In order for ships to be profitable, they need to be operated efficiently. ‘Efficiently’ in this context covers many different disciplines, e.g. deciding the optimum hull shape in the design phase, welding and metallurgical issues in the production phase or root cause and failure analysis in case of breakdown.

Whichever phase you are in, it is important that the advice or service you seek is delivered in a swift yet thorough manner. At FORCE Technology, we have more than 200 experts and specialists within the maritime industry, covering almost any technical area relating to ships and doing so all around the world.

At FORCE Technology we care about our customers’ business, and with our large number of highly skilled experts we are dedicated providers of services to the maritime industry. This dedication has characterised FORCE Technology for the more than 70 years we have tested, measured and analysed designs, structures and materials.

Further, our dedicated approach and vast experience has made us the preferred supplier of critical services such as design recommendations, failure analysis and investigation, chemical analysis and metallurgical examinations. We take great pride in this position and we are willing to strive to maintain it. For us, a good customer is a happy customer. And even though we are often called upon when something has gone wrong, we take pride in solving any problem quickly and efficiently.

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

Ernst Tiedemann
CEO
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HYDRODYNAMIC CONSULTANCY

The strength of FORCE Technology is the unique combination of hydrodynamic experience, specialised know-how and modern facilities.

FORCE Technology has more than 50 years experience within hydro- and aerodynamic testing and evaluation. Since 1959 we have used our towing tanks to test and measure more or less everything related to ships, ports and offshore structures.

Through the years, FORCE Technology has been entrusted with hydrodynamic consultancy for numerous prestigious projects for clients worldwide. Our experience covers all types of vessels including container vessels, tankers, bulkers, offshore vessels, etc.

Specialist know-how
Our specialists within hydrodynamics are supported by advanced testing facilities such as the towing tanks and several in-house developed numerical design tools. This, combined with first class CFD codes and parametric optimization tools makes us able to assist our customers in the development of their projects. Typically, our customers consist of shipyards, Shipowners, oil companies and consultancies.

With the current focus on green shipping and eco friendly solutions FORCE technology provide an extensive range of services where we can help the clients to reduce fuel consumption and minimize the environmental footprint. Today the assignments starts earlier in the design spiral and we assist owners in the very early design stages where main parameter, speed etc. is selected. Being able to work on the main parameters and operational parameters ensures that that the vessel can be optimized towards an entire operation and not just in a single point.

Our hydrodynamic services include
• Expert appraisals
• Initial design services
• Parametric main dimension study
• Advanced numerical assignments
• CFD analysis
• Hull line development & optimization
• Route analysis
• Trim analysis and optimisation
• Still water tests
• Manoeuvring assignments
• Seakeeping assignments
• Mooring and station keeping tests
• Sea trials and analysis
• Onboard decision support tools
• In-service assignments

CFD is a strong tool which can be applied for evaluation of design variants in the early design phase.

The Division for Maritime Industry has tested the maritime world for more than 50 years.
Our customers face a major challenge in optimizing a vessel’s operational requirements while keeping costs at an acceptable level. In that context, the aerodynamic competencies within FORCE Technology offer to help the client in finding the best possible solution for his project.

**Wind and currents loads**
Any vessel will be subjected to considerable wind and current forces during operations which affect the operational requirements, stability, manoeuvring and propulsion. A vessel sailing is subjected to high relative wind speeds due to the vessel’s forward speed in combination with the free wind speed. High wind speeds mean considerable increase in the required propulsion power and thereby fuel consumption. With the increased focus on green shipping, FORCE technology also provides an extensive service where focus is on reducing the wind resistance on vessels during operation.

**Analysis of funnel performance**
Our customers face a major challenge to ensure that smoke nuisance onboard the vessel in outdoor working areas and near ventilation inlets is minimized, thus enabling the crew to work without experiencing the discomfort of smoke or noxious gases, e.g. SO₂ and NOₓ near ventilation inlets. The latter – if exceeding the given exposure limits – can cause severe health problems and non-compliance with authorities.

**Streamline investigation of propeller-induced vibrations**
Reliable estimates for flow streamlines and wake fields on vessels are very important, especially in cases where problems such as noise and vibration have been encountered during trials and/or operation. For evaluation of streamline problems and corrections, FORCE Technology uses the wind tunnel as a supplement to CFD calculations, streamline tests and wake field measurements in the towing tank. FORCE technology offers a vortex fin design to correct the problems based on the above analyses and can provide both design and class approval drawings ready for approval by class.
FORCE Technology has developed and produced maritime ship simulators for more than 10 years. Our ship simulators are generally recognised for offering the most accurate and lifelike simulator experience on the market for maritime simulation and training.

The software in our ship simulators is the in-house developed SimFlex4 which enables the user to work professionally with a large range of assignments from minor port alterations to major training exercises with coupling of multiple simulators. Our simulator clients cover everything from small consultancies to large shipowners, providers of training facilities and maritime academies. Today, our software is used in more than 70 simulator centres worldwide.

**The SimFlex4 software**

Being accurate is everything when it comes to performing realistic simulator training of professional mariners. Through the SimFlex4 software, FORCE Technology offers the market’s most realistic and flexible professional maritime ship simulator.

The cornerstone in creating an optically realistic and professional simulation scenario is the realism of the underlying mathematical model DenMark1, which is accepted as the best ship manoeuvring model on the market.

**The different configurations**

Our simulators range from small desktop to large full-mission solutions. Depending on customer requirements and specifications, we offer shiphandling simulators using the latest and most sophisticated COTS technology and simulation software developed in-house.

