OFFSHORE SERVICES

Contact: oilgas@forcetechnology.com

OIL & GAS

Contact: oilgas@forcetechnology.com
DEAR READER

The oil and gas industry is currently adapting to extremely low oil prices due to oversupply and fierce competition from unconventional production. What is more, exploration is getting trickier and more hazardous.

FORCE Technology provides multi-disciplinary services focused on energy sector companies that are engaged in upstream activities – from exploration and extraction to transmission and distribution. We serve designers, contractors and operators in oil and gas projects all over the world that range from the smallest assessments through to major projects.

Whichever phase your project is in, it is important that the advice or service you seek is delivered swift and thorough. To meet this enquiry, we have more than 200 experts and specialists within the offshore oil and gas industry and the maritime industry, covering almost any technical area.

Our experts have more than 40 years of experience within the oil and gas industry, which has positioned us with a well-deserved reputation as a preferred supplier of critical services such as design review, inspection and testing and integrity management. We are proud of this position and strive to maintain it.

Thank you for taking the time to learn more about FORCE Technology’s offshore competences.

Ole Øivind Andersen Clement
CEO

CONTENTS

Design
Wind tunnel test of offshore constructions ............................................ 6
Hydrodynamic offshore consultancy ....................................................... 8
Select materials with care ................................................................. 10
Advanced welding & realistic tests of large structures .............................. 12
Hook-up at turrets ............................................................................. 14
Structural design & engineering ......................................................... 16
Training dynamic positioning .............................................................. 18
Jack-up training ................................................................................ 20
Cathodic protection (CP) .................................................................... 22

Construction
Coatings for corrosion & wear protection .............................................. 24
Materials & welding ............................................................................ 26
Materials & testing .............................................................................. 28
Surveillance, owner’s representative ..................................................... 30

Operation
Equipment condition assessment ......................................................... 31
Audit ....................................................................................................... 32
Management systems: design, implementation & optimisation ................. 34
Advanced subsea inspection ................................................................. 36
Load & response monitoring ................................................................ 38
Calibrations & tests ............................................................................. 40
Services on oil, chemical & gas carriers .............................................. 42
Customise the process equipment to new methods ............................... 44
Monitoring of flexible risers ................................................................. 46
Top side corrosion monitoring .............................................................. 48
Non-destructive testing (NDT) .............................................................. 49
CFD in the offshore sector ................................................................... 50
Is the pressure equipment safe? ........................................................... 52
Verification of pipeline pigging results ............................................... 54
Tether weld inspections ....................................................................... 56
Wellhead & riser monitoring ................................................................. 58
Drone inspection solutions ................................................................. 60
Asset integrity management .................................................................. 62
Reassessments & life extension studies ............................................... 64
Cathodic protection (CP) inspection .................................................... 66

Damage & breakdown
Root cause & failure analysis ............................................................... 68
 Decommissioning studies ..................................................................... 70
Fracture mechanical evaluation & fitness for service ............................... 72

Education
NDT, welding & materials courses ....................................................... 73
Lack of “soft skills” & accidents ........................................................... 74
Radiation protection courses ............................................................... 76
OVERVIEW OF OIL & GAS OFFSHORE SERVICES
Wind and current loads
Offshore platforms are often subjected to harsh marine environments, e.g. strong wind and currents. This makes heavy demands on the platforms' dynamic positioning, mooring and stability capabilities.

At FORCE Technology, we have performed tests on platforms for a wide range of customers. As such, our professional staff of naval architects can test your platform whether it’s a semi-submersible, spar, tension leg, concrete gravity based, jack-up or jacket. By performing load tests on the above-water and underwater parts of an offshore platform, it is possible to determine the wind and current loads that can be used for towing, dynamic positioning, and stability analyses.

Analysis of smoke stacks
Our customers face a major challenge to ensure that smoke nuisance in outdoor working areas is minimised, thus enabling the crew to work without experiencing the discomfort of smoke or noxious gases. We provide a full suite of services to evaluate smoke nuisance including smoke visualisation, smoke dispersion tests from funnel and tracer gas measurements to evaluate noxious gases in crew areas, engine intakes etc.

Helicopter operations
A large number of offshore platforms and vessels are equipped with a helicopter landing deck. The helicopter landing deck can be used for commercial, exploration or safety purposes. Especially for safety purposes, a permanent serviceability even under difficult and adverse wind and sea states is of paramount importance.

Testing a vessel or offshore platform in a wind tunnel experiment at an early stage of the design is an ideal tool to explore potential risks concerning helicopter operations. At FORCE Technology, we have years of experience with wind tunnel testing as to helicopter operations and can therefore help you with almost any challenge you may have with regard to optimising helicopter operations on ships and offshore platforms.

Wind chill index analysis
For offshore units, it is often the harsh environments with low air temperatures and high wind speeds that will affect the outdoor working environment; sometimes even to a degree where the working time for the crew is limited due to risk of human injuries. Therefore, a major challenge faced by our clients is to foresee and document the outdoor environment in order to reduce risk as well as expensive limitations in working time.

A way to evaluate the outdoor working environment is by assessing the “Wind Chill Index”, which estimates the cooling rate of skin exposed to the surroundings. WCI is affected by the wind speed and air temperature and can be precisely measured in our wind tunnels.
At the early design stage, numerical analysis and initial model tests can help the designer with valuable input to the design process. The investigations can provide information about motions, accelerations, wave run ups, load on mooring systems, wave impact loads on deck equipment, wave impact loads on segments or specific points on the structure etc. This information is crucial for the designer to tune and optimise his platform design.

FORCE Technology provides early design stage services on any type of floating structure including semi-submersibles, SPAR platforms, FPU’s, FPSO’s, jack-up platforms, cable layers, special purpose vessels etc.

Detailed design phase
In the detailed design phases, assignments are either performed as advanced model test in our large towing tank or by utilizing our CFD tools to perform advanced seakeeping or flow calculations.

Here we offer numerous types of more detailed model test assignments where key areas are seakeeping studies, vortex induced motion (VIM) investigations and manoeuvring assignments on offshore structures. This information is crucial for the designer to verify and obtain approval from class and authorities.

A better performance can be obtained by optimisation of the aft ship for the best bollard pull as well as of the fore ship using CAESERS for minimum resistance. This combination provides optimum performance for the vessel in transit or working mode.

Through the years, FORCE Technology has provided advanced model test campaigns and CFD based optimisation on a wide range of floating structures including semi-submersibles, SPAR platforms, FPU’s, FPSO’s, jack-up platforms, cable layers, special purpose vessels etc.

Seakeeping tests.
SELECT MATERIALS WITH CARE

Selecting the right material is crucial for operators within offshore oil and gas where equipment and structures must operate in some of the harshest environments found on this planet.

Offshore oil and gas production takes place in particularly harsh environments involving stringent requirements for the materials applied. Sea water and high temperatures, CO₂ and hydrogen sulphide, rare minerals and complex chemicals are just some of the tough conditions met in the offshore oil and gas sector. Pipelines, process plants, utility systems and other structures are exposed 24/7 to a multitude of different substances. The combination of harsh environment, pressure and temperature poses a risk of corrosion, cracks and fractures in metallic materials.

Selecting the right types of materials is therefore essential for companies in the offshore oil and gas sector, both in terms of safety concerns and environmental protection, but also to minimise unscheduled downtime and to ensure maximum service life of equipment and structures.

Independent advice
FORCE Technology provides independent and qualified advice on material selection for all types of equipment and installations, whether it comes to new structures or modifications and replacements of equipment, for example as a consequence of failures.

The optimum solution
The overall challenge in material selection is to align the material properties with the conditions to which the material shall be applied. Is it sufficient to use carbon steel for the specific process? Or does the corrosive environment or other circumstances require an upgrade to corrosion resistant alloys (CRAs) such as stainless steel, copper, nickel or titanium alloys?

By means of thorough analyses based on existing standards, material knowledge and experience, our specialists provide the optimal solution to ensure that the requirements of quality, safety and environment are fulfilled, taking the cost level into account.

Insight into current standards
We have a vast knowledge of applicable standards in this area such as ISO 15156, DNV GL and NORSOK, and we master the interpretation of standards. This way we are able to ensure that equipment and structures may be approved by international classification societies such as DNV GL, BV or Lloyds. Moreover, we often assist operators in developing their own company standards.

Experience from failure analysis
Our evaluations are partly based on FORCE Technology’s extensive material database which is updated regularly based on the latest international research. We also actively participate in international networks, such as NACE International, to exchange experiences in the relevant field.

In addition, we gain a significant amount of knowledge about the material properties from failure analyses that we conduct regularly for companies in areas such as the oil and gas sector.

Rapid response
With a large organisation of specialists, we are able to provide fast and accurate results for all types of customers within the oil and gas sector.

