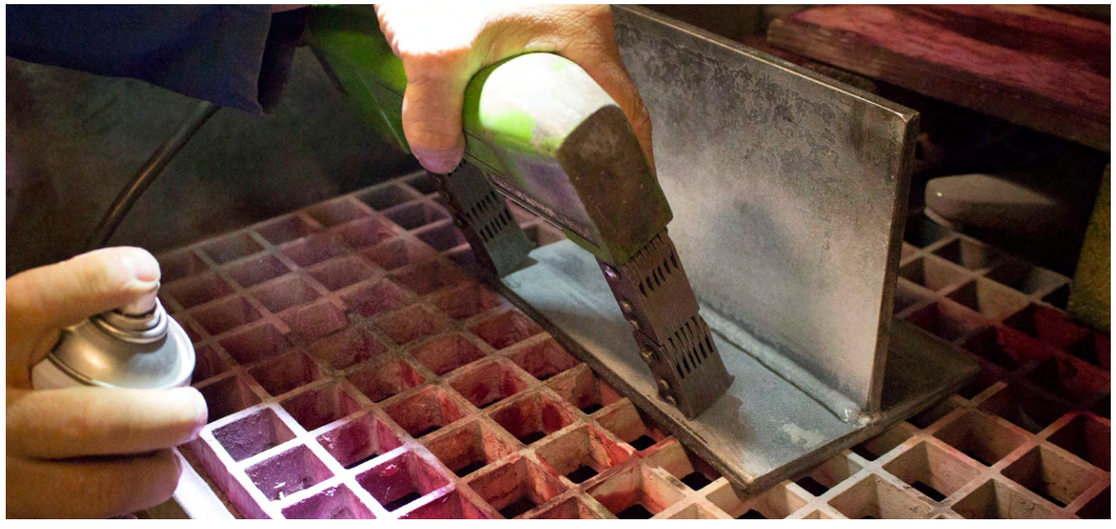
Verify and examine the mechanical properties of various materials and welded assemblies through destructive testing at top modern facilities.

At our modern laboratory facilities in Kristiansand, Norway, and at Brøndby, Denmark, we are able to ensure that you achieve an effective material economy. We hold several years of experience within destructive testing for a wide range of industries, including offshore, maritime, infrastructure, food processing and many more.

Through various types of testing, we secure that your chosen material is prepared and tested in accordance with appropriate material and application specification.

Our destructive testing:

- Verification of material physical/mechanical properties
- Material certification
- Testing of welded assemblies in order to verify compliance between weld and base material
- Verification of welding consumables
- Failure and crack analysis



Modern testing facilities

Our testing facilities are among the most pristine and advanced testing facilities within destructive testing in the Nordics. We provide mechanical and corrosion testing in accordance with numerous of international and national standards, codes and specifications upon request.

Tests and measurements:

- Tensile testing (0-600KN)
- Charpy V-notch impact test (0-450 Joule)
- Hardness measurements (HV5, HV10, HV30)
- Macro examination (1-50x magnification)
- Micro examination including ferrite count and determination of intermetallic phases (50-600x)
- Fatigue testing CTOD testing
- Corrosion testing (ASTM G48 and ASTM G28)
- Chemical analysis (Optic emission spectrographic, OES)

Risk based inspection approach

Focusing on high risk areas (defined from a risk based analysis), inspections are often carried out according to an inspection plan, which is either designed in collaboration with client or provided by client.

Tailor made solutions

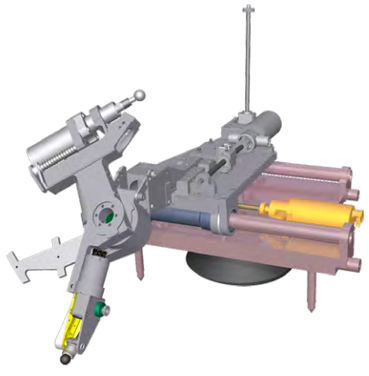
Additionally, FORCE Technology is among the leading suppliers of customised scanners for both topside and subsea inspection. These inspections are often highly advanced and require special equipment and qualifications.

Training

We are the leading provider of courses within NDT in the Nordics, with modern training facilities located in Kristiansand, Norway. Click here for more information on this (please note that all information will be provided in Norwegian).

ADVANCED SUBSEA INSPECTION

Dive in and discover our innovative subsea inspection solutions. We offer a wide range of solutions to inspect and repair damages on subsea infrastructures and pipelines..



The GRIM - a grind, inspection and repair tool that saves saves you the trouble of setting up seperate dives for inspection, repair and control of surface cracks.

Inspection, suited to your needs

At FORCE Technology, we combine our core strength within integrity management, material technology and engineering design in order to create solutions that not only inspect with a level of accuracy that meets or exceeds the market standard, but that can also be tailored to solve almost any challenge. Considering the risks and implications of flaws going undetected, it is essential that you feel confident in the inspection solutions provided to you.

Our tools and methods

Although several of our scanners are "off-the-shelf", 20 years of experience in designing and creating customised subsea inspection solutions allows us to solve and assist with whatever challenge you may be facing.

The system that we apply is modular, making it easily adapted and easily modified to fit most geometry. We offer simple and and advanced inspection on both pipelines and structures.

Some of the tools that we currently hold:

- F-Pipe: Ultrasonic scanners for pipelines and pipe geometry
- F-EIM: Eddy Current inspection on structures, pipelines and pipe geometry
- FiGS: Field gradient sensor for pipeline inspection
- F-GRIM: Crack detection and crack repair on structures
- F-Level: Fluid level measurements, such as in buoyancy tanks
- F-FMD: Flooded member detection in vessels and structural members

Customised bend scanner ready for testing.

Ultrasonic scanner for pipelines and pipe geometry

We hold several ultrasonic pipe scanners for different purposes, all of which can be fitted for a variety of geometries, in all shapes and sizes, including pipe bends.

Key features include:

- Corrosion mapping of piping, both straight and bent pipes, ranging (but not limited to) from an outer diameter of 2" to 36"
- Precise ovality measurements for subsea piping interventions, hot taps and more (qualified accuracy of up to 0.2mm)
- Narrow access scanners (line scanners, ring scanners, segment scanners and sector scanners)

All scanners can be fitted with eddy current testing probes in order to map surface-breaking flaws/imperfections on piping.