**Desktop solutions**

With a desktop solution, the client will receive tools to solve his specific challenges without compromising the quality of his data.

The typical clients are engineering consultancies with expertise in development of port design, who uses the desktop solution for fast-time analysis, or port studies.

**Part task solution**

The part task solution is relevant where more advanced training and simulation is necessary. The part task solution covers every simulator configuration between desktop simulators and full-mission simulators. Depending on the client’s need, a part task solution consists of a mix of soft and hard equipment and with a design that fits the training purpose. The typical clients of our part task simulators are shipowners, operators and maritime academies, who use the part task simulator for training in shiphandling, crew resource management, Tug operator handling, Ship-to-ship transfer, Watch keeping, system training (Radar, ECDIS, IBS,) etc. Common for the customers are the need for more realism concerning instruments besides the always present realism provided through the SimFlex4 software.

**Full-mission solution**

The most visible difference between our full-mission simulators and the other solutions on the market is our bridge-wing concept, increased fields of view and the possibility to adjust the hardware and change the consoles after the simulator is build, thereby increasing the flexibility. The typical clients for our full-mission simulator solution are the professional provider of maritime training or the large shipowner with the need for continuous training of captains and crew. Common for the customers are the need for superior graphical training exercises combined with market leading mathematical precisions delivered in real-time.

**Tug bridge solutions**

When it comes to simulation and training with tugs, FORCE Technology is by far the leading supplier on the market. Our mathematical models of the tugs are superior and we use experienced, seagoing tug masters when we test and evaluate our models.

Due to our accurate models, Voith Schneider cooperates with FORCE Technology on the development of their simulator module for the VSP tug. Further, we supply Svitzer with courses, courseware and training simulators – both regular and portable simulators.

We are able to configure our tug simulators in any way possible but we recommend our 360 degrees build on 30 m² as it provides the most realistic training environment.
cal ship manoeuvring model DEN-Mark1. This model is considered to be the most accurate on the market for maritime simulation and is continuously developed and improved on the basis of the knowledge gathered in our department for Hydro- and Aerodynamics.

Our database of simulator-ready ship models consists of more than 200 different ships (30+ types) and more than 500 specific models. These models are based on the experience gained through more than 50 years of maritime testing in our towing tanks and wind tunnels.

Flexible modularity
The keywords for SimFlex4 are flexibility and modularity. When using SimFlex4 it is possible to interact with all other systems, for example integrated bridge systems such as NACOS Platinum.

Further, the SimFlex4 software offers state-of-the-art visual effects in 3D and our continuous development ensures that our simulators will stay on top of the market when it comes to actual and perceived realism.

The flexible hardware
It is our core belief that realism in training demands realistic surroundings but at the same time the chosen simulator configuration must fit the client’s purpose. Therefore, we are very focussed on clarifying the client’s actual need on beforehand. For all our different simulator configurations we offer both real bridge equipment, such as ARPA radar, ECDIS, VHF and satellite communication or equivalent soft systems. Further, it is also possible to integrate different kinds of integrated ship management systems.

An example on our abilities to configure the simulators according to the client’s needs is the training centre we made for a large shipowning conglomerate with a special bridge design and the need for training procedures when using the bridge wings. Here the flexibility of the product meant that they were able to use the centre bridge for multiple purposes, thus enhancing the use of the simulator and thereby achieving much higher training goals for the client.

DNV certified simulators
FORCE Technology’s software, SimFlex4, has been certified by the Danish Maritime Authority for use for certification of mariners. In addition to this, SimFlex4 is certified according to DNV 2.14 to comply with the Class A standard for Bridge Operation Simulators.
As ship sizes increase, ports all over the world face new challenges. The new and larger ships require larger berthing facilities and manoeuvring space as well as improved training of Pilots, Captains and Navigators who have to handle the ships in different and adverse weather conditions.

**New berths**

Changing a berthing facility or constructing a port is a comprehensive decision both in an financial perspective and in regards to the surrounding environment. With today’s technology and our competencies within mathematical modelling, we are able to make a very precise and realistic simulation of how a given change to a port will affect the operation of vessels. By using simulation you ensure that the port design is done perfectly right the first time.

With close to 50 years of experience in comprehensive manoeuvring and simulation studies, FORCE Technology performs around 30 port studies in our simulation facilities every year.
The studies are conducted in order to ensure safe and efficient navigation of different types of vessels in existing or planned port facilities.

FORCE Technology’s Division for Maritime Industry (DMI) has a very long record of engineering studies and optimization of port designs carried out for clients around the world. Our mathematical ship and port models are recognized as being extremely realistic, which is a prerequisite for accurate verifications.

For all studies we use our in-house developed simulation software, SimFlex4, which is based on DEN-Mark1, the most accurate mathematical framework on the maritime market.

Our competencies are based on combining our hydro- and aerodynamic facilities and know-how with state-of-the-art graphical simulation in our four full-mission and three part-task training simulators with real bridge equipment.

The in-house developed SimFlex4 simulation software offers the possibility of using coupling of simulators allowing Pilots and Tug Masters to work together in the same simulator environment.