In a typical workflow, our specialists obtain all necessary data in co-operation with the customer and then conduct all calculations, evaluations and tests and examinations, if any. Based on this, we prepare a detailed report with recommendations that may form the basis for the right selection of materials or be part of a more comprehensive basis for decision.

Experience in material selection
FORCE Technology holds more than 40 years’ experience in helping operators and suppliers to the oil and gas sector to ensure optimum material selection.

Our specialists have great insight into material properties, industry-specific issues and international standards. We cover everything from analyses of pressurised equipment to qualification testing of materials, welding and inspection.

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 pipelines, includes all these models.

In order to evaluate corrosion resistant alloys for sea water applications, we utilise our understanding of electrochemistry and material characteristics.
ADVANCED WELDING & REALISTIC TESTS OF LARGE STRUCTURES

FORCE Technology and LORC have established a test centre with focus on full-scale testing of components and systems mechanically and in climatic chamber. Furthermore, Lindoe Welding Technology (LWT) may assist in developing new welding technologies.

The high power equipment makes it possible to introduce laser welding and laser hybrid welding for heavy section components.

We can help you test and implement high-power lasers within all aspects e.g. process development, prototyping, small-scale production, implementation and training.

Can your system withstand the environment?
In the climatic test chamber, realistic atmospheric sea conditions can be simulated even for large components, not to mention entire systems.

The climatic test chamber is equipped with three individual environmental systems:
- Temperature control
- Humidity control
- Salt water spray.

The three environmental parameters can be individually controlled or programmed as consolidated systems to come as close to the harsh offshore atmosphere as possible. In addition, accelerated tests can be conducted in combined parameter cycles.

Examples of test items to test in the climatic chamber include e.g. top-site cranes and other functional equipment exposed to the environment, but also test of process equipment to verify the functional durability and the long-term maintenance operability is possible due to a realistic test regime. Additionally, coatings, material combinations, NDT equipment, insulation systems etc. can be tested for resistance to the harsh environment.

Testing, evaluating and optimising your equipment properly before installation will confirm lifetime sturdiness of your product.

Introducing excessive strain on the structure - to be on the safe side
Mechanical testing of components is widely used to determine whether these comply with standards or other requirements. But how about the performance of complete systems? The mechanical test bench can be used to test large components for simple strain robustness or for fatigue resistance.

It has a large strong floor and inter-related reaction walls along two sides of the plane.

This structure makes it possible to test full-size structures with a three-dimensional stress set-up, relevant for structures exposed to e.g. waves, wind and alternating loads simultaneously.

It is possible to simulate realistic fatigue loads based on recorded operational loads. Special test set-ups incorporating sea water exposure to fatigue relevant areas in order to run tests for corrosion fatigue can also be prepared.

The possibility to test full-scale systems will give you the documentation for the durability of the structure based on real-world effects.

Various programmes are developed to suit the testing requirements: Sinus, abrupt, saw tooth etc.
Preceding, FORCE Technology has been assigned to evaluate and perform simulation studies of hook-up procedures. The simulations should form the basis for deciding the tug size needed during the hook-up between the FPSO and the buoy at the oil field. The simulation studies were performed by means of in-house developed mathematical and visual simulator model of the FPSO.

Seen from FORCE Technology’s point of view, the project was special as all departments in the Division for Maritime Industry were involved in model testing, simulating, training and evaluating different aspects of the complex operations.

Wind tunnel testing and mathematical models

The tests started in one of FORCE Technology’s five wind tunnels to determine the wind and current forces acting on the FPSO which are crucial in the structural design of turret and moorings.

By combining the aerodynamic data from the wind tunnel tests with the hydrodynamic forces acting on the ship, a simulator model of the FPSO was generated using our in-house developed maneuvering prediction and ship generation tool ShipYard which is a part of the SimFlex simulator setup.

Fast-time simulation

Once the mathematical model was developed, fast-time simulations of the hook-up between the turret and the FPSO were performed, and the size and number of the necessary tugs needed to bring the FPSO safely on top of the turret were evaluated.

The hook-up simulations focused on the ability to move the vessel to a fixed position and to keep the vessel in that position during the operation. To make the scenarios as realistic as possible, the simulations covered periods of three hours to confirm the ability of the tugs to bring the vessel in position over the turret and maintain its position for a long period of time. Tolerance-wise, the most critical part is just before the connection starts, since the turret, after connection, will gradually help maintaining the position as it is being pulled in.

Subsequently, FORCE Technology evaluated the tug size needed in order to perform the riser pull-in procedure. This is the operation where the vessel is connected to the turret and is pulling in and connecting the risers. Maintaining heading during this operation is crucial.

During the simulation of the riser pull-in procedure, the FPSO was moored to the turret, and its mooring system provided the right response in all degrees of freedom relevant to the assignment under the influence of wind, waves and current.

Training of crew

Finally, the tug captains assigned to perform the installation were trained in the approach and riser pull-in maneuvers with the FPSO. This training was carried out in the advanced full-mission simulators at FORCE Technology.

The simulations were performed at FORCE Technology’s facilities with the mathematical model of the FPSO and two mathematical tug models with similar dimensions and bollard pull as the tugs considered for the real hook-up operation.

By performing both model testing, simulation and training at FORCE Technology, it was ensured that the data generated and used for the mathematical model of the FPSO was as precise as possible in order to make the best replica of the way the actual installation would take place.
Choosing a design that is optimal for its purpose, is safe for its people and its environment while maintaining low costs is a challenge that we solve daily. We review all aspects from concept studies to front-end engineering and detailed engineering, as well as fire and gas explosion studies. Applying a multidisciplinary approach with highly specialised engineers within a range of fields allows us to find the solution that suits your needs.

**Concept studies**
Choosing a concept that will both support the topside and sustain environmental forces and impact, is vital to ensure a long and reliable service life. We aim at finding the concept that is right for you.

Several designs are evaluated, reviewing the overall dimensions, bracing arrangement, number and size of piles, all of which are highly dependent on topside size and weight as well as water depth. In-place conditions are also analysed.

**FEED studies**
Once a concept is determined, we continue with a FEED study. FEED stands for front end engineering design, and comprises more detailed analyses and reports such as the ones listed below.

- Design drawings describing the structure
- Layout drawings for appurtenances
- Conceptual drawings for installation aids
- Conceptual drawings of walkways, access platforms, rigging platforms, ladders
- Installation and transportation drawings
- Documentation reports covering the
- Operation phase (ULS, ALS, FLS), the transport and installation phases (ULS, FLS)
- Fabrication schedule and plan
- Weight and material take off.

In addition to the in-place conditions and boat impact analyses, other phases such as load-out, transportation and installation are evaluated.

**Detail engineering**
For jackets and smaller offshore structures or modifications to flares, helidecks and similar, a detail design is performed. We offer detail design, covering all aspects including temporary phases and sea fastening.

**Third party verification**
We perform verification during all design stages, reviewing drawings and documentation and providing an independent analysis of all design-related aspects. We also provide consultancy and review of specifications. Our experience involves verification of structural design and construction of jackets, topsides and floating structures.

We perform design verification on:
- Fixed platforms
- Floating platforms
- Marine installation.

**Computational fluid dynamics**
We offer computational fluid dynamics (CFD) analysis within various areas, performed in full-scale dimensions and flow conditions.

CFD makes it possible to simulate and describe flows that are complicated, expensive or even impossible to create using experimental methods. CFD can thereby ensure that the amount of experiments are reduced, thereby minimising cost.

**Advanced structural analysis**
We provide linear and non-linear analysis of global and local structure. We can also offer refined and detailed finite element analysis. Advanced structural analysis makes it possible to optimise the structure and reduce both weight and unnecessary cost.

**Hazard engineering**
We offer assessment of loads and response due to: gas explosion, fire actions, boat impact, falling objects, and more. In combination with advanced structural analysis, the potential to optimise the structure and save both weight and unnecessary cost is high.

**Integrated assessment of fire and structural response**
Structural response due to fire actions is assessed by applying heat flow, based on radiation, convection and conduction to the system. As temperatures change, the material properties are likely to be degraded. We analyse both thermal and structural responses. These assessments determine the need for corrective actions such as passive fire protection or any other modifications necessary.

**Gas explosion assessment**
The objective of assessing gas explosion loads is to meet the design specifications for the design and/or strengthening of main topside structures and blast restricting walls, and to establish input to a risk analysis, documenting the safety of the installation.

We have experience from various projects in the field, and we employ experts within all relevant areas. Assessment of gas explosion loads is also used as a basis for weight optimisation of topside designs built to reduce gas explosion hazards.
Operating in harsh weather introduces particular challenges and increases risks because the weather windows for the operations become narrower. As a consequence, dependable DP performance is necessary during the approach, touchdown and soft pinning. This, again, requires both training in a given operation and the ability to verify the feasibility of it.

Train the risk down
To support the need for training and verification, we have developed an advanced simulation model including jack-up functionality and interfaces enabling integration of DP systems. This offers crews of jack-up vessels the opportunity to train the challenging operation before performing it in real-life.