Crack detection and crack repair on structures

The GRIM (grind repair inspection machine) is an Eddy Current crack detection tool with built-in mitigation. If any crack indication is detected, the tool easily grinds away the indication with incremental grind depths. From there, we are able to rescan the indication at any time during the grind process, ensuring perfect mitigation.

Key features include:

- 3D scanning of exact surface topography
- Inspection by Eddy Current of the topography
- Mitigation through precise and traceable grinding of any surface imperfection

Cathodic protection inspection

With our state-of-the-art sensor for cathodic protection inspection (CP), FiGS®, we are able to provide on-site subsea inspection of CP systems. The sensor measures electric field gradient vectors and can detect electric currents in seawater. Its design allows for highly accurate measurements with a resolution and detection level that surpasses all other field gradient sensors available in the market.

Key features include:

- Measurement of current output from anodes
- Measurement of current density on structures (bare steel, coated steel and concrete) and pipelines
- Detection of coating defects on structures and pipelines, including buried pipelines
- Measurement of current drain to buried structures such as piles and wells

Eddy Current inspection on structures and pipes

The EIM, a very small eddy current inspection machine, is designed to follow complex weld geometry on nodes. The Eddy Current crack detection feature has a high sensitivity towards surface imperfections, and the size of the scanner allows it to access nodes with sharp angles. The scanner can be designed to move along a skid , to drive the scanner precisely along a large structural weld, reducing the ROV handling time.

Fluid level measurements in buoyancy tanks

The F-level uses ultrasound for level measurements inside submerged buoyancy tanks. When placed on the bottom surface of the tank, perpendicular to the water level, the scanner is able to measure the water level inside the tank with high accuracy. This may be useful if the built-in sensor is old or likely to be measuring incorrectly.

Flooded member detection (FMD)

This tool detects flooding in structural members and horizontal buoyancy tanks. It consists of an ultrasonic probe that detects water ingress behind offshore steel structure members. We provide various ultrasonic solutions for flooded member detection, typically tailored to each assignment, depending on geometry and thickness.

PIPE & PIPELINE

- Corrosion scanning and mapping
- Thickness readings
- Lamination detection
- Ovality measurements
- Weld inspection, ToFD (time of flight diffraction)
- Crack detection

SRUCTURES

- Crack detection
- Corrosion scanning and mapping
- FMD (flooded member detection)
- Weld inspection, ToFD

MATERIALS & CORROSION

A prerequisite for safe operation is the understanding of how materials perform under normal operating conditions, as well as under unintended exposure.

Approximately 30 percent of the incidents and leaks that occur in offshore process facilities are related to corrosion and erosion. Corrosion management is therefore essential in order to maintain the integrity of the facility.

To achieve full control, all relevant data must be used, including data on process and production, corrosion and erosion as well as inspection and maintenance. The key to success is related to the complete management of all data available, achieving corrosion control and ensuring focus on high-risk items.

We provide:

- Material selection and verification
- Corrosion management
- Corrosion monitoring
- Corrosion modelling and assessment

Material selection

We provide material selection and verification as part of ensuring the technical integrity of installations throughout their service life, at a low cost. We can assist during both design of new installations, as well as during modifications and life extension studies.

Years of experience within material selection and corrosion evaluations for the oil and gas industry ensure robust material selection based on a high competence within materials and degradation mechanisms.

In addition to following client specific recommendations and guidelines, we comply with NORSOK M-001 and ISO 21457, which provide guidance and requirements for material selection and corrosion protection for oil and gas production systems. Environmental limits for materials exposed to H2S containing environments are defined by ISO 15156.

Corrosion management

Corrosion management is a dynamic approach where we control and monitor an asset's technical integrity related to material degradation such as corrosion, erosion, cracks and fatigue. It is a part of the overall management system, and is described in a Corrosion Management Strategy.

A corrosion management strategy aims to define roles and responsibilities and ensure ownership, ensure focus on high risk system and identify Barriers and Key Performance Indicators (KPI).

Four steps of a continuous cycle:

- Planning
- Implementation
- Measure
- Improve

Corrosion monitoring

FORCE Technology, together with our sub-suppliers, offer a comprehensive range of corrosion monitoring services, applicable to any offshore or onshore oil/gas production and storage asset. Our services are built on years of experience from both servicing and manufacturing of corrosion monitoring equipment.

We provide:

- Installation/replacement/maintenance of probes and coupons
- Corrosion monitoring support systems to analyse and present corrosion status and trends
- Management of the necessary operations for the installation/replacement of monitoring equipment in onshore/offshore installations
- Collection, analysis and presentation of biological contents to control Microbiologically Induced Corrosion (MIC)

Enabling you to:

- Be aware of corrosion status in all monitored systems at any given time
- Predict and prevent leaks and failures due to corrosion
- Reduce maintenance cost by performing proactive actions
- Receive valuable feedback on chemical treatments and other corrosion mitigation actions
- Minimise unplanned downtime, thus enhancing profit
- More accurately predict asset/system remaining useful life

…thereby reducing risk and increasing asset and personnel safety

Corrosion assessment and modelling

Corrosion assessment

Corrosion performance sets the premises for material selection for new installations.

In addition, there is a demand for evaluation of corrosion and other degradation mechanisms to ensure further operation as a consequence of process modifications, life extensions and incidents. Corrosion assessments are also an integrated part of material degradation risk assessments or risk based inspection where corrosion performance under various conditions is essential.

When appropriate, recommendations for corrosion control and mitigating actions are given. In-depth knowledge of degradation mechanisms and extensive field experience are the foundation of our corrosion evaluations.

Corrosion assessments are the foundation for:

- Material selection
- Degradation risk assessments (RBI)
- Failure investigations

The assessment covers both internal and external environment.