FORCE Technology offers a range of services and products that supports our clients in the engineering phase:

- Evaluation of arrival/departure conditions for existing or new port facilities
- Evaluation of breakwater layout and alignment, including width and alignment of approach channels
- Ship motions in both frequency and time domains giving accurate assessments of e.g. risk of grounding
- Ship motions of moored vessels
- Controllability of vessels at limited water depth
- Operational guidelines including e.g. determination of tug assistance
- Risk analysis
- Placement of navigational aids
WELDING TECHNOLOGY AND ADVISORY SERVICES

With our extensive knowledge in welding technology we can help you assure a good quality of the weld processes in your company. We can assist you before, during and after your welding work. FORCE Technology provides professional consultancy from the first idea to the turnkey product.

Prior to welding we conduct review of:
- The quality control system for the welding, including welding and control plans
- Work description and procedures
- Welding procedure
- Review of WPS and WPQR
- Heat treatment procedures
- NDT procedures
- Welding certificates
- Material certificates
- Process inspection
- Steel audit with regard to subsequent surface treatment

We have listed a variety of competences within welding technology and advisory services below to give you an idea of the many assignments on which we can assist you and which are related to weld technical processes in your company.

**Welding supervision/inspection**

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, the shipowner or a supplier.

We may participate in pre-qualification of suppliers and sub-suppliers as well as review of production and product requirements in cooperation with the contractor and supplier.

**Weld technical consultancy**

We provide practical as well as theoretical consultancy in connection with weld technical questions.

Prior to welding we conduct review of:

- The quality control system for the welding, including welding and control plans
- Work description and procedures
- Welding procedure
- Review of WPS and WPQR
- Heat treatment procedures
- NDT procedures
- Welding certificates
- Material certificates
- Process inspection
- Steel audit with regard to subsequent surface treatment

We tailor our services to meet your specific demands.
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's for your requirements. Furthermore, we optimize welding processes and choice of equipment and solve problems regarding production equipment and optimization.

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

**Specialist**
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.

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

We have conducted supervision and welding inspections for many years. The staff is fully confident with relevant standards within supervision and inspection. Supervision and/or inspection may be performed as either internal or external controls.

We assist you before, during and after your welding work.
COATINGS AND PROTECTION

Rust never sleeps . . . however, proper attention to rust delays attacks and breakdowns. Coatings offer protection against rust – but only if they are used correctly. Protection with coatings starts at the drawing board and in the meeting rooms and ends at the time of commissioning. Our assignment is to offer professional service all the way on all corrosion-protective issues.

Consultation on Corrosion Protection

Already at the planning stage, FORCE Technology can assist shipowners and shipyards in evaluating the need for corrosion protection and necessary inspection levels. We select the optimum paint types and systems for the individual parts of the vessel and tailor-make control procedures before, during and after paint application for the client.

Dry docking services

While the ship is in operation, we offer coating condition surveys with the aim of recommending the best and most economical way of reprotecting your ship during its upcoming dry docking period. A typical survey carried out by FORCE Technology’s certified inspectors will provide the shipowner and shipyard with a comprehensive and informative guideline on the optimum maintenance. The report includes recommendations of repair, paint systems and inspection levels during repair.

This condition assessment benefits shipowners as it will inform about the most rapid and economically feasible ways of reprotecting the ship.

Once in dry dock, FORCE Technology’s certified inspectors monitor all painting operations from beginning to end to certify that all planned repairs are carried out according to specifications and mutual agreements. Thereby the shipowner will be certain that the ship has acquired the desired level of maintenance and protection.

The inspections cover the coating control procedures for ballast tanks as specified in IMO’s PSPC (Performance Standard for Protective Coatings), IMO-Resolution MSC.215(82).

FORCE Technology’s independent survey and painting inspection reports will be an asset in the event of the ship being sold. With these illustrated reports, both vendor and buyer will have knowledge of the ship’s condition and a sound technical base of negotiation.
FORCE Technology offers consultancy and services regarding surface treatment of ships, tanks and cargo hulls. Our certified FROSIO Inspectors and corrosion specialists have extensive experience in providing specifications for surface treatment as well as on-site inspections including failure analyses and troubleshooting.

Selecting materials
To supplement corrosion protection by painting, FORCE Technology also offers consultancy services on the choice of corrosion-resistant material for major or minor parts of the ship. Occasionally, special parts may beneficially be hot-dipped galvanized or thermally sprayed instead of being painted, or ceramics or composites may be introduced. The cost benefits by introducing these materials and means of protection can be verified.

Training programmes
FORCE Technology offers comprehensive training programmes on surface treatment, coatings and corrosion. The courses are carried out by instructors with long-term experience in the topic and can be carried out both in-house or at the client’s premises. When required, we offer tailor-made classes to clients to cover specific educational needs.

Failure analyses
In the event of claims, FORCE Technology’s non-biased surveys will provide the ship-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 coating type(s), material quality, chemical composition of corrosion products etc. to support the investigations.

Services
- Verification from a certified and professional partner that your product meets all requirements of contractual specifications and desired relevant product standards
- Competent full project supervision
- Permanent and certified overview of project progress
- Third party professionals supporting or replacing in-house staff
- Independent and impartial monitoring by specialists
- Professional consulting and training

The coating condition survey is the basis for the subsequent paint repair specification.
Our profound knowledge of materials, cracks, fractures and wear and tear of reciprocating and rotating machinery has traditionally been utilized in connection with breakdowns and various incidents, mainly in order to characterize the breakdown mechanism itself.