As the vessel’s legs are lowered, making contact with or being raised from the seabed, the environmental forces, wind, waves and current, acting on the legs change. Consequently, considerable changes occur in the motional behaviour of the vessel, its stability and often also in the effectiveness of its manoeuvring devices, thus affecting the performance of the DP system. Such situations may benefit greatly from simulator training to reduce uncertainties and risks.

Fast-time simulations
The new simulator model allows fast-time simulations to be carried out during which the legs are lowered or raised while manoeuvring the vessel into a position or maintaining a position on DP. This contributes to a risk and capability/performance analysis in all kinds of weather conditions.

An example could be a simulation of an approach for a jack-up vessel equipped with azimuth thrusters and bow tunnel thrusters. Initially, the legs are lowered to a short distance above the seabed while remaining at a standoff position some 400 m away from the final position.

Next, the vessel is moved under DP control at a speed of approximately 0.5 knots to a soft pinning position where the legs are soft pinned. The legs are then raised a few feet, and the vessel approaches the final position at a reduced speed of 0.2 knots. As standard practice, the vessel heading is maintained constant throughout the approach.

The simulated approach is then repeated for different wind, waves and current scenarios, leg deployment depths and water depths, thus allowing an evaluation of the feasibility of the operation.
We have developed an advanced simulation model to support the final lifting sequence of self-propelled lift vessels. The simulation model includes jack-up functionalities interfaces enabling integration of DP systems.

Self-propelled lift vessels provide a very efficient and cost-effective platform for many offshore operations including wind farms. Once on site and with the legs lowered, the final lifting sequence can commence.

This is a critical moment where the value of all the preparations unfold as the spudcans penetrate the seabed. Our advanced simulation model supports this. It includes a model of the bearing capacity versus penetration of the seabed, allowing for realistic penetration of the spudcans, horizontal forces from spudcan sliding and incidents such as rapid penetration (punch-through) and suction. The soil-bearing capacities are modelled as a function of depth and associated with the individual spudcan.

Training not only challenges the extreme and dangerous situations, e.g. punch-through, it also covers the daily routines which can be fine-tuned, thereby building competences quickly and safely which otherwise would take years at sea.

**Modelling of the seabed**

Correct modelling of the seabed bearing capacity is essential but also one of the more complicated and inherently non-linear issues. The model assumes equilibrium between bearing capacity and the load carried by the legs/spudcans which is a combination of mass, environmental loads, and buoyancy-induced loads.

The seabed is modelled with the characteristics of a real seabed including stratification, i.e. different layers with different bearing capacities. Seabed liquefaction, i.e. the slow compression of the seabed after the rig has settled, is included in the model.

**Comparison case**

To illustrate the capabilities of the new jacking functionality, a simple comparison case has been arranged in which the jacking out of a rather small barge-shaped 3-legged jack-up vessel is simulated with two different soil-bearing capacities. The first case has a linear bearing capacity, i.e. resembles an ideal uniform soil, whereas the second case has a non-linear bearing capacity for only one of its jack-up legs.

The simulation starts with the jack-up legs already deployed to a short distance above a horizontal seabed. All three legs are then being lowered at a speed of 1 m/min., and shortly after the legs make contact with the seabed, thereby giving a short impulse load to the vessel which is visible in the time-history of the first few seconds of the trim angle.

At a penetration depth of around one metre for the uniform soil case (solid lines), the rate of penetration depth and leg force over time is slightly decreased. The cause is the hull now being lifted out of the water whereby its buoyancy is gradually reduced. At a penetration depth of around 2 m, the vessel is lifted completely out of the water, and the forces do not increase further as they are in equilibrium with the total displacement of the vessel minus the weight of the three legs.

In the case with a non-linear soil, a punch-through is seen as expected for leg 1. The force on leg 1 is also larger, and the vessel is undergoing both heel and trim – which in a real-world situation would have required manual intervention.
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 (page 66)
• CP management and consulting.

Many of these services draw from our in-house developed 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 and hybrid systems. SeaCorr™ is an excellent tool to use when considering anode retrofit and life extension, as it utilizes 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 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 structure.

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.

Resistor controlled cathodic protection (RCP)
Resistor controlled cathodic protection (RCP) prevents internal corrosion of stainless steels. It is highly applicable in chlorinated sea water 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 6,000 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.
Protection with coatings never ends
FORCE Technology offers professional consultancy and services regarding surface treatment of oil and gas constructions – on- and offshore. Our certified inspectors and material specialists have extensive experience in providing specifications for surface treatment as well as on-site inspections including failure analyses and trouble shooting.

Protection of material
In the initial phase, FORCE Technology can assist owners and refineries in evaluation and specification of the protection against wear and corrosion and the necessary inspection levels. We select the optimum coating types and systems for the individual parts of the constructions, and tailor-make control procedures before, during and after the protective application.

Selecting materials
FORCE Technology also offers consultancy services on the choice of the optimum resistant materials. It may be an advantage to have special parts galvanised or thermally sprayed instead of being painted, or ceramics, particular alloys or composites, may be introduced. The cost-benefits by introducing these materials and means of protection can be verified.

Thermal spraying
Thermal spraying can significantly reduce the cost of replacement and/or redesign of critical offshore components as the process permits local improvements to the surface. The spraying process does not induce material changes in the base material, and the surface properties can be tailored to the specific needs for any given application, e.g.

- Repair and refurbishing of damaged surfaces on costly parts, e.g. shafts, bearing houses etc.
- Protection against wear of critical areas by application of hard and wear-resistant layers
- Corrosion-resistant surface coatings
- Thermal barrier coatings.

FORCE Technology has more than 25 years of experience in thermal spraying. We perform repair and optimisation of single components as well as high-volume production in our state-of-the-art thermal spraying facility.

On-site maintenance services
FORCE Technology may provide on-site consultancy on maintenance. A typical survey carried out by FORCE Technology’s certified inspectors and material specialists will give our customer a report including recommendations of repair, coating systems and inspection levels during repair. While the refinery or rig is in operation, we offer coating condition surveys with the aim of designing the best and most economical way of re-protecting your asset during its upcoming maintenance period.

During the overhaul, FORCE Technology’s certified inspectors (FROSIO NS 476) monitor all coating operations to certify that all planned repairs are carried out according to specifications and mutual agreements.

An independent survey or inspection report from FORCE Technology always includes designs aimed at future protection.

Failure analyses
In the event of claims, FORCE Technology’s non-biased surveys will provide the owner with solid technical information for the contract negotiations and court litigation. Our forensic services comprise (but are not restricted to) an investigation of root causes of coating failures and corrosion damages. These services include professionally executed microscopic and chemical analyses of coatings, material quality, chemical composition of corrosion products etc. to support the investigations.

Your benefits
- Verification of your product’s compliance with specifications and standards
- Competent full project supervision
- Permanent and certified overview of project progress
- Third-party professionals supporting in-house staff
- Monitoring by independent specialists
- Professional consulting and training.

Contact: oilgas@forcetechnology.com
MATERIALS & WELDING

FORCE Technology’s consultancy is based on extensive knowledge of materials and practical experience obtained through many years’ intensive work within this field. In that context, FORCE Technology has been developing a solution for an optimised welding method of on-site pipewelding on a production platform for Maersk Oil.

Supervision during welding
- Materials and filler materials
- Preparation of joints and tack welds
- Data during welding
- The completed weld
- Heat treatment
- Non-destructive testing.

Supervision after completion of the welding work
- Carry out regular surveys in service to ensure compliance with standards and roles.
- Checking the structure according to the standards required for their class
- Visual control
- Witnessing pressure testing
- Surface treatment inspection
- Reviewing end documentation
- End treatment of all deviations.

Automated pipewelding at Tyra West

The overall requirements were that, as compared to the present methods, the new welding method must save time, and the quality must be improved (e.g. reduce the number of welding defects on the basis of selected welding process).

But when talking about an oil rig, the superior requirement when welding is safety.

Analysis and verification
During the analysis, different welding methods and tests were used to verify the different solutions. In the final verification, the focus was on whether the welding of parts met the specifications of the oil industry.

A demonstration of the selected welding method was conducted for the customer and the supplier of the equipment at a 1:1 scale.

Solution
The selected solution was manual welding of root pass in vertical downhill position and build-up by automated welding process which resulted in time saving for each welding.

FORCE Technology performed procedure testing according to customer specifications and preparation of welding specifications and work instructions for use when welding on-site.

Weld technical consultancy
We provide practical as well as theoretical consultancy in connection with weld technical questions. We have welding engineers, welding technicians and specialists with many years’ experience.

We advise on interpretation of standards and material tenders as well as in interpretation of specifications for welding, WPS for your requirements. Furthermore, we optimise welding processes and choice of equipment and solve problems regarding production equipment and optimisation.