Corrosion modelling

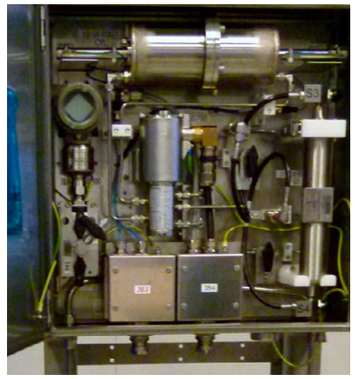
We prefer to use models for degradation rate predictions. However, good models are only available for certain environments. Under more complex conditions, in-depth knowledge on material performance, field experience and literature surveys are basis for our analyses.

Recognised models are used for CO2 corrosion (e.g. NORSOK M-506) and exposure to H2S containing environment (ISO 15156). From years of experience, we have developed in-house models for galvanic corrosion, H2S and O2 corrosion as well as MIC (microbial induced corrosion). Our software tool, CorPos-AD, which is used for corrosion predictions in pipeline, includes all these models.

In order to evaluate corrosion resistant alloys for seawater applications, we use our understanding of electrochemistry and material characteristics.

MONITORING OF FLEXIBLE RISERS

Increase safety and reduce the risk and implications of damages or reduced service life through careful, real-time monitoring of your flexible pipelines. Since the early nineties, FORCE Technology Norway has taken an active part in the development of monitoring systems for flexible risers.



VGM Flexible Riser monitoring unit

Real-time data for improved decision making

We offer three systems for monitoring flexible pipelines; vent gas monitoring (VGM), polymer coupon monitoring (PCM) and motion monitoring.

Vent Gas Monitoring

The increased focus on health, safety and environment (HSE) in the offshore industry calls for pre-emptive actions in order to increase safety and minimise unnecessary stress on the environment.

The VGM system answers to that by supplying real-time and historical data on the condition of the flexible riser annulus, providing the operators with an opportunity to make qualified decisions based on actual measurements.

Vent gas monitoring monitors vent gas rates, annulus pressure and annulus free volume, in order to determine the integrity of the flexible riser. The system looks at the main components of the flexible riser; such as the outer sheath, armour layer, the inner polymer sheath and the end-fitting. Sudden fluctuations suggest a change of integrity, which calls for action.

This is highly beneficial:

- at start-up
- during routine inspections to see that the riser is working according to specifications
- during the day to day normal operation
- in case of unplanned events
- when considering life extension
- when planning for replacement.

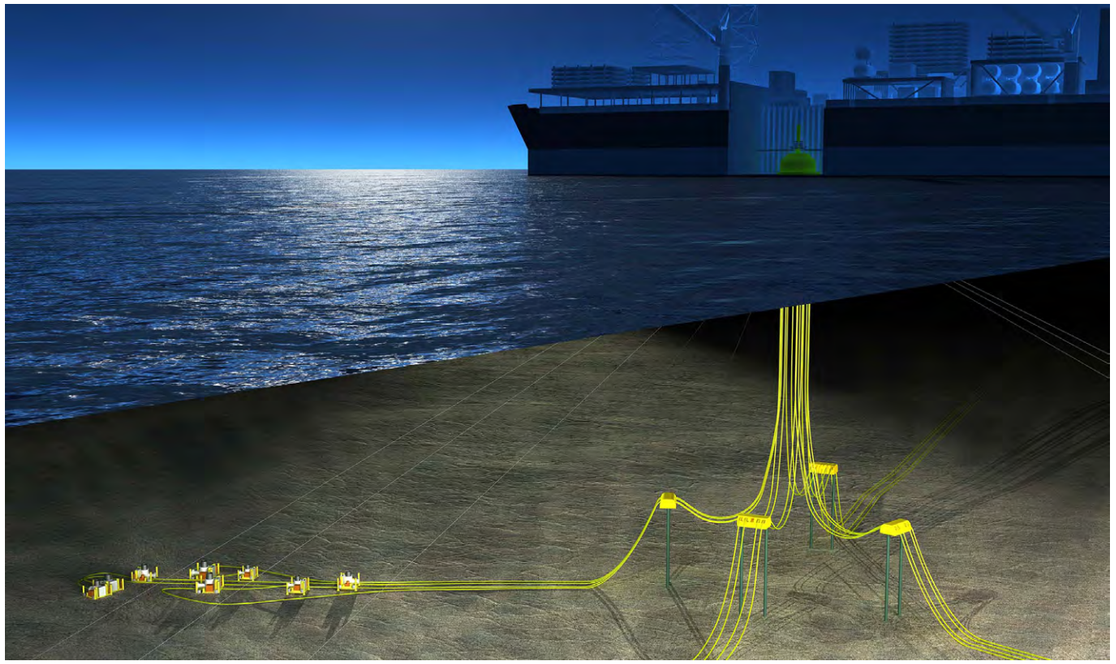
Sudden changes in the annulus composition may suggest a breach in the outer sheath, in the inner liner or in the end fitting seal. Via composition data and monitoring of flow rates and volume directly, it is possible to detect the various types of breaches.

Polymer coupon monitoring

Flexible risers consist of several layers of polymer, one of which works as a sealing between the bore fluids and the surrounding layers. Keeping this layer intact and under control is crucial with regards to operational safety. The PCM system allows for continuous monitoring of the integrity of this layer, maintaining your security and control.

Polymer coupon monitoring monitors the integrity of the polymer sheath of the flexible riser. Coupons are placed inside the pipeline in order to expose them to the exact same conditions as the riser in question. The coupons are easily retrieved for examination with our patented method for evaluating polymer integrity.

Unlike metal parts, the deterioration of plastic parts is difficult to assess. Typically, one would periodically replace the pipelines prior to the end of its expected service life. This often leads to unnecessary replacements, which is ineffective when considering the huge costs involved for such a replacement, in addition to profit-loss during unexpected shut-downs due to a pipeline integrity breach. The PCM system is intended to determine the remaining service life, as well as evaluating the performance characteristics of the sheath of a flexible riser, providing the operator with a powerful decision tool.



Exposure to bore fluids and bore environment ages the polymer, either chemically or physically. It has been found that the underlying ageing mechanism for PA-11 (a polyamide) is a chemical degradation of the polymer chains themselves. Therefore, monitoring the molecular weight of the polymer chain allows one to determine the exact rate of deterioration, and hence predict the remaining service life. This method has been developed and patented by FORCE Technology.