Today, however, our knowledge of propulsion and auxiliary machinery with regard to the operation, performance and design details has been enhanced. Consequently we are now in a position to provide the ‘full package’, i.e. to clarify not only the breakdown mechanism but also the reason why the breakdown initially started and how similar incidents could be avoided in the future. This along with our expertise which is materials, metallurgy and corrosion paired with the available expertise from other departments within FORCE Technology, e.g. welding technology, advanced NDT, SEM-EDX, chemical analysis, mechanical testing etc., enables us to deliver technical services, solutions and support at a very high level to ship operators, the oil and gas industry, power plants, wind generator operators, OEM’s and insurance companies.

Difficulties or problems operational- and performance-wise are usually caused by a combination of factors which may be harmless individually but could have a devastating effect when two or more factors occur simultaneously. However, in some cases it could be entirely related
In many cases, the basic failure or root cause analysis requires in-depth study as a supplement, either to eliminate the last chip of doubt or to support the findings e.g. in case of costly incidents which could end up in court.

To the design of the machinery or design criteria which may be either initially poor or inappropriate for the actual application. In any case, it finally results in an extra burden financially and a nuisance to the operators.

It goes without saying that a continuous collection and analysis of performance data and the history of events etc. by the operator is preferred as it makes the investigation and root cause analysis somehow easier due to the fact that some influencing parameters and factors may be ‘taken out of the equation’ at an early stage of the investigation.

Beside the basic and root cause analysis, we have in-house expert knowledge to additionally offer model failure mechanism analysis, evaluate new designs and assess the effects of failure on operating systems utilizing extensive analytical capabilities.

To perform in-depth studies, FORCE Technology applies:
- Finite element analyses
- Experimental stress analyses
- Damage tolerance analyses
- Life extension predictions
- Mechanical testing
- In-service condition assessment
- Hazard and risk assessment
- Failure modes and effects analyses
- Non-destructive evaluation

Facilities
The modern laboratories and workshops at FORCE Technology are equipped to handle all aspects of failure analysis. Our instrumentation includes:

- Scanning electron microscopes for fractographic and metallographic analysis
- Energy-dispersive X-ray systems to identify aggressive corrosion products
- A photographic laboratory to document investigations
- Fully equipped mechanical testing laboratories
- Optical Emission Spectrometry analysis
- Advanced electrochemical laboratory for corrosion studies
- Advanced NDT laboratories
ONBOARD SYSTEMS

With more than 50 years of experience with hydro- and aerodynamic testing, FORCE Technology has a unique knowledge regarding the forces and physics surrounding ships. Therefore, onboard systems are naturally in line with FORCE Technology’s product portfolio.

Suppliers of onboard systems come and go, but what give the onboard systems from FORCE Technology an edge, is the mathematical ship models which are based on more than 50 years of practical experience within hydro- and aerodynamics.

FORCE Technology has developed the SeaSuite range of onboard systems with the objectives to ensure safe sea passages, to optimise the ship’s performance, to maximize fuel efficiency and to reduce CO₂ emissions.

The SeaSuite consists of four modules; the voyage planner SeaPlanner, the performance monitoring system SeaTrend and the trim optimisation system SeaTrim. Further, we have developed the propulsive performance monitoring tool Sea-Logger in order to provide documentation of the effects when changing underwater flows, adding various fuel saving devices or changing propellers.

SeaLogger, SeaPlanner and SeaTrend are all based on the same advanced in-house developed propulsion model. The model is highly comprehensive and covers all major aspects of resistance and propulsion of a vessel in a seaway, allowing high-quality predictions of fuel consumption and emissions. Today, more than 500 ships are sailing with or have ordered one or more of the ship performance systems.

Integrated data sharing
During 2013, the onboard systems have been developed to be able to exchange data, thereby enhancing the advantages gained from having more than one module installed. The modules are still equally valuable as stand-alone software, but by being able to exchange data, clients will be able to upgrade in steps according to their wants and needs.

SeaPlanner - weather forecasting and route planning
Choosing the optimal route, adjusting the speed and avoiding hard weather reduces the fuel consumption significantly.

SeaPlanner is a tool that enables the navigator to plan a route with minimum fuel consumption and at the same time avoid unacceptable weather conditions and ship motions.

With SeaPlanner, the operator can calculate routes as combinations of great circles and rhumb lines or let the system calculate the optimal rhumb line or great circle route taking wind, waves and currents into account.

Further, selecting the optimal route based on operational criteria includes the possibility to optimise the total fuel consumption with regards to either minimum en-route time, fixed ETA with constant power, fixed ETA with optimised speed, fixed ETA with constant RPM, or with a fixed calm water speed.

Besides data from the ship, SeaPlanner relies on weather data from the Danish Meteorological Institute, thereby making route predictions and evaluations more accurate.

SeaTrend – monitoring performance worldwide
The performance of a ship will deteriorate over time mainly due fouling of the
hull and propeller. Fouling leads to added resistance through water and increased fuel consumption. The performance monitoring application, SeaTrend, gives the shipowner, technical manager or the ship operator a tool to monitor changes in the performance of his ship.

The performance assessment covers both the technical performance of the ship and the performance related to efficient voyage planning and execution.

A new feature in SeaTrend is the engine performance module which makes it possible to use engine data proactively with regard to maintenance, service and optimisation of the engine, thereby improving the ship’s overall performance.

**SeaTrim**
- **selecting the optimum trim**

SeaTrim is a decision support tool designed to provide a quick and safe guidance to selecting the most favourable trim for any given combination of speed and displacement, and for the current loading condition and speed in particular.

SeaTrim offers large fuel savings and reduction of emissions on all types of vessels. Especially vessels with large bulbous bows operating at light loading conditions can obtain large fuel savings. But also smaller ship types with a less pronounced bulbous bow can gain attractive savings by trimming optimal.