Procedure tests
We supervise and verify procedure tests according to EN ISO 15614-XX and other relevant standards.

We supply surveyors, material specialists, mechanical specialists, welding specialists and NDT specialists to ensure that you meet the technical rules, standards and other specific requirements, e.g. from the classification societies.

Certification
We perform certification of welders according to EN 287-1, ISO 9606-2, -3, -4, -5, EN 1418, ASME IX and other relevant standards as well as approval according to the PED directive.

Our consultancy is based on extensive knowledge of materials and practical experience, obtained through many years’ intensive work within this field.

We have wide experience in performing welding supervision/inspection in companies with production or as a third party auditor to verify the capacity of other companies within steel producing companies, shipyards, refineries, power plants, medical manufacturers, fuel oil installations on new constructions, repair and overhauls worldwide.

With insufficient welding inspection you risk quality problems, and it is therefore important to make ‘prior to’, ‘during’ and ‘after’ welding inspection.

Welding supervision/inspection prior to production start
This is a crucial point at which to ensure the correct quality of the product, whether you are the contractor or a supplier.

We may participate in pre-qualification of suppliers and sub-suppliers as well as review of production and product requirements in co-operation with the contractor and supplier.
Mechanical and chemical properties of materials are key factors in all oil and gas engineering designs. Practical applications often use the materials close to their limits and harsh environments, high pressures and tremendous mechanical loads are part of the everyday challenges met by engineers in the oil and gas industry.

Material limits
Materials in facilities on a production platform, a FPSO unit or for subsea application are evaluated with regard to the mechanical properties as well as chemical resistance. Especially corrosion and cracking phenomena related to sulphide service may require special attention, e.g. for flexible pipelines. Stainless steel and other high-alloyed materials are widely used in these areas. FORCE Technology holds great expertise within highly corrosion-resistant materials, including evaluation of corrosion properties and testing in relation to specific materials and to welding and surface treatment of units such as tanks, pipes and pumps.

Standardised and customised testing
FORCE Technology’s expertise includes metallic as well as non-metallic materials, and our laboratories service all types of oil and gas segments from consultancy on material selection to testing of chemical and mechanical properties. Defining appropriate material tests and acceptance criteria is often a challenge. In many cases, test and requirements may be found in international standards. If not covered here, we establish customised testing to evaluate whether the materials are fit-for-purpose.

Accredited services
Modern materials are specified according to international standards, and materials and methods used in the oil and gas industry are subject to the industry’s own very strict quality control. FORCE Technology is accredited within all our chemical and mechanical testing and analyses as well as NDT activities. Tests are routinely surveyed by certified bodies.

Welded specimen failing ASTM G48 corrosion test.

Corrosion attack in flange of type 6Mo assembled with duplex stainless steel spiral wound graphite gaskets.
Globalisation, requirement for “local content”, increased competition on price, tight project time schedules and much more, all increases the need for use of suppliers and sub-suppliers unknown to the owner/end user. The representative can act as:

- **Owner’s representative** – direct reference to end user, serving only one “master”
- Process (welding, NDT and coating) specialist surveyor – monitoring craftsmanship, better quality
- Close first-hand monitoring of progress – any delays can be identified early and action initiated without delay
- Flexible resource – man up/down according to project intensity.

The quality of the entire delivery depends on numerous factors:

- Design quality
- Specification detail
- Communication between designer, owner, workshop and classification body
- Experience and attitude of workshop
- “Enforcement” of procedures and specifications.

**Owner’s representative**

Numerous consequences of poor quality in the manufacturing processes normally show after delivery and commissioning. They can result in leakages, cracks, corrosion or excessive wear, often during operation when most inconvenient, maybe resulting in unplanned shutdown etc. at great costs to the operation.

FORCE Technology has a long history of acting as an owner’s representative in all phases from design, evaluation of suppliers, processes, construction, installation, in-service monitoring, maintenance and repair. Assignments can vary from participating in meetings for a few hours to surveying on site for the entire duration of the project.

Close and frequent reporting from the owner’s representative to the client is an important and natural part of the service. Extent and intensity can be adjusted according to project activity throughout the contract period.

Experience shows that placing a qualified owner’s representative at the construction site during the project can have a significant impact on the final success of the project.

**SURVEILLANCE, OWNER’S REPRESENTATIVE**

**EQUIPMENT CONDITION ASSESSMENT**

The continuous development of new technologies makes it possible to enhance the degree of extraction of oil and gas from the reservoirs. Thus life extension of ageing field production platforms is often required.

The condition of offshore equipment is essential with respect to safety and to avoid environmental impact. Based on many years of experience within offshore structures and facilities, FORCE Technology is able to perform equipment condition assessment.

**Pre-yard stay inspection**

FORCE Technology’s experience within corrosion and protective coatings makes it possible to make a production life extension and to identify the scope of a possible coating repair programme. Furthermore, FORCE Technology has experience in pre-yard stay inspection of coating on drilling rigs in order to determine the costs and time consumption which is to be expected during a yard stay.

FORCE Technology also has experience within inspection of the condition of e.g. rotating equipment, cranes, vessel and pipe work in order to evaluate the condition and extent of possible repair work.

In offshore environment, corrosion resistant alloys (e.g. stainless steel) may corrode very fast. FORCE Technology may inspect the damaged parts to clarify whether the failure is due to poor materials selection, incorrect handling or nonconformity of materials to relevant standards.

**Unintended incidences**

In case of unintended incidents where a metallic material has been exposed to either mechanical damage or unintended heat, FORCE Technology is able to perform an on-site metallurgical examination and hardness test. This is done in order to verify if the material has been severely damaged and needs replacement.
FORCE Technology provides a wide range of services within this field, including auditor training, internal audits at your premises and external audits of your suppliers.

The result of an audit shows if the company is able to achieve its objectives with the present management system structure and activities.

Auditor training
FORCE Technology trains auditors at all levels – from the new and inexperienced auditor to the experienced auditor who wishes to develop further skills.

Training is conducted in several ways:
- Planned training with a duration of 1, 2, 3, or 5 days – including IRCA-approved lead auditor courses with examination (the International Register of Certified Auditors)
- Company-adapted training – tailored to the requirements of your company
- On-location training of auditors, including audit coaching, with focus on identifying opportunities for improvement. This type of training would typically consist of 3 separate training days with intervening assignments.

Internal audits
An offshore company may benefit greatly from having an impartial authorised body conduct the internal audits.

The company may benefit by:
- Improving its ability to manage limited personnel resources
- Professional sparring in relation to the management system
- Having audits performed in areas where the company’s resources are inadequate or there are no internal auditors who are not involved in the audited area available; e.g. internal audit of the company’s QHSE organisation
- Getting an outside view of the company and its management system.

Our consultants hold extensive experience in conducting internal audits for offshore companies, and their focus is pragmatic and value adding. Our consultants look at the different aspects of the management system from the company’s perspective as well as from the perspective of their own extensive experience.

We supply objectively assessed facts as input to the company’s management decisions.

Supplier audits
You may choose our consultants to perform your supplier audits if you lack in-house resources or require special competences.

Audit is an excellent tool for assessing the supplier’s level of compliance with legal and contractual requirements, both at the technical and the management level.

FORCE Technology provides audit teams that cover a wide range of technical and audit skills and have extensive experience regarding planning, execution and reporting of audits in an international setting.

Specific audits – onshore/offshore
FORCE Technology has a wide variety of technical competences. This enables us to perform audits in a number of areas where very specific requirements have to be met. An example of this is audit of metering installations both offshore and onshore to ensure compliance with the company procedures, external requirements and/or statutory requirements.

Several of our auditors perform third-party verification (under approval of the Danish Environmental Agency) of sampling and analyses of oil in water and of compliance with e.g. OSPAR.

We also perform audit of the methods and procedures for documenting NOx emissions and verification of such accounts. Furthermore, we audit procedures, methods and accounts of CO2 emissions and climate accounts etc. This service may include verification of data, calculations, and methods for compliance with various statutory requirements as well as assistance in building up relevant documentation, e.g. measuring uncertainty budgets, measuring methods and measurement of produced water emission.
Our many years of experience have provided us with in-depth knowledge of the requirements and standards in the offshore industry, among these OSPAR, NORSOK and IMO.

Examples of services provided by our consultants are:
- Determining the requirements regarding the management system
- Drafting of proposals for design and contents of management systems
- Drafting or review of procedures (SOP)
- Implementation of management systems and procedures, including participation in the management review and performance of internal audits
- Review of the value-adding effect of existing systems
- Optimisation by means of LEAN tools.

The Offshore Supply Network
We also work as facilitators on innovation projects for small and medium-sized companies. An example of this is our participation in the Offshore Supply Network where we have upgraded small and medium-sized companies in all industries in order for them to become suppliers to the offshore sector.