Motion monitoring

Motion Monitoring monitors motion within the flexible riser over time in order to estimate the level of fatigue. Several techniques may be used to determine the level of fatigue, but we typically monitor critical areas, such as the bend stiffener and sag bend, which are the most fatigue prone areas of the flexible riser.

By installing inclinometers, accelerometers, strain gauges, temperature sensors and pressure gauges, the mechanical state of the riser can be monitored and analysed in real-time. The mechanical state may be influenced by local forces and bending moments, curvature, inclinations, accelerations and velocities on any axis. The combination and distribution of various sensors can be optimised to give a better estimation of any mechanical property of interest.

Through the implementation of a proper combinations of sensors, we are able to assess loads and calculate the accumulated fatigue damage and load history of near all structural elements in a riser or other mechanical structure.

Consultancy and Expertise

With FORCE Technology, you can always count on receiving expert consultancy throughout the process. Because of our extensive experience within monitoring systems in the offshore industry, we offer solutions that are tailored to your needs specifically.

WELLHEAD AND RISER MONITORING

Subsea wells have a limited fatigue life. For new wells, the utilisation and fatigue damage can be accumulated from day one to reduce future uncertainty. For existing aged wells with an uncertain predicted remaining service life, control of the additional damage for each new additional operation may increase the number of days the well can be accessed.

Riser Fatigue mounting of sensor

Placing a new rig on top of the wellhead obligates the operator to ensure operational safety given the history and the loads a new rig will add to it.

Although there have been few, if any, actual failures, wellhead fatigue issues are a key topic for the offshore oil and gas industry and authorities for new wellheads, wellheads in operation and old wellheads to be reopened or reused. Safe reuse or prolonged use of existing wellheads can prove very profitable.

Operational life

The operational life of the wellhead based on fatigue is a limiting factor for the efficient production from a well. The operational life based on fatigue is normally estimated based on riser and rig models and statistical weather, wave and current information as well as appropriate safety factors. Being a limiting factor, wellhead fatigue is currently of great concern in the oil and gas industry where the industry would like to reopen or prolong the use of a large number of wells with limited estimated remaining service life.

By using monitoring equipment, the actual loads inflicted on the structure can be measured. In many cases, monitoring will reveal an extension of the operational life of the structure since the actual loading for a set of operating conditions is less than the loads predicted from calculations.

While calculations are based on a combination of worst-case scenarios and conservative safety margins, monitoring can give a more accurate picture, and the gathered data may be used to improve the calculations.

Monitoring increases the safety

This implies that the use of monitoring equipment and data from monitoring increases the safety of the operations because the actual loads are better known. Besides, the operational window can be increased while the level of safety is maintained which, in the end, provides the operator with cost-benefits.

Several small fields with existing wells may be reopened because new technology now makes the production viable.

The monitoring equipment can be attached to the blow-out preventer (BOP) of the rig with sensors measuring the actual loads close to the x-tree or wellhead, and the loads applied to the wellhead during the drilling operations can be found. The monitoring data is continuously available through the corresponding online data acquisition system.

This monitoring method is a technological breakthrough that supplies the operators with useful data, assuring that the wellhead is not entering a phase of uncertainty. With our monitoring solution, you gain full control of your operations.

Monitoring is often difficult as the conditions at the field can be rough. Under certain circumstances, it can be beneficial to use monitoring systems on new wellheads as well, e.g. if the rig is large and heavy or in areas with strong current or shallow waters.

We also provide other equipment that can be attached close to the BOP connector of the rig or on the riser system and provide other measurements such as monitoring of tension, moments, movements and vibrations, for instance by use of an inclinometer that can measure tilt angle and linear accelerations and rotation velocities.

More than an analysis

In addition to providing the monitoring equipment including acquisition and visualisation of acquired data, we also analyse the data and add to the analysis know-how from areas such as riser analysis, wellhead fatigue, structure design, material analysis and corrosion control.

FORCE Technology is continuously improving and developing the reliability, user friendliness and accuracy of our monitoring systems. They may be used in rig advisory systems and as part of safety-critical applications.

LOAD & RESPONSE MONITORING

Knowing the actual loads affecting your structure and how the structure responds to these is the starting point for cost efficient risk based inspection planning.

The trend of reducing labour and cost intensive inspection, especially subsea and other inaccessible / hazardous areas, through the use of monitoring equipment is also relevant for offshore structures. Such effects can be reached when the monitoring activities becomes part of the risk based inspection philosophy, and in particular when the monitoring systems are installed as part of the design.

In order to maintain safety and ensure full continuous operation, it is vital to prevent excess utilisation of components. Strain, curvature, vibration, pressure, temperature, geometry, corrosion and movement are all factors that affect the remaining service life of an asset.

We hold more than 25 years of experience, and all our solutions have been field proven. Having our systems installed allows you to make more qualified decisions regarding utilisation, fatigue damage and life extension, which can lead to considerable cost savings, and decisions to modify and remedy can be taken at an early stage, before damage has occurred.

This provides increased operational reliability and safety, as well as prolonged service life, while at the same time meeting government requirements in a cost effective way.

Verification of the design

During design, the structural assessments are made using the available information of the load cases coming from sea current, wind and wave exposure, mass, drag etc. combined with the geometrical considerations of the structure. The load transfer into the structure is of key importance to get the simulation to reproduce the behaviour of the structure for various load cases. Using design codes and regulations in the design work, the model also includes an unknown safety factor.

A monitoring system measuring how the structure actually responds to the various combination of exposures can verify that the models and boundary conditions used are conservative, and that the responses are according to the design assumptions.

Calibration of the structural model

The next step is to use the load response information to calibrate the structural model and simulations. Improving the transfer functions bringing the correct load into the structure for the different exposure conditions, and tuning structural model so that the simulated response reflects the actual measured data.

This implies adjusting stiffness, material properties, soil interaction, interfaces, and safety factors etc., as well as the exposure, to transfer functions until one finds agreement, i.e. a model that reproduces the actual exposure to a reasonable load and response. Known safety factors may be added into such a model.

Exposure history & accumulated damage

Continuous monitoring of the structural response and exposure conditions improves the calibration of the model or identifies abnormal behaviour indicating changes in the integrity of the structure.