SeaTrim can be used both in the overall cargo planning and onboard the vessel during daily operations. Being aware of the most fuel efficient trim for a given displacement at the planning stage will help the ship’s officers maintain a fuel efficient passage and reduce the need for further ballasting.

**SeaLogger – what works, what doesn’t work?**

In the quest to optimise vessel performance, FORCE Technology has been challenged by several shipowners in need of a way to document their efforts to improve their vessels’ performances.

FORCE Technology has developed an onboard tool that can be installed for a period prior to the upgrade and for an equivalent period after the upgrade. By thorough analysis based on our propulsion model also used in both SeaTrend and SeaPlan- ner, FORCE Technology can then provide an in-service evaluation of the fuel saving initiative and detect any improvements made.

SeaSuite is a range of products that use real-time data to maximize fuel efficiency and reduce CO₂ emissions.
EMISSION MEASUREMENTS

Emissions from ship engines contribute to air pollution affecting the environment and human health on a regional and global scale. At FORCE Technology, we carry out measurements of air pollutants and thereby assure that your ship is performing according to national and international standards.

The International Maritime Organisation (IMO) has with MARPOL Annex VI and the NOX Technical Code 2008 introduced a new scheme for NOX reduction as well as stricter regulation with respect to the content of sulphur in oil. The strictest requirements are imposed on ships sailing in designated sea areas, the so-called ECAs (Emission Control Areas).

For more than 30 years, FORCE Technology has carried out accredited emission measurements and reduction of air pollution from land based industries. In recent years, we have experienced an increasing demand for our emission measurement services from both the shipping industry, producers of NOX- and SOX-reducing equipment as well as from maritime administrations monitoring the compliance of emission regulation.

Exhaust emission measurements

Estimates of pollution from marine diesel engines are typically based on test bed results. However, there is an increasing need for documentation of compliance with regulatory requirements regarding NOx and other air pollutants from on board emission measurements. These requirements come from shipping companies, maritime administrations and classification societies carrying out inspections. FORCE Technology carries out both test bed and on board measurements of NOx, SOx, CO, HC, PM etc. in accordance with international standards.

Measurement and characterization of ultrafine particles (UFP)

Within recent years, special attention has been directed to the potential health effects of ultrafine particles. In cooperation with the industry, we are currently engaged in research activities and projects aimed at addressing the problems and developing solutions to reduce health risks.
The enforcement of stricter regulations with regard to the emission of air pollutants from ships implies that new NO\textsubscript{X} reducing technologies have to be installed on ships in order to fulfil the requirements of MARPOL Annex VI and the NO\textsubscript{X} Technical Code 2008. At FORCE Technology, we can assist you with information about the legal requirements that you have to fulfil in order to be in compliance as well as the technological solutions.

**Advice on type of abatement technology**

Our knowledge about the different NO\textsubscript{X} reduction technologies available such as SCR (Selective Catalytic Reduction), SNCR (Selective Non-Catalytic Reduction) and EGR (Exhaust Gas Recirculation) enables us to assist you in the choice of a retrofit system that achieves the most cost-efficient NO\textsubscript{X} reduction within the space available for the modification.

**Flow investigation and optimization of SCR units**

FORCE Technology offers flow investigation and optimization of SCR or SNCR units customized to fit the requirements of the catalyst supplier and the shipping company. We deliver cost-effective solutions in the design and construction phase and ensure improved lifetime conditions for the SCR/SNCR unit in order to improve the economic performance of the unit.

**Test and verification of technologies**

We carry out tests in connection with environmental verification of technologies (ETV) within areas such as the efficiency of emission reduction technologies or the quality and accuracy of emissions monitoring systems.

**Life Cycle Assessments (LCA) and Carbon Footprint**

An increasing number of companies are documenting their effect on the environment and climate. FORCE Technology is specialized within the field of GHG emission accounting, LCA and Carbon Footprint. Our analyses and documentation is carried out in accordance with internationally recognized standards.
MARINE EQUIPMENT SERVICE

With our extensive knowledge in cargo handling systems, we are able to provide preventive maintenance, repair and calibration services on Chemical, LPG and LNG carriers. Our service engineers are available worldwide, and based on their training and experience we can provide high-quality services in dry dock as well as when the ship is in operation.

FORCE Technology Marine Equipment Service have great experience in the marine field – with special knowledge within cargo handling systems on Chemical, LPG and LNG carriers.

Marine Equipment Service provides preventive maintenance, repair and calibration of almost all equipment related to the cargo handling systems.

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

The team at the office is capable of performing all kinds of technical services related to the cargo handling systems but will also be able to quote and advise within many other scopes of the marine field due to a large knowledge and relationship with other companies all over the world.

We have a team of service engineers with great experience and travelling all over the world providing service and calibration in dry dock as well as at sea.

In order to increase our flexibility, all technicians are trained in at least two of the below service areas.

Pre-docking inspection

The pre-docking inspection is typically done at one of the last discharge ports in order to be able to make a performance test of the cargo pumps. The inspection can include inspection of all equipment related to our services. The objectives of the pre-docking inspection are performance test and assessment of the cargo pumps.
Repair and preventive maintenance on pumps
FORCE Technology is specialist in many different types of long shaft cargo pumps like Svanehøj, Thune Eureka, Desmi, Worthington, Nigata Worthington, David Brown, Shinko, Thermo mechanical, Guinard, Teikuko.