The Offshore Supply Network was a sub-project of a wider project, Energy at Sea, established in 2010 and focusing on growth and employment in the offshore oil and gas industry towards year 2020.

Meeting the requirements of the offshore industry
Experience shows that small and medium-sized companies often reject the oil and gas industry as a business area since the requirements for documentation and certification are very high in order to become an approved supplier.

Through their participation in The Offshore Supply Network, twenty potential suppliers/subcontractors were given an overview of the requirements to be met, among other in relation to their management systems. FORCE Technology assisted each company in prioritising the company’s management system, and training in for instance the design of management systems was carried out during the project.

FORCE Technology can perform accredited emission measurements, including parallel measurements for QAL2 calibrations at offshore platforms. Our experts have the relevant courses and experience from offshore work.

NOx emission measurements
In recent years, we have performed an increasing number of NOx emission measurements and QAL2 calibrations at oil and gas offshore platforms. The implementation of the Danish NOx tax involves a demand for automated measuring systems (AMS) for NOx at the platforms. The most common way to measure NOx continuously offshore is with the predictive emission monitoring system (PEMS). The monitoring system needs calibration (QAL2) at regular intervals, which is performed by parallel measurements with accredited standard reference methods.

FORCE Technology can provide parallel measurements and QAL2 calculations following the requirements in the NOx regulation.

Offshore measurements
We have a highly skilled service team with experience in on-site accredited measurements at offshore platforms. The calibration measurements are carried out in accordance with DSEN 14181.
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.

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 also can 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 customized 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 modified to fit most geometry. We offer simple and advanced inspection on both pipelines and structures.

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.

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.

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 0.2 mm)
- 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 reinspect 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), FiGSTM, 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 sea water. 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.

Fluid level measurements in buoyancy tanks
The F-level uses ultrasound for level measurement 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.

Contact: oilgas@forcetechnology.com
OPERATION

Structural monitoring

Structural monitoring

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 the 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 Technology’s scope of expertise.

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.

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 Technology’s scope of expertise.
FORCE Technology calibrates and tests a large number of equipment types which are applied directly or indirectly for measurements in the offshore industry.

Gas flow meters
FORCE Technology is in the absolute elite of suppliers when it comes to high pressure calibration of gas flow meters.

Our customers include offshore companies and gas transmission companies worldwide. We provide calibration of gas meters with diameters up to 500 mm applying natural gas as a medium.

To meet the industry’s need for calibration of large meters, we have recently expanded our calibration facilities with the construction of a new high-pressure calibration system.

Our facilities consist of:
- 12” (300 mm) high-pressure loop for calibration of gas meters
- 4” primary twin piston prover system
- 24” (600 mm) high-pressure loop for calibration of gas meters.

We can now provide high pressure calibration of meters with a diameter up to 1,250 mm.

FORCE Technology has its own equipment for generation of the unit m³/h, and we partake as primary laboratory within The harmonised European gas cubic meter for natural gas (EuReGa). This ensures our customers that calibration is performed within the stated levels of uncertainty.

Pulse transit measurements using radioactive tracers
Covering the full range of flow rates, FORCE Technology is able to provide measurements of gas flow for general control or calibration of flow meters for the offshore sector as well as onshore installations handling gas.

Drawing on 30 years of experience and having performed flow measurements on practically all offshore installations in the Danish sector several times as well as a number of land-based installations, FORCE Technology has the experience and equipment to accurately, safely and reliably deliver flow measurements using radioactive tracer gas.

The services also include calibration of customers’ reference equipment and calibrators for calibration of their own equipment. FORCE Technology offers to notify customers and call in equipment for calibration.

Water meters/gauges
Water is a significant parameter in offshore production, and not least because of the authorities’ focus on the amount of emitted water in the sea, it is necessary to calibrate water meters/gauges.

We have recently expanded our water calibration facilities to include one of the largest full automated test rigs in Northern Europe. With this new test rig, FORCE Technology now performs tests and accredited calibration of water meters/gauges at a flow of 1,000 m³/h.

Oil meters/gauges
FORCE Technology calibrates oil meters/gauges in two systems:
- One that applies diesel as a medium and calibrates meters/gauges up to 4”
- One that applies bozechm (0.778 g/cm³ at 15° C) as a medium and calibrates meters/gauges up to 6”.

Pressure and temperature
As a national reference laboratory, FORCE Technology calibrates pressure measuring equipment in the following areas:
In our laboratories: -100 kPa – 80,000 kPa
On-site with the customers: 0 kPa – 80,000 kPa

Furthermore, we calibrate temperature measuring equipment in the areas:
In our laboratories: -70° - 1,205° C
On-site with the customers: -20° - 1,205° C.

Other equipment
- Power calibration (transducers, weighing cells, dynamo meters, lifting jacks etc.)
- Torque calibration (keys, screwdrivers, transducers etc.)
- Calibration of weights and mobile weighing systems
- Verification, calibration and sale of weights
- Calibration of volume meters (dispensers, volumetric flasks etc.)
- Calibration of arenometers and viscosity pipes (not accredited).

Contact: oilgas@forcetechnology.com
SERVICES ON OIL, CHEMICAL & GAS CARRIERS

Worldwide services
We provide preventive maintenance, repair and calibration of almost all kinds of equipment related to handling systems.

Our facility is placed in Frederikshavn in the northern part of Denmark from where all quotations, accounting and technical support take place.

Our team of highly experienced service engineers travel all over the world providing service and calibration.

FORCE Technology is capable of performing all kinds of technical services related to gas handling systems. We are also able to quote and advise within other scopes of the offshore/marine field due to an extensive knowledge and interrelations with companies all over the world.

Pre-inspection
The objectives of the pre-inspection are performance test and assessment of the pumps.

The inspection can include inspection of all equipment related to our services.

Repair and preventive maintenance on pumps
FORCE Technology is a specialist in many different types of pumps such as those of Svanehøj, Thune Eureka, Desmi, Worthington, Nigata Worthington, David Brown, Shinko, Thermo mechanical, Gunard and Teikuko.

All technicians hold mechanical educations and are trained in repair and service of pumps as well as on-site service and repair, reconditioning of impellers, shafts and mechanical seals.

Service, repair, test and calibration of safety valves
FORCE Technology is specialised within the area of safety relief valves.

We provide repair and service of almost all types of cargo lines valves, tanks valves and void space valves in co-operation with major manufacturers such as Fukui and Anderson Greenwood.

Usually, all overhaul, repair and calibration is performed on on-site facilities as our service engineers bring special tools, measuring equipment and spares.

After overhaul/repair and test, the technician issues a certificate and a service report.

Service, repair, test and calibration of measuring and automation systems
The service and calibration of measuring and automation systems are carried out by technicians who are trained and educated in the field of electronics.

Our services within this area include service, repair, test and calibration of:
- Pressure-transmitters, gauges, switches and alarms
- Temperature-transmitters, gauges, switches and alarms
- Level gauges (Enraf, Whessoe, Musasino etc.)
- Level alarms
- Fixed gas detection systems.

After overhaul/repair and calibration, the technician issues a certificate.

Repair and preventive maintenance of cooling and cargo compressors
FORCE Technology has extensive experience with many types of cooling and cargo compressors.

All technicians have mechanical educations and are trained in repair and service of compressors.

Spare parts
Our large stock of various spare parts and good relations to manufacturers and sub-suppliers result in the best possible supply of spare parts.

FORCE Technology provides the following services:
- Pre-inspection
- Repair and preventive maintenance on pumps
- Service, repair, test and calibration of safety valves
- Service, repair, test and calibration of measuring and automation systems
- Repair and preventive maintenance of cooling and cargo compressors
- Supply of spare parts and components
- High development potential for additional applications.

Contact: oilgas@forcetechnology.com
The technological development also makes it increasingly possible to investigate and exploit the older and deeper layers of the sub-surface, including high pressure/high temperature fields. These new methods and technologies require an extended service life of the equipment under new conditions.

FORCE Technology has the expertise to advice on how these changes in production methods affect the existing process equipment.

**More CO$_2$, new chemicals and increased pressure**

The fact that oil fields can be in operation for more years than previously expected also has implications for the choice of materials as longevity increases the demands for maintenance, overhauls of equipment and upgrade of materials in offshore process plants and other equipment.

Content and composition of the fluids affecting the process plant and other equipment are also being continuously modified. This could relate to the amount of water and solids in production fluids or content of CO$_2$, H$_2$S and new types of chemicals. In addition, changes in temperature and pressure during operations interact.

In most cases, the changes in production methods or tie-in of new fields imply that materials are affected in a different way than before, for example in the form of increased corrosion, scaling, pressure loading or wear.

**Deep insight into the industry**

FORCE Technology has extensive knowledge of material properties and extensive experience in analysing how changes in production conditions of oil and gas affect the materials used.