Structural simulations identify hot spots and accumulate fatigue damage to these, providing the structural integrity management with updated information on areas of interest, where the condition is acceptable or where there may be a need for further inspection.

Service life extension

Having the calibrated structural model with the accumulated damage at the various hot spots, forecasting and scenarios of future damage is done using the statistical exposure cases providing accurate input to service life extension process and decisions.

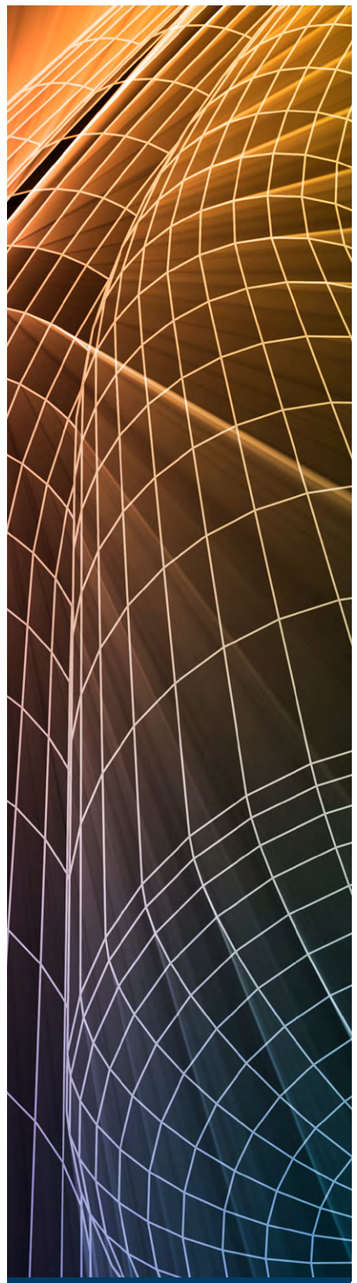
We offer monitoring solutions during fabrication and after the structure is offshore, above and below sea level for:

- Jackets and mono piles
- Foundations and grouted connections
- Concrete structures
- Risers and mooring

We use sensors measuring both the structural response and exposure with interfacing to existing sensor system, using online or autonomous units. Data handling, data quality assurance, data storage and data analysis and structural model calibration are all within FORCE scope of expertise.

REASSESSMENTS & LIFE EXTENSION STUDIES

We extend the service life of ageing offshore structures through structural reassessments and life extension studies, leaving you confident in the current state and future performance of your asset. Additionally, through SRS, we ensure that models of your structures are kept up-to-date with any recent changes in addition to performing analyses for revised loads, when necessary.



Assessments & extensions

Most offshore structures in use today, have a projected service life of about 20 to 30 years. The improvement of drilling and well technology, which has allowed for extended oil recovery, has lead to an increased interest towards extending the service life of these structures.

We offer an accurate and well founded assessment of your structure with regards to fatigue life, new environmental conditions and subsidence to verify life extension. We have an extensive track record with offshore load bearing structures, comprising design, verification and reassessment studies.

Work process and outcomes

In addition to evaluating the general condition of the asset, we also determine the effects of modifications, tie-in and corrosion - possibly revealing reserve capacities.

When suited, this is carried out via inspection and non-destructive testing (NDT) monitoring, involving continuous monitoring of critical components or areas.

The outcome of these analyses is either an inspection programme, a proposal for structural modifications or validation for extended operation. We have listed a few of our services as follows.

Engineering

- Evaluations
- Analyses
- Documentation

Drafting

- 3D models
- Conceptual level
- Detailed level
- Shop Drawings

In order to meet or exceed expectations, we maintain a close cooperation with our clients when defining the design basis and quality assurance program.

Structural reanalysis system

During the service life of an offshore asset, the structure will be subjected to a number of modifications, be it new risers or pipelines, or new and additional process equipment.

We provide a structural reanalysis system (SRS) for your structures with regards to in-place analyses, new environmental conditions, modifications or subsidence to verify the jacket for any modification.

Emergency response

Accidents can cause reduced capacity, making an immediate structural analysis highly important. We offer re-evaluation of the structural integrity at very short notice.

Benefits of SRS

By using updated models of your structure, we can quickly and accurately perform a reanalysis, ensuring our clients, as well as the authorities, that the structure is fit for purpose.

Significant changes performed during the service life is systematically implemented into the computer model. We keep track of all changes and any part accessing the SRS. We apply advanced analysis techniques and leading industry software when performing our assessments.

We maintain a close cooperation with our clients, and we take part in any structural discussions related to the structural integrity.

Estimations of the possible inspection areas for each inspection point

CERTIFICATION OF PERSONNEL

Make sure you or your personnel holds the appropriate certificates in order to perform tasks related to welding and brazing.

FORCE Technology Norway AS is an accredited and recognised third party certifier within both welding and brazing, and we hold the appropriate approvals to certify welding personnel. Our services may be executed at the learning facilities, in your workshop or on-site prior to performing the tasks.

The certification process

Certification is maintained in accordance with international standards and legislations for approval of such personnel. When the welder/brazer holds the necessary skills and workmanship, we usually follow up with an exam, which may result in a welder or brazer approval certificate.

Certification typically includes the following steps:

- Assessment of the welder's professional skills
- Welding of test coupon in accordance with an approved WPS (Welding Procedure Specification)
- Testing of the weld test coupon (The test coupon shall undergo Non-destructive and/or mechanical testing)
- Issuance of certificate

If the examiner judges that the welder is not capable of passing the welding test, we advise more training on areas of weakness. FORCE Technology Norway AS does not participate in the training of welding or brazing personnel.

Get your welding certificate digitally or on paper

On average, testing and issuance of certificate is taken care of within the week. The certificate is issued digitally, or you may have it printed on paper.

If you receive a digital certificate, as a customer, you will be registered in the FORCE Certification's on-line database, as well as the WeldEye PQ® database. This allows you to receive information on biannual confirmation and extension of certificates. Your company can perform the biannual confirmation of the welder's certificate on FORCE Certification's server.