All technicians hold mechanical education and are trained in repair and service of pumps as well as on-site service and repair reconditioning of impellers, shafts and mechanical seals. Our large stock of various spare parts and our good relation to our sub-suppliers results in very fast delivery of spare parts.

Service, repair, test and calibration of safety valves
FORCE Technology is safety relief valve specialist. Due to our close relations to the representatives of major makers such as Fukui and Anderson Greenwood, we can offer repair and service of almost all types of cargo line, cargo tank and void space valves.

All overhaul, repair and calibration can normally be done at the shipyards’ workshop facilities as our service engineers will bring special tools, measuring equipment and spares.

After overhaul or repair, 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 done by trained technicians, all with an education within electronics.

Our service within this area includes 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 have a great experience with many types of cooling- and cargo compressors.

All technicians hold mechanical education and are trained in repair and service of compressors and besides on site service and repair reconditioning of valves.

Our large stock of various spare parts and our good relation to makers and our sub-suppliers results in best possible delivery of spare parts.

Turnkey Projects
Marine Equipment Service is able to provide the full service scope as a turnkey project. When we are handling a turnkey project for one of our costumers, all our services are included in the project. Further, we also manage the services from subcontractors and assistance of ship’s personnel.

These types of projects are typically done on larger carriers where local workshop assistance and assistance for cleaning and simple mechanical task is needed.

The advantages with this type of projects are:

- Cost estimate for the complete project including possible external assistance as subcontractor and/or local assistance.
- The overall responsibility for the service is handled by FORCE Technology
- Reduced cost to due to efficiency improvement in regard to assistance from local workshop and ship’s crew.
- Reduced cost for spares due to:
  - The correct spares in the correct amount and on time
  - Reduced shipment costs
- Reduced work load for the ship manager during the dry dock period.
STEAM AND AUXILIARY BOILER SYSTEMS

Due to the high pressure and temperatures, steam boilers and their pipe systems represent a risk area where safety is always in focus.

Expert appraisal and troubleshooting

Leaks and failures in boiler tubes are commonly known problems to most marine engineers. One thing is to get a boiler repaired by a qualified boiler company. Another thing is what the cause of the failure was and how to prevent new and possibly more extensive and costly repairs. In order to be profitable, the ship has to be in operation. Often delays in the ship’s schedule may be significantly more costly than the cost of the repair itself. At FORCE Technology, we recognize this fact and are known for our flexibility, efficiency and reliability when it comes to helping out in critical situations.

It is a general experience that, when the root cause of a failure has not been fully identified, there will be a high risk of recurring failures. It is also a fact that the extent of the failure is increased every time it recurs. Due to the confined space in engine rooms, the steam boiler system is the single most hazardous part of the machinery installations. To our experts, every crack or failure contains valuable information, which can be uncovered in a failure and root cause analysis.

Boiler water

Corrosion damages in boilers and systems are, in most cases, related to inadequate water treatment and control routines.

The quality of the boiler water is what the lubrication oil is to the main diesel engine. This also includes feedwater and makeup water. Poor boiler water chemistry caused by insufficient daily analytical control of boiler water or contamination of feedwater or condensate are the most commonly found causes of the many boiler and boiler tube damages seen in our metallurgical and corrosion laboratories.

Boiler water and the boiler water chemistry are main areas of our services in the boiler specialist group in the department of Corrosion and Metallurgy.
Our services on water chemistry include:
- Consultancy and specification of water treatment
- Water treatment plant and performance
- Ship Inspector Training
- Off-load corrosion and prevention

**Boiler acid cleaning**
Cleaning of boilers for scale deposits and corrosion products is demanding and requires careful planning, specification and supervision.

**FORCE Technology’s boiler experts can assist with the following services:**
- Consultancy and evaluation of deposits for selection of boiler cleaning procedures
- Specification of cleaning method and procedures
- Chemical analysis of deposits
- SEM-EDX (Scanning electron microscopy and analysis)
- Testing of cleaning method on actual boiler tube samples and deposits
- Delivery of test weight loss coupons
- Supervision of boiler cleaning and the results
- Troubleshooting

**Remnant life assessment**
In a high pressure steam boiler plant, superheater tubes and outlet heaters as well as the main steamline and valves are operating in the temperature range above 400°C where material creep is taking place. For many years FORCE Technology has carried out remnant life assessment onsite by replication of the microstructure of the outlet heaters and steamlines. Superheater tubes are examined by cut out samples in our metallurgical laboratory where the microstructure is evaluated and the remnant life can be calculated based on API and EN standards.

**Auxiliaries**
FORCE Technology also provides services relevant for other parts of the steam system e.g. pumps, heat exchangers, condensers and tank heating systems.

FORCE Technology has many years’ experience with all types of marine boilers. This covers steam boilers for propulsion as well as auxiliary boilers for tank and heating systems, auxiliary turbines, turbines for pumps and generators.
FITNESS FOR SERVICE AND STRESS ANALYSIS

FORCE Technology has a comprehensive experience in performing stress analysis of welded ship hull structures. Further, we have great experience with analysis of strength and fitness for purpose of welded joints, engines and machinery.

FORCE Technology carries out strain gauge measurements on propeller shafts for determination of motor torque and power.

Competences

- Fatigue and fracture mechanics assessment
- Fitness for service assessment
- Failure investigation
- Strain gauge measurement
- Finite element method (FEM)

Fatigue cracks in the hull or the engine bedplate are often caused by weaknesses or overload of the welded joints.