We have considerable insight into the processes and chemicals used in offshore operations in the North Sea sector where we have been involved from the very beginning. We continuously follow the developments and changes in production conditions and methods at close range, e.g. from our Esbjerg department that is located in the most important offshore base in Denmark.

A significant portion of our knowledge of materials and the related specific challenges in the offshore oil and gas business is gained through our analysis and evaluation of equipment condition, failures and accidents in the industry.

**Our test facilities**

By using FORCE Technology’s own advanced testing and computational facilities, we are able to undertake most types of testing of materials. This may be necessary if there is no data to assess the impact of a change in production or chemicals in relation to the materials used.

**Safety for employees and the environment**

By in-depth analysis, testing and advising, we assist the players in the offshore oil and gas industry in selecting the right materials or the optimal treatment of the existing materials if the production conditions change.

The proper solution assures low risk of unforeseen material losses or leaks due to corrosion or erosion.

Failures could have serious safety, health and environmental consequences and cause unintended down time with a significant financial impact.
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.

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 vent gas monitoring (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.

The VGM system 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 lifetime 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 polymer coupon monitoring (PCM) system allows for continuous monitoring of the integrity of this layer, maintaining security and control.

The PCM system monitors the integrity of the polymer sheath of the flexible riser. Coupons are placed inside the pipeline in order to expose them to the 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 allows one to estimate the level of fatigue through monitoring motion within the flexible riser over time. 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 combination 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.
In connection with operation and maintenance of vessels and pipe systems on offshore installations, FORCE Technology has for several years carried out the following in-service inspections:

- Automated ultrasonic scanning (T-scan “corrosion mapping”) for measurement of the minimum remaining wall thickness as well as mapping of corrosion patterns in scanning areas on vessels and pipelines. After repeated scanning of the same areas, data can be compared to review corrosion rates, determine corrosion mechanisms as well as planning replacement of pipes etc. Scanning can be carried out on all pipe dimensions with OD >2” and on all types of carbon steel (incl. painting), duplex, cunifer and SMO materials etc.

- Manual ultrasonic scanning for determination of minimum remaining wall thickness in areas with limited access for automated scanning as well as small pipe dimensions.

- Automated ultrasonic ToFD (Time of Flight Diffraction) scanning of welds in steel pipes or vessels for detection of internal selective corrosion around welds in pipes with OD >4”. ToFD scanning is carried out by means of 2 ultrasonic probes placed on each side of the weld.

- Manual ultrasonic Phased Array scanning of welds at e.g. flanges by scanning from one side only on pipes with OD >4”.

- Computerised radiography for determination of tangential measured remaining wall thickness, especially of isolated pipe systems as well as in areas with limited access for ultrasonic inspection. Furthermore, computerised radiography is used to determine remaining wall thickness in areas with heavy external corrosion. If it is possible to determine functionality of valve bodies as well as indications of possible internal corrosion/erosion in choke valves by means of computerised radiography, finally, the method can also be used to detect internal scale in pipe systems.

One of our latest news on the market, developed by FORCE Technology, is scanners which can collect data in connection with automated ultrasonic Phased Array scanning of flanges – primarily with a view to detect corrosion in sealing surfaces and in sealing grooves on RTJ flanges.

Reliable non-destructive testing (NDT) is essential to ensuring and documenting construction quality with regard to materials and craftsmanship in casting, forging and welding. Subsequently, credible NDT is paramount when monitoring structures, vessels, piping etc. for in-service induced flaws such as corrosion, fatigue cracks and similar.

FORCE Technology is a full NDT service provider offering all the traditional manual testing methods. FORCE Technology has a 75-year history of providing NDT services to industry in general and more than 30 years to the offshore industry.

Our NDT inspectors hold accredited EN ISO 9712 Level I or Level II certificates or equivalent. They are supervised by our team of experienced NDT technicians with Level III certificates, also accredited according to EN ISO 9712 or equivalent.

250+ NDT inspectors operate worldwide out of Scandinavia where FORCE Technology has a total of 25 offices in Denmark, Norway, Sweden, the Middle East as well as Asia with offices in China and Singapore.

FORCE Technology is approved service supplier of NDT on offshore projects and offshore units/components, classed by DNV-GL, in accordance with Approval Programme No. 4028.

NDT results can be reported:
- In digital easy-to-read reports delivered by mail and also accessible online
- In FORCE Technology’s database “PipeCorr” format for easy automated export to the customer’s system
- Directly into the customer’s own reporting system, database or integrity management support system.

Contact: oilgas@forcetechnology.com

TOP SIDE CORROSION MONITORING

Contact: oilgas@forcetechnology.com
Often, a combination of wind tunnel test and CFD will provide the best result. One of the major benefits offered by CFD is the possibility to obtain detailed information about the flow field as well as temperature and concentration fields within a large domain.

Gas dispersion
CFD can be applied to predict the dispersion of gasses and to determine temperature fields due to exhaust gasses and flares. This is e.g. crucial for helideck in-flight safety which depends on temperature gradients.

The detailed information about the total flow, including pressure and velocity fields, provides a good basis for diagnostics and optimisation. Furthermore, the exhaust funnel performance can be evaluated and optimised to avoid smoke nuisance in working areas and near ventilation inlets.

Safe helideck operation
CFD is used to analyse the wind flow, turbulence and temperature gradients in the vicinity of helidecks on e.g. offshore platforms. This is essential when evaluating safety aspects of helideck operation.

The flow results obtained for all wind directions can be summarised in a map with indicative response magnitude (IRM) of the aircraft to vertical gust wind speeds. The IRM map can help to ensure safe helideck operation during take-off and landing while also identifying potential restrictions for helideck operation.

Oil/water settling tank systems
FORCE Technology has carried out several projects within optimisation of oil/water settling tank systems on floating storage and offloading vessels.

Optimisation of the settling tank layout is performed using CFD as a tool to analyse the fluid dynamic behaviour of the crude oil consisting of a mixture of oil and water. The use of CFD in the settling tank design phase results in a drastic reduction in design costs and time from design to operation.

In addition to documentation of the general flow pattern and settling of the oil/water mixture, CFD analysis can be used as an efficient and valuable tool to optimise the settling tank layout, for example with respect to position and dimensions of inlet and outlet pipes.

The CFD analysis can provide useful information on
- Water contamination at oil decant system
- Oil content at water drain system
- Oil/water settling time
- Crude oil import capacity.

Other services
Other examples of our consultancy services related to the offshore oil and gas industry are:
- Optimisation of crude oil storage systems
- Ventilation in offshore platform living quarters
- Explosion and fire scenarios
- Simulation of fluid structure interaction
- Analysis and optimisation of equipment related to oil and gas:
  - Liquid separators
  - Desalination units
  - Pipeline clean-up tools
  - Heat exchangers
  - Valves.
Today, the main part of Europe fortunately has a common set of rules for construction and manufacture of new pressure equipment for use onshore. These rules include guidelines for evaluation of the equipment in order to ensure that the equipment fulfills specific requirements for engineering. Before these rules have been fulfilled, the equipment cannot be traded, commercialised or commissioned.

In other words, the set of rules helps to get a common level of safety for new pressure equipment, regardless of the country it is used in. The same set of rules has also been adopted by the authority of offshore business in Denmark as well as, among others, the Norwegian offshore sector.

When the equipment has been marketed, it becomes subject to national requirements for application, and the future safety level thus depends on use and is practised according to:

- Set-up/installation/filling/commissioning/operator attendance
- Operation/maintenance.

How is it checked that new pressure equipment fulfills the requirements?
Pressure equipment is classified in four categories (I-IV). The highest category represents the most hazardous equipment. The manufacturer of the pressure equipment handles the conformity assessment and must also take care that the equipment is CE marked.

The conformity assessment of equipment in categories IV, III and II involves a notified body. As visible evidence that the requirements are fulfilled, the manufacturer must finally issue an EU declaration of conformity which must follow the equipment. The manufacturer must also supply user guidelines in the language used in the country where the equipment is to be applied.

The declaration of conformity must state:
- If the equipment is in accordance with EU Pressure Equipment Directive PED
- The notified body.

CE marking and the corresponding declaration of conformity can create the presumption that the actual equipment is engineered in a proper manner regarding health and safety.

Fulfillment of the requirements
Unfortunately, CE marking, corresponding declaration of conformity and guidelines do not always guarantee that pressure equipment is engineered according to the rules or in a proper manner regarding health and safety.

It is often necessary for the future user of new pressure equipment to arrange making the necessary specifications for the equipment, including carefully choosing the advisor or notified body in order to ensure that requirements have been met, and that the equipment can be used safely for a long time after commissioning.

FORCE Technology and our independent third-party body, FORCE Certification A/S, can to a great extent contribute to providing this assurance.

FORCE Technology can, at all levels, contribute with experience and professionalism so that the manufacturer of your new pressure equipment installs the equipment in accordance with the requirements in PED as well as fulfils necessary PED-harmonised standards or technical specifications such as ASME, AD-M, BS etc. as well as individual, national and customer-specific requirements.