Standards for certification of welders

Our Certification Body (CB) FORCE Technology Certification are appointed third party by Norwegian authority, Norwegian Directorate for Civil Protection (DSB), within the following:

- Certification of welders, welding operators and brazers/brazing personell Approval of welding and brazing procedure qualification (WPQR/BPQR)
- Some of the standards we follow:
- ISO 9606-1 Qualification testing of welders – Fusion welding – Part 1: Steels
- ISO 9606-2 Qualification testing of welders – Fusion welding – Part 2: Aluminium and its alloys
- ISO 9606-3 Approval testing of welders – Fusion welding – Part 3: Copper and copper alloys
- ISO 9606-4 Approval testing of welders – Fusion welding – Part 4: Nickel and Nickel alloys
- ISO 9606-5 Approval testing of welders – Fusion welding – Part 5: Titanium and zirconium
- ISO 14732 Welding personnel – Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials
- ISO 13585 Brazing – Qualification test of brazers and brazing operators

The 5 ISO 9606-x standards all apply to handheld welding, while ISO 14732 is for welding operators that perform either automated or mechanical welding. Welders and welding operators that are certified according to these standards are also approved for welding pressure equipment, in accordance with PED Pressure Equipment Directive.

You may also have certified welders and brazers for other standards*:

- ASME IX Welding, brazing, and Fusing Qualifications
- AWS D1.1 Structural Welding Code – Steel
- AWS D1.2 Structural Welding Code - Aluminium
- AWS D1.6 Structural Welding Code – Stainless Steel API 1104 Welding of pipelines and related facilities

*This activity is not accredited and the certificate/approval sheet will not carry the accreditation logo.

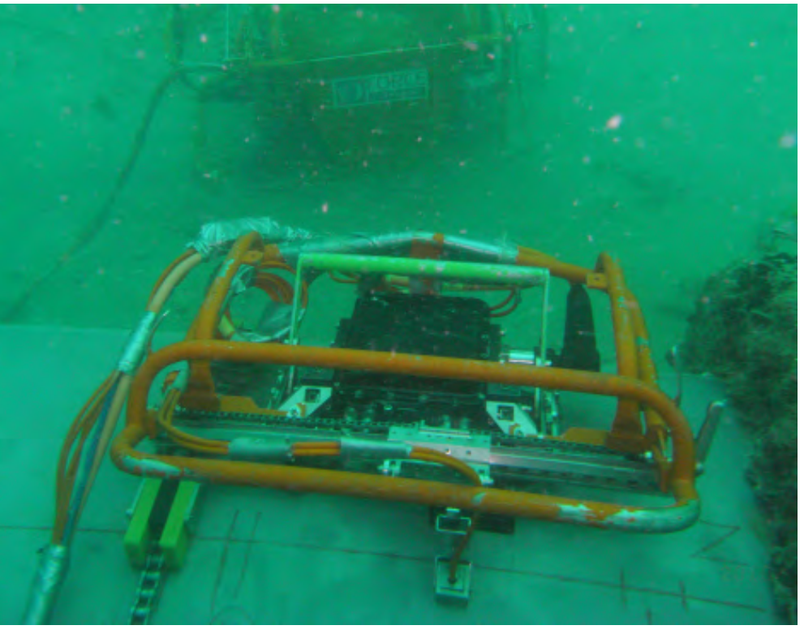
VERIFICATION OF PIPELINE PIGGING RESULTS

Cost-effective, fast and flexible subsea inspection services. For decades, FORCE Technology has secured owners of subsea constructions worldwide high quality data for optimal maintenance.

Condition monitoring of pipelines is carried out by intelligent pigging. Pigging is a fast technique to get a reliable status of the individual pipeline but the technique only provides relative wall thickness measurements. This is acceptable when there is limited or no corrosion in the pipeline. When more severe corrosion is detected the pigging must be supplemented with an additional inspection technique to provide absolute wall thickness measurements in order to provide a more accurate remaining life assessment.

Subsea P-scan

For more than two decades, FORCE Technology has provided subsea corrosion mapping with the subsea P-scan inspection tool. The subsea inspection tool is based on the P-scan system, which is an automated ultrasonic inspection system developed in-house by FORCE Technology.



This well proven technology has been used worldwide to provide accurate measurements of remaining wall thickness in pipelines and subsea structures.

The P-scan system is a computerised ultrasonic system for automatic, mechanical or manual ultrasonic examination of welds and materials. The P-scan system is in regular use in the industry for applications in power plants (conventional, nuclear, wind), offshore industry, refineries, shipbuilding etc. The P-scan system has documentation and storage facilities (hard disk, USB stick, optical disk etc.) for all data related to each inspection operation, and includes visualisation of the inspection results in the form of images of the material volume examined. The subsea P-scan can be deployed either by diver or by ROV.

The corrosion mapping can be supplemented with Time of Flight Diffraction (ToFD) corrosion measurements of the welds to provide full coverage of the pipeline.

Magnetic wheel scanner

The base of the P-scan inspection system is the magnetic wheel scanner, which can be configured for numerous applications. The scanner is fitted with powerful permanent magnetic wheels, which will attach to any steel surface including paint coating. The wheels are mounted in a boogie setup, which gives the scanner a small foot print on the surface to be inspected and allows the scanner to be easily steered remotely. For sideways movement of probes, the scanner can be fitted with tracks of different length from 250 mm and upwards. Standard is 500 mm. The scanner is fitted with encoders, which gives accurate position measurements of all the thickness measurements allowing for an accurate mapping of the obtained data.