FORCE Technology can verify the actual stresses in hull structures and machinery by strain gauge measurements. And should a failure occur, we can conduct a failure investigation to determine the cause and help avoid similar problems in the future.

The fatigue actions can be determined by on-site strain gauge measurements and Rain-Flow Counting of the stress load spectrum. And complex welded connections may be analysed by our ANSYS finite element program in order to estimate hot spot stress concentration areas (see figure).

Fatigue life assessment of welded joints is based on fatigue curves from classification societies or from codes and standards. Furthermore, we perform analysis based on experimental fatigue properties developed by our mechanical test department.

Fitness for service assessment 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.

Our services include development, calculation and design of components and entire structures. The design and stress analysis of ship hull welded joints is made according to international ship standards and recommendations.

Measurments on propeller shaft

FORCE Technology carries out strain gauge measurements on propeller shafts in order to determine whether the propeller shaft delivers the required torque and power.

The consequence of having less power than needed is an increase in fuel consumption or a decrease in speed.

FORCE Technology can verify the actual torque and power and act as impartial third party in case of disagreements between the supplier and the shipowner.
Uniform and reliable mechanical and chemical properties of the engineering materials are key factors in all modern marine engineering designs where the properties are often utilised close to their limits. Modern materials are specified according to international standards requiring strict quality control.

FORCE Technology's metallurgical and mechanical testing laboratories service all types of maritime segments from consultancy on material selection to testing of chemical and mechanical properties.

Specialised ships such as chemical tankers, LNG and FPSO ships require special attention regarding not only the mechanical properties but also chemical resistance. Stainless steel and other high-alloyed materials are widely used in these areas.

At FORCE Technology, our expertise includes metallic as well as non-metallic materials. We hold great expertise within stainless and other highly corrosion-resistant materials, including evaluation of corrosion and testing in relation to specific materials and to welding and surface treatment of tanks, pipes and pumps. Selection and testing of the corrosion properties of stainless steel are performed in our electrochemical laboratories.

FORCE Technology provides on-site inspection and non-destruction examinations worldwide. Our NDT services also include automated NDT inspection e.g. remote ultrasonic P-scan, tank scanning, long range ultrasonic testing. Trouble-shooting is a key activity for us.

**Accredited services**

FORCE Technology is accredited within all our chemical and mechanical testing and analyses as well as NDT activities.

**FORCE Technology provides material services within:**

- Consultancy on selection of materials
- Design of cathodic protection
- OES analysis of materials
- Welding properties
- Heat treatment
- Tensile mechanical testing
- Impact testing
- Metallurgical examinations
- NDT testing e.g. X-ray and ultrasonic testing
- Metallic coatings
- Supervision of production
- PMI on-site check of materials
- On-site metallurgical and hardness testing

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Inspection of defects in a shaft at a sub-supplier in the Far East
Our activities include a variety of fields such as material selection and welding surface treatment as well as forensic and failure analysis. Shipowners, operators, manufacturers and insurance companies are our main clients in this field. FORCE Technology also provides these services to a large variety of transportation and industrial branches.

The most important goal of a root cause analysis is to prevent new and repeated failures and thereby prevent loss for the shipowner and improve the safety for the ship and its crew.

Failure analysis
FORCE Technology performs failure investigations and subsequent analysis in order to find the root cause of failures. It is often referred to as Root Cause Analysis (RCA). The failure investigations are performed by on-site inspection and by laboratory examination and analysis for our customers located all over the world. Investigations and analyses are necessary in order to find the cause of any mechanical or corrosion failure and to support corrective actions in either design,
manufacturing or operation. This is the only possible way to avoid new and repeated failures.

Over the years, FORCE Technology has completed failure investigation and analysis on many ship components. Most components are engine parts like bearings, pistons, cylinder liners, valves etc. But also structures and components like cargo tanks, boilers and boiler pipe systems are often investigated due to various deterioration mechanisms or catastrophic incidents.

The technique of failure analysis was first introduced in the aviation business and is now well recognized in many industries where safety breaches the cost of breakdown and production stops exceed the cost of the repair itself. The shipping industry is among these industries where every hour of stop counts.

A complete failure investigation and analysis is a multi-technical task requiring several engineering and scientific disciplines in order to find the primary cause of the failure and the root cause.

In the root cause analysis all data and information are linked up, and a chain of events are lined up in order to find the starting point of the failure. Experience tells us that this might be anything from failures in the design, materials, production, installation, commissioning, operation, maintenance etc.

The most frequent failures in ships are caused by:
- Corrosion
- Material and weld defects
- Mechanical fatigue damages
- Wear and lubrication failures
- Fire

FORCE Technology’s activities include a variety of fields such as material selection and welding surface treatment as well as forensic and failure analysis. Shipowners, operators, manufacturers and insurance companies are our main clients in this field.

**Our services include**

- Inspection of failed components, typically performed by one of our experts onsite
- Collection of operation data and records from the plant control systems
- Selection of items or samples to be sent to the laboratory
- Planning of examination using NDE techniques, metallurgical examination etc.
- Laboratory examinations including fractographical and metallurgical examination, scanning electron microscopy and EDX analysis
- Stress and structure analysis of the failed parts
- Mechanical testing and chemical analysis of the material
- Review and analysis of the recovered data and design of the component or system
Automated Non-Destructive techniques make it possible to perform more accurate inspection in difficult accessible places covering hull and tanks welds from topside to underwater inspection. Scaffolding and diving time can be minimized. Examination for critical cracks or defects in highly loaded components can be achieved with the various modern NDE techniques.