This work may be performed either as notified body or through consultancy services. FORCE Technology has accumulated decades of theoretical and practical experience in approval, certification and inspection of pressure equipment.
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 time 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.
Subsea inspection.

Qualification in test tank.

Force Technology uses the in-house developed automated ultrasonic system, 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, TOE, 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.

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.

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.

Contact: oilgas@forcetechnology.com
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.
Visual inspection by unmanned drones is a quick and cost-effective inspection method of critical areas on offshore constructions. Drone inspection offshore enables access to otherwise inaccessible structures and details, offering immediate action as an alternative to more traditional, time-consuming and costly inspection methods like rope access, sky-lifts, cherry pickers and scaffolding.

During inspection the drone is operated by a FORCE Technology pilot. During the flight the inspector operates the camera, records video and directs the pilot to the points of special interest and views of different angels of the construction.

Benefits of drone inspection
Using drone inspection solutions for visual inspection provides benefits such as:
- Inspection of areas difficult to access
- Preventive maintenance planning and optimised production
- Access to areas that pose health, safety and environmental risks to humans
- Quick on-site deployment of the inspection system
- Authorised and qualified inspection personnel
- Reduced down time.

Drone inspection of offshore constructions
Drone inspections can be applied anywhere outdoor, indoor and offshore. Any limitations from national or local regulation must be taken into account. Furthermore, any safety procedures of the facility owner must be complied with.

For instance, FORCE Technology has conducted drone inspection of the following hard to reach areas offshore.

Flares
The remote control feature enables both pilot and inspector to distance themselves from the danger zone, allowing drone inspection of high risk areas, such as the flare and its tower. Detailed images of critical components on the flare and the flare tower can be obtained without shutdown or disturbance of the process.

Bridges
FORCE Technology’s drone is capable of viewing an item at any angle between +45° up and 90° down. The drone’s ability to look up is particularly useful when inspecting bridges. Flying underneath the bridge and inspecting for damages in the concrete, corrosion etc. without the cost of e.g. a rope access team makes drone inspection an attractive alternative.
An essential aspect to complying with health, safety and environmental requirements is establishing excellent routines for inspection planning and inspection. Through systematic approaches, we provide full management of all inspection related tasks throughout an asset's life cycle.

**Integrity project management**
FORCE Technology has extensive experience with the development and set up of modern integrity management systems and the use of several methods for the optimisation of inspection planning and execution of assets.

**Topside inspection management**
A large amount of the unforeseen incidents that occur in process plants are related to corrosion and erosion. Corrosion management is therefore essential to maintain the integrity of the facility, increase the level of safety and improve cost-effectiveness of operations. Safe operation depends on preventing containment loss. However, cost savings are also obtained through managing critical parameters and activities related to corrosion and material degradation.

By achieving corrosion control, ensuring focus on high-risk items, one can reduce the amount of hydrocarbon leaks and a number of unplanned shutdowns due to material degradation. The activities we perform with regards to topside corrosion management are:
- Risk based analyses/assessments (RBA)
- Risk based inspection planning (RBI)
- Follow-up of inspection and analysis of findings.

**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 envelops various activities performed in order to optimise the use of inspection resources, 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 and subsea inspection management**
 Pipelines and subsea equipment represent a very important part of the energy infrastructure. Proper management of pipelines and subsea equipment is critical for maintaining continuous production for oil companies. This includes identification of high risk areas for corrosion, effective use of mitigation, implementation of monitoring activities and inspection resources in addition to improved public health, safety and environmental protection. 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 service life estimations, software)
- 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.

**Well corrosion management**
Corrosion control for well operations is performed with a focus on optimisation of production. Costly work-over’s and loss of production can be avoided by implementing corrosion control for wells, using models and experience to understand the mechanisms driving corrosion.

In this field, we offer, among others:
- Analysis and assessment of corrosion for wells (e.g. degradation of tubing, remaining lifetime of wells/tubing due to corrosion)
- Corrosion monitoring.

**ASSET INTEGRITY MANAGEMENT**

**OPERATION**

**Corrosion & materials**

**INSPECTION / MONITORING**

- NDT inspection
- Advanced inspection
- NDT certification of inspectors & equipment
- Load & response sensors
- Monitoring systems

**MATERIALS**

- Material selection/verification
- Cathodic protection (CP)
- Coating & surface protection
- Corrosion control
- Laboratory service (testing/analyses)
- Failure assessments

**STRUCTURE**

- Design
- Reassessment/Modification
- Third party verification
- Global/local analyses
Assessments and 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 lifetime 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. A few of our services are listed under:

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 programme.

Structural reanalysis system
During the service life of an offshore asset, it 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.
As subsea infrastructure ages, 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 clients new and 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 sea water, enabling us to assess the overall status of the CP system. It allows us to 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 among others predict the remaining life of a CP system, providing our clients with an increased level of confidence.

The uniquely high sensitivity of FiGS® enables inspection of buried structures and pipelines, possibly saving the cost of 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. FiGS® data is for instance used to 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 AUV/AIV
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).

CASES
Weight coated buried pipeline
The line was inspected to determine the current density and anode performance of a 35 years 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 the 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.

X-mas 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 shell. By combining data with CP modelling we were also able to estimate the size of the damage.

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.
ROOT CAUSE & FAILURE ANALYSIS

Failures on offshore machinery and constructions are highly unwanted because they may be extremely costly and may compromise safety. Once a failure has occurred or the early stages of a potential failure have been identified, it is important to identify the cause of the failure and initiate preventive measures to stop the failure or avoid recurrence of the failure.

FORCE Technology provides on-site inspection and root cause analysis based on your background data, our own observations, and measurements as well as the most advanced laboratory equipment.

The most important goal of a root cause analysis is to prevent both new and recurring failures and thereby improve the safety for workers and environment and prevent loss for the operator.

Root cause analysis

In many oil fields, the wells have reached an age where increasing water cuts and reservoir souring may cause severe corrosion problems. The increasing corrosivity of the well stream affects the production pipework, tanks and machinery (pumps, separators, spools etc.) and in many cases results in very premature failure. In several cases, material selection has been optimised for a specific well stream composition no longer present in the well after many years of production.

FORCE Technology performs failure investigations and subsequent analysis in order to find the root cause of failures. This procedure is often referred to as root cause analysis (RCA). The first part of the failure investigation is typically performed by our specialists on-site and, based on their recommendations, samples are examined in detail with advanced laboratory techniques.

Identification and solution

Identification of the cause of failure is the first step towards mitigating future corrosion. The solution may for example be injection of corrosion inhibitors or biocides or introduction of more corrosion-resistant materials, for example a suitable stainless steel or nickel alloy. For coatings or polymer/rubber/composite constructions such as pipes, tanks and seals, the cause of failure is often poor materials selection for the specific conditions (temperature, pressure, chemicals). Failure may also be due to conditions differing considerably from originally specified conditions.

FORCE Technology has the leading service material laboratories in northern Europe and has over the years completed failure investigations and analysis on numerous offshore components and constructions. A complete failure investigation and analysis is a multi-disciplinary task requiring several engineering and scientific disciplines in order to find the primary cause of failure and the root cause.

Examples of typical failure causes:

• Sigma phase in 254 SMO duplex stainless steel due to poor heat treatment
• Corrosion of welds or heat affected zones due to erroneous welding
• Fast corrosion of tubings due to increasing corrosivity of produced liquids
• Fast corrosion of underwater structures due to insufficient or lacking corrosion protection
• Incorrect polymer/rubber material for specific conditions.

The most frequent failures in offshore constructions are caused by:

• Corrosion
• Materials and weld defects
• Mechanical fatigue damages
• Wear and lubrication failures
• Rubber-seals exposed to too high temperature/pressure
• Chemical exposure of polymer/rubber materials.

Our main services

• On-site inspection of failed components
• Collection of operation data and records from operator and manufacturer
• Selection of representative items or samples to be shipped to the laboratory
• Planning of examination using non-destructive examination techniques, metallurgical examination etc.
• Laboratory examinations including fractographic and metallurgical examinations and scanning electron microscopy
• Chemical and surface analysis of components and coatings by advanced techniques such as SEM-EDX, XRF, OES, FTIR and 3D optical microscopy
• Mechanical testing of components and materials
• Prediction of remaining service lifetime
• Review and analysis of the recovered data and design of the implied component or system
• Consulting on future failure prevention and corrosion mitigation.

Contact: oilgas@forcetechnology.com
When offshore oil and gas installations approach the end of their service life, they become unprofitable if kept operational. After permanent cessation of production, the installation should be safely removed and secured.

Well founded HSE (health, safety and environment) procedures are important aspects of this work, considering all possible facets and outcomes. We hold the highest standards for HSE and quality assurance (QA), continuously improving and perfecting our routines and methods.