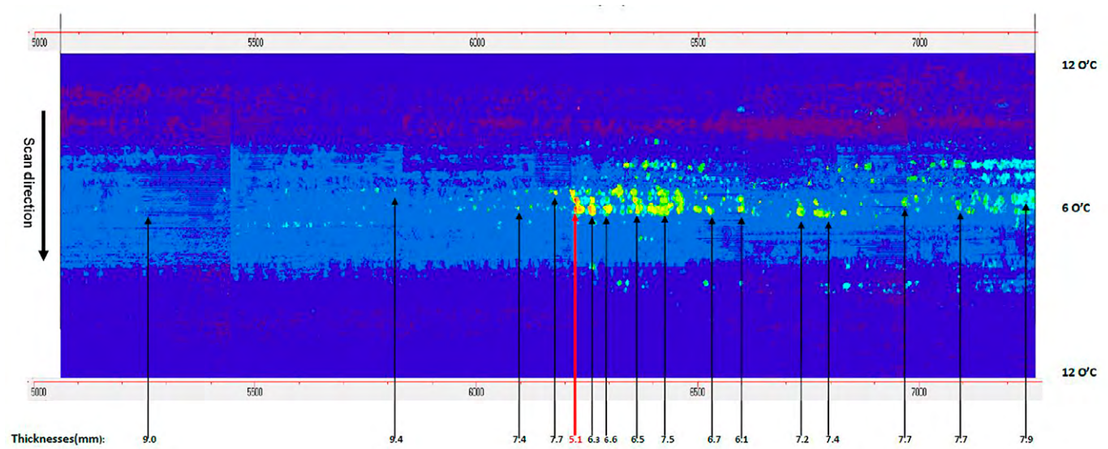
The magnetic wheel scanner is fitted with a handle, which lifts the magnetic wheels from the surface allowing for easy mounting and removal from the pipeline by diver or ROV.

Preparation of surface

In order to get accurate measurements, the surface of the pipeline must be thoroughly prepared. Eventual concrete weight coat must be removed and the pipe surface grit blasted.

Reporting of results

The obtained data can be visualised as a color coded map in the P-scan software and exported as images for reporting. The corrosion mapping data can also be exported to a spreadsheet for further evaluation. The level of reporting can be adapted to fit client requirements.

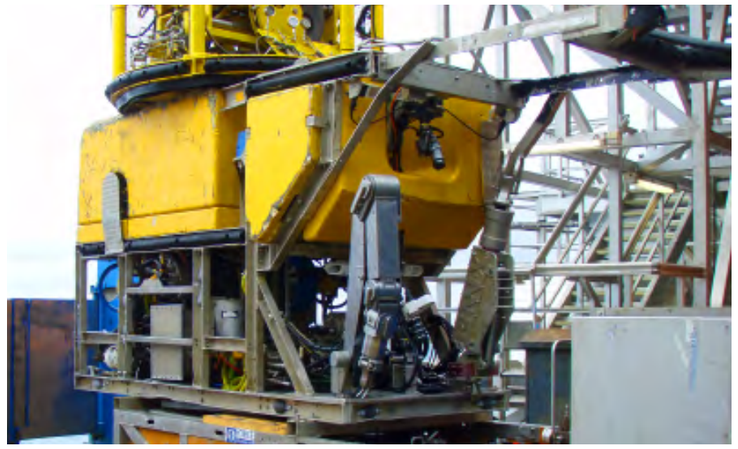


The benefits of subsea P-scan are

- Cost-effective, sturdy durable design which is easy to handle by diver or ROV and hence fast inspections
- Wide range of technologies ensuring the most beneficial equipment for the individual task
- High quality data with high resolution, providing excellent basis for remaining life assessment
- Flexible magnetic wheel scanner which can be adapted to numerous applications
- Proven track record.

TETHER WELD INSPECTIONS

Life extension of offshore platforms and change of loads at the platforms has led to increasing requirements for documentation of the condition of the welds. FORCE Technology has developed a specialised tool for subsea inspection of welds at tethers, and has since 2003 performed inspection at the Norwegian platforms "Heidrun" and "Snorre A", and latest at the American platform "Jolliet".



To perform these inspections, FORCE Technology uses the in-house developed automated ultrasonic system, P-scan.

P-scan

The P-scan system provides A-scan, B-scan, C-scan, T-scan (thickness mapping) and Time of Flight Diffraction (ToFD) mode, including averaging for sizing of defects.

Furthermore, the system provides projection images of the object under examination, e.g. images of the weld or part of an object. In the three projected images, TOP, SIDE and END views, the flaws, which are detected, are automatically shown at their correct location.

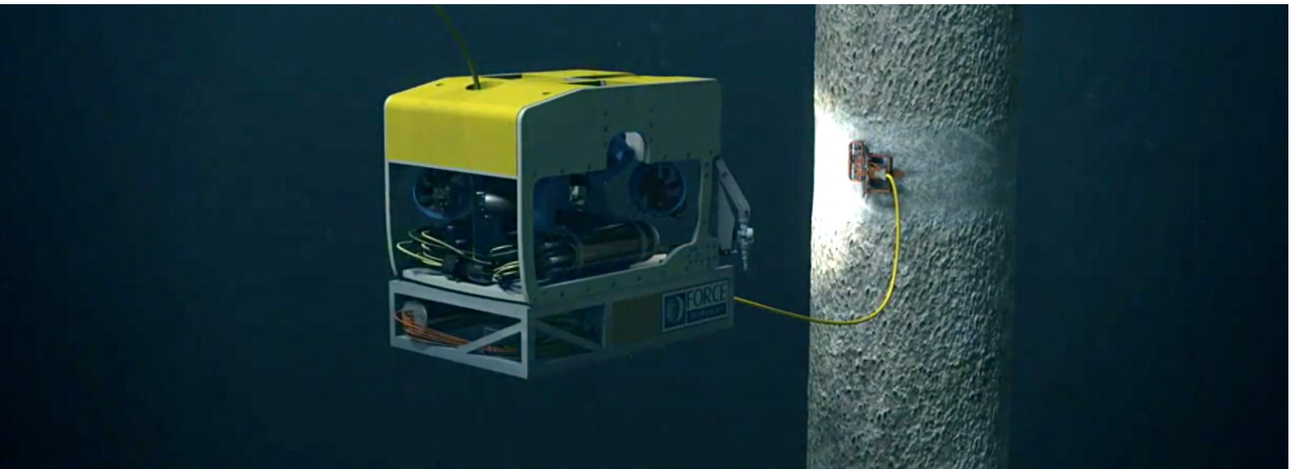
The base of the inspection system is the magnetic wheel scanner, which can be configured for numerous applications. The scanner movement is programmed and controlled remotely, and includes both forward and sideways movement of the probes.

The current subsea scanner is pressure tested down to 1,000 m water depth, and a scanner for 3,000 m is under development.