FORCE Technology uses the P-scan system. This is a portable computerized ultrasonic inspection system developed by FORCE Technology. The P-scan system comes with a wide range of scanners including multipurpose and special purpose scanners to match specific job requirements. Most scanners are remote controlled magnetic wheel scanners.

The P-scan system offers a unique visualization and documentation. P-scan software is used for easy retrieval and comparison of results. The ultrasonic inspection is performed by highly trained and experienced personnel. The personnel are certified to level 2 in the EN 473/NORDTEST.

The Department of Advanced NDE Services is set up for world-wide operation using conventional as well automated inspection techniques based on ultrasonic, eddy current and visual inspection methods.

Automated ultrasonic P-scan inspection of welds and critical components is used where the demand for quality, documentation and reproducibility of the inspection results is high. The automated solution is visible at areas where access is difficult and scaffolding expensive.

Automated NDE services:
- P-scan ultrasonic weld inspection
- P-scan corrosion mapping
- Visual inspection, both direct and aided by video endoscope, camera crawlers etc.
- Leaktesting, helium, ultrasound
- Thermography
- Eddy current crack and flaw detection
- Eddy Current tube inspection of heat exchangers

Automated NDE inspection with the P-scan system is typically used in regard to production control, baseline inspection or in-service inspection where quality demands are very stringent, e.g. in submarine manufacturing.

Further, P-scan is used for corrosion mapping or crack detection and sizing. When performing crack detection and sizing, FORCE Technology uses Time of Flight Diffraction (ToFD) and Synthetic Aperture Focusing Technique (SAFT).
Ships are exposed to rough sea and extreme weather conditions. 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 cracks and breakdowns.

Handling corrosion issues, materials technology in general and maintenance of an entire ship requires a broad variety of competences among the crew and the staff on-shore.

Visual control of welded materials can be quite difficult without the proper competences, as the welded surface rarely says anything with regard to the quality of the welding.

If you operate a fleet of a certain size, it may be feasible for the ship owner to have the competence to perform NDT testing and control of the welding in-house.

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 deliver tailored and customer-specific courses e.g.

- Weldability of materials
- Welding quality control
- Repair welding
- Marine corrosion
- Damage - Failure analysis
- Corrosion protection – painting systems
- Water treatment and cooling systems
- Visual weld inspection and welding defects
- NDT methods, possibilities and limitations
- Ultrasonic thickness gauging

Our courses can be conducted in accordance with the following standards:

- NDT-testing: ISO 9712, EN 473 and ASNT
- Weld inspection and technology: EWF and IIW examinations and issuing of diplomas
- Welding certificates

Training and educating your personnel is an ongoing process that contributes to keeping the professional skills up to date, and at the end of the day, it will strengthen your competitive advantages. Our courses are targeted towards ship owner representatives and classification society surveyors.

Our teachers have a relevant theoretical education and extensive practical experience which is used to develop and conduct planned courses as well as tailored training programmes. The courses consist of lectures, demonstrations and workshops.

We train your staff to perform NDT testing on-site
We build our maritime training courses on proven principles using effective learning and best practice methods. We find these principles important in regard to making the output of the training courses as valuable and efficient as possible.

**Pedagogical tools**

The right software and hardware are important aspects of an efficient and useful training, but without the right people to transfer and anchor knowledge and skills within the participants, the training will never be a success.

In order to ensure the best foundation for learning, all our instructors have received pedagogical training relevant for simulator training and for training of junior officers as well as experienced senior officers.

Our pedagogical methods are primarily based on participant logical methods and discovery learning. We have been engaged in development of simulator based training methods for many years, and our methods are internationally recognised and used in other training domains, e.g. air traffic controllers and power station operators.

**Extensive debriefing - discovery learning**

We use debriefing sessions after each training session where we use replay systems and video footage to illustrate the participant’s performance. This is done as a part of a continuous process during the training course with the objective of making the participants conscious and reflective about their behaviour and decision processes.

**Officially approved courses**

All our courses and our Train-the-trainers programme are approved by the Danish...
After many years of conducting training for a number of different clients, we have documented that training is not an expense but a value-adding investment as the training increases the officers’ skills as well as awareness on efficiency, safety, environment and communication.

Maritime Authority and Det Norske Veritas (DNV). Our simulator training centre is certified by DNV.

FORCE Technology offers a full range of simulator based maritime courses from small exercises to full-mission training with coupling of multiple simulators. Our training uses our advanced SimFlex4 software with the market’s most accurate ship models developed by our specialists.

Further, all our instructors has operational experience as Maritime Pilots, Captains and Tug Masters.

Tailor-made training courses
A certain degree of tailor-making is always required to adapt the course content and structure to the client’s needs. Tailor-making of operational and technical courses and courses with human factors elements is a cornerstone in the training packages provided by FORCE Technology’s Division for Maritime Industry.

Onboard courses
Courses that require simulators will be held at our location in Lyngby, close to Copenhagen, Denmark. But some of the courses we offer can be held locally at the clients’ premises or on board during port stays or during shorter or longer voyages.

An emergency towing exercise in one of FORCE Technology’s four full-mission simulators

The ideal course
Through our long experience in offering tailor-made training solutions to the maritime industry, we have found that an optimal training sequence could be planned as follows:

• Assessment of near miss incidents and audit reports
• Interviews with management, officers and crews
• On board observations
• Tailor-making of course material
• Execution of training
• Follow-up workshops
• Performance evaluation
• On board valuations of training transfer and feedback on training and procedures
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