Decommissioning studies from beginning to end
Our mission is to find the solution that suits your needs. Below, we have listed up some of the activities that we typically perform.

We provide:
- Independent review consultancy.
- We assist in the preparation of:
  - Design premises of topsides and jackets
  - Definition of criteria for strength and weather under operation
  - Definition of as-is conditions
  - Designing of sequential removal plans.

Extensive experience combined with strategic risk management and qualified HSE procedures allows us to deliver an optimal and safe decommissioning programme.

History and experience
We have contributed to the success of some of the world’s largest projects, including EKOFISK for Conoco Philips (2004-2013) and FRIGG for Total (2000-2009).

Our experience covers the majority of the decommissioning projects in the North Sea. Through this, we have gained knowhow and expertise within all proven methods and approaches.

DECOMMISSIONING STUDIES

During operation we take part in:
- Technical assistance and company representative during offshore operation
- Hazard identification (HAZID)
- Hazard and operability analysis (HAZOP)
- Inspection.

We also assist in the process of acquiring approval from relevant authorities, which is a requirement prior to any decommissioning.

Procedures and regulations
Decommissioning of installations and pipelines is governmentally regulated, which means that there are strict methods and guidelines to follow when performing a decommissioning.

An environmental statement and a comparative assessment support the decommissioning programme, and in some cases, it includes a wide range of activities such as handling of hazardous material, removal of debris from seabed and monitoring of the environmental impact of the area post-removal.

We ensure continuous follow-up on crucial activities, allowing our clients to feel confident with regards to both progress and quality assurance.
**FRACTURE MECHANICAL EVALUATION & FITNESS FOR SERVICE**

Fatigue cracks in steel structures are often caused by weakness or overload of the welded joints. FORCE Technology can verify the actual stresses by strain gauge measurements. Should the failure occur, we can conduct a failure investigation to determine the cause and help avoid similar problems in the future.

**Engineering critical assessment**

An engineering critical assessment is an analysis based on fracture mechanics principles. The analysis is applied in cases where our inspection department has detected weld flaws or initial fatigue cracks. With knowledge of the weld flaw size and the stress spectrum, the remaining fatigue life is estimated by fracture mechanics calculation.

FORCE Technology has comprehensive experience in performing stress analysis on offshore structures. Further, we have extensive experience with analysis of strength and engineering critical assessment of welded joints etc.

**The competences of the staff**

A broad variety of competences among the staff both offshore and onshore are required for handling corrosion issues, material technology in general, and maintenance of production facilities and support systems.

Visual control of welded materials may be quite difficult without the proper skills, since the welded surface rarely shows anything with regard to the quality of welding.

If you operate facilities of a certain size, it may be feasible for the operator to have the competences to perform non-destructive testing and control of the welding in-house. The ability to initiate failure analyses, planning of maintenance and redesign requires that the engineer or technical responsible holds suitable knowledge of material performance and protection strategies.

FORCE Technology provides a number of planned courses in non-destructive testing, welding and materials, and since our customers often have unique demands and requirements, we also prepare and supply tailored and customer-specific courses e.g.:

- Weldability of materials
- Welding quality control
- Repair welding
- Damage/failure analysis
- Marine corrosion
- Cathodic protection
- Corrosion protection by coating systems
- Corrosion types
- Materials selection
- Water treatment and cooling systems
- Visual weld inspection and welding defects
- NDT methods, possibilities and limitations
- Ultrasonic thickness gauging

In general, oil and gas structures are exposed to rough sea and extreme weather conditions. Furthermore, the production facilities must operate reliably under quite harsh conditions in contact with e.g. 3 phase production fluids under high pressure and temperature. Therefore, it is of the utmost importance that the materials and the welding quality live up to the necessary standards in order to avoid expensive and hazardous cracking events, failures, and production shutdowns.

**Training and educating your personnel is an ongoing process in order to keep the professional skills up to date. Strategically, investment in education strengthens your competitive advantages. Our courses are typically attended by oil and gas operators, engineering companies, subcontractors and classification society surveyors.**

Our instructors apply their relevant theoretical education and extensive practical experience into the development and execution of the courses as well as tailored training programmes. The courses consist of lectures, demonstrations and workshops.

**NDT, WELDING & MATERIALS COURSES**

**Our courses may be conducted in accordance with the following standards**

- NDT-testing: EN ISO 9712 and ASNT
- Weld inspection and technology: EWF and IIW examinations and issuance of diplomas
- Welding certificates.

**Contact:** oilgas@forcetechnology.com
LACK OF “SOFT SKILLS” & ACCIDENTS

“Soft skills” do not often exist in practice, and when conducting on-site assessments, it is like observing pieces of isolated knowledge that are not utilised in a consistent, systematic and practical way. Managers have the knowledge as such, but there is no practical implementation. And when investigating incidents, the absence of leadership at critical moments is more than evident.

Capabilities and demands
Requiring knowledge about human factors is recognising the fact that major accidents like the Texas City refinery explosion, P-36 Petrobras and Deepwater Horizon all demonstrated lack of practical implementation of Human Factors and poor leadership in critical situations.

Deepwater Horizon – a sad example
One of the latest and most serious examples of how the so-called “soft skills”, human factors and leadership, played a role in a major offshore accident is Deepwater Horizon. Considered the largest marine oil spill in the history of the petroleum industry, the Deepwater Horizon is a good example of how lack of knowledge and poor implementation of soft skills can have fatal consequences.

In the case of the Deepwater Horizon accident, it has been proven that e.g.
- More than 20 sensors indicated a high level of gas, but the personnel didn’t trigger the general alarm
- Despite gas alarms, oil-mud and gas gushing out of the platform, but still no alarm was triggered
- Policies and procedures were ambiguous and open to free interpretation
- Poor maintenance prevented the normal activation of core safety components at critical moments
- Training had not included scenarios with a major blowout, explosions, fires and a total loss of power
- The warning system was too complex and could not be managed properly in critical situations
- Warning signs were neglected or wrongly interpreted for a long time.

Deepwater Horizon exemplifies the importance of human factors and leadership and points out that these competences are essential to safety, performance and reliability in safety critical domains.

FORCE Technology can offer you
FORCE Technology has been developing two innovative courses that address the challenges of human factors and leadership. The courses offered by FORCE Technology together with the Danish Maritime Cluster project highlight the practical use of this knowledge in critical situations.

The two courses offer both insight into and training in the subjects human factors and leadership. Although we have come a long way in the area of safety since the Herald of Free Enterprise and Piper Alpha, there are still lessons to be learned about the importance of human factors and leadership when ensuring the safety of the personnel and protecting the environment.

The two courses FORCE Technology and the Danish Maritime Cluster project are offering will contribute to changing attitudes towards dealing with the use of human factors and will allow personnel to identify the areas in need of improvement of leadership.

State-of-the-art simulator systems, a highly qualified staff and 50 years of experience within innovative development and use of knowledge are the basis of FORCE Technology as a recognised training facility. FORCE Technology does not only deliver a strong technical expertise – we also offer a profound pedagogical knowledge on the importance of the human factors when working in the maritime sector. Poor knowledge of this subject can mean serious consequences to both people and the environment.

Human factors knowledge builds on man’s strengths and weaknesses and helps ensure that individuals are not exposed beyond their capabilities – a situation that could have disastrous consequences in safety-critical domains, e.g. the offshore sector.
Oil and gas
In many oil and gas installations there is a risk of build-up of radioactive scale as well as occurrence of other radioactive substances such as sludge or dust. These substances are collectively known as NORM: Naturally Occurring Radioactive Material.

Work around pipes, tanks, separators etc. contaminated with radioactive substances requires proper training and instrumentation.

We provide training in radiation safety when it comes to in-field measurements both offshore and onshore as well as consultancy regarding acquisition and use of instruments to measure the radiation emitted from these substances.

The training can encompass work with and around other types of radioactive sources such as fixed installations containing radioactive sources, for example level gauges and sand alarms.

Regarding the Danish sector, the courses can include training in the legal and regulatory framework governing radioactive material. In addition, consultancy services in these areas can be provided.

Finally, we are able to provide analysis services for NORM.

Shipping
For companies engaged in the transport of irradiated nuclear fuel (INF), we are able to provide radiation safety training. The training can be oriented towards the general activities of the crew but can also be expanded to train onboard personnel to perform measurements, keep track of personnel doses using a work scheme and other such duties, effectively enabling a crew member to function as radiation protection supervisor for an INF-transport.

Our courses, both in the oil and gas sector and in the shipping sector, are tailor-made for the individual customer based on thorough dialogue and our extensive industrial knowledge.

RADIATION PROTECTION COURSES

Drawing on more than 40 years of experience in the use of radioactive substances in industrial processes and devices, we are able to offer comprehensive training in radiation safety in a number of maritime scenarios in the oil and gas sector as well as in shipping. Our courses are tailor-made based on the individual customer.