Inspection procedure

The main purpose of the inspection is to verify that no service-induced indications are present in the welds. Welding flaws are also detected, but it is assumed that their size is below the original acceptance criteria and therefore shall not be taken into consideration during development of an inspection procedure.

Subsea inspection.



The development of the inspection procedure includes a simulation of the inspection setup on the actual weld geometry to ensure that the chosen setup fulfils the requirements. The simulation can also include a "Probability of Detection" (PoD) study for selected flaws. The simulation is afterwards verified on a full-size mock-up.

FORCE Technology has the facilities to qualify the inspection system under realistic conditions with a large water tank and overhead crane for hoisting mock-up and inspection system into position.

Preparation of welds

To ensure that inspection of welds can be carried out fast and without interruptions, the marine growth must be cleaned off the weld and the area where the scanner will operate. Usually, this is 200-300 mm on each side of the weld.

The selection of welds for inspection is normally carried out by the owner of the offshore construction. The decision is based on the loads on the tether strings and history, if any of the tethers have been exposed to stress larger than normal, or records show that welding defects close to the original acceptance criterion are present in the welds.

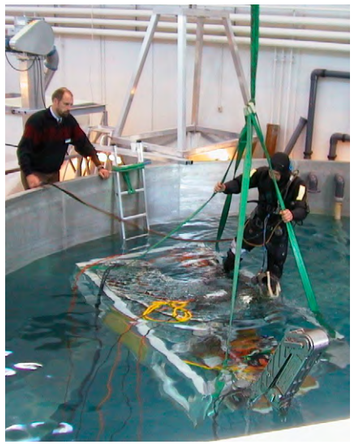
FORCE Technology has an in-house development department with substantial capacity within mechanics, electronics and simulation, which allows continuous adaptation and construction of new inspection systems for a broad variety of applications.

Conclusion

The FORCE Technology subsea inspection system has over a decade proven to perform valuable inspection on tether string welds and has at least the same capability as the inspection system used to perform inspection during production.

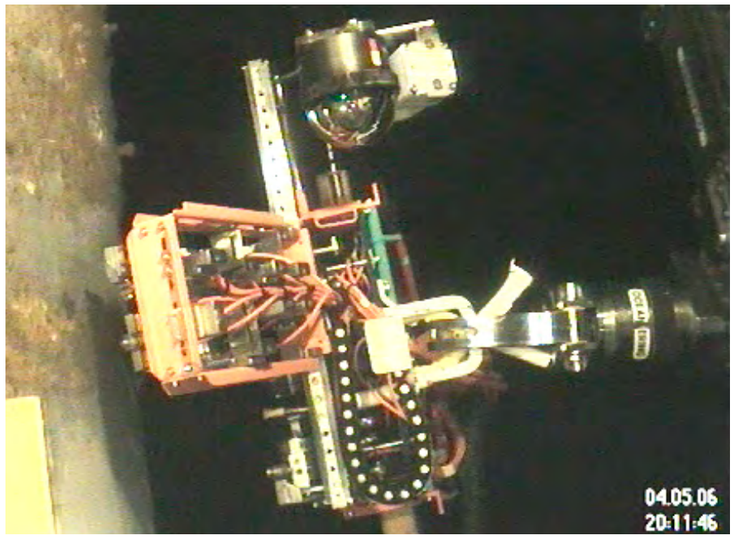
The inspection system has 16 ultrasonic channels which can be fitted with any type of ultrasonic probe, shear wave, compression wave, creep wave or ToFD. The probes can be combined arbitrarily as required by the inspection procedure. The inspection system also allows for addition of up to 8 eddy current channels.

FORCE Technology participates in projects involving extensive specialised knowledge, from the initial concept until delivery of the turnkey project.



Qualification in test tank.

Subsea scanner.



ADDRESSES

FORCE TECHNOLOGY NORWAY

Hvalstad - headquarters
FORCE Technology Norway AS
Nye Vakås vei 32
1395 Hvalstad
Tel. +47 64 00 35 00
info@force.no
Post adress:
Post box 76
1378 Nesbru

Bergen
FORCE Technology Norway AS
Salhusvegen 55
5131 Nyborg

Kristiansand
FORCE Technology Norway AS
Mjåvannsveien 79
4628 Kristiansand

Stavanger
FORCE Technology Norway AS
Luramyrveien 40
4313 Sandnes

Trondheim
FORCE Technology Norway AS
Hornebergvegen 1
7038 Trondheim

Harstad
FORCE Technology Arctic AS
Mercurveien 86
9408 Harstad

Hammerfest
FORCE Technology Arctic AS
Leirvikhøyda 6
9610 Rypefjord

Tromsø
FORCE Technology Arctic AS
Strandveien 41
9007 Tromsø

Tananger
FORCE Technology Arctic AS
NorSea Base Bygg 40
4056 Tananger

FORCE TECHNOLOGY INTERNATIONAL

DENMARK
FORCE Technology
Park Allé 345
2605 Brøndby
Tel. +45 43 26 70 00
Fax +45 43 26 70 11
info@forcetechnology.com

SWEDEN
FORCE Technology
Sweden AB
Tallmätargatan 7
721 34 Västerås, Sverige
Tel. +46 (0)21 490 3000
Fax +46 (0)21 490 3001
info@forcetechnology.se

USA
FORCE Technology
USA Inc.
3300 Walnut Bend Lane
Houston Texas 77042, USA
Tel. +1 713 975 8300
Fax +1 713 975 8303
info@forcetechnology.com

CHINA
FORCE Technology
(Beijing) Co., Ltd.
Room 707, No. 6, Ritian Road, Chaoyang District, Beijing
Tel. +86 10 85306399
Fax +86 10 85306399
info@forcetechnology.cn

SINGAPORE
FORCE Technology
Maritime Simulation
Services Pte. Ltd.
(Singapore)
1, CleanTech Loop
#03-03 CleanTech One
Singapore 637141
Tel.: +6564998280
fta@force.sg

FORCE Technology
Singapore II Pte. Ltd.
1, CleanTech Loop
#03-05 CleanTech One
Singapore 637141
Tel. +65 6499 8284
Fax +65 6499 8281
sy@force.sg

FROM KNOWLEDGE TO VALUE