MARITIME AND OFFSHORE

TNO innovation for life

– SUSTAINABILITY
– PERFORMANCE ENHANCEMENT

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FOREWORD

The name TNO is familiar but not everyone really understands what it is that we do and can do. While TNO is often cited in the news, our field of work is so broad that many lack a clear perception of us.

TNO has the statutory task of boosting the competitiveness and innovative capacity of industry and advising government. This means that TNO's activities must meet the needs of industry, like the maritime and offshore sector. This is one of the industrial sectors in which our country has for centuries been prominent worldwide in terms of new products, services and systems.

And even though companies may be smart enough, the Dutch maritime cluster still has much to gain from the strong knowledge institutes that have long been present in our country. In recent years they have been actively partnering one another; TNO, MARIN, IMARES, TU Delft, the Dutch Defence Academy (together with the Maritime Knowledge Centre) harmonise their activities wherever possible. The needs of industry have been sounded out and ratified in discussions, and the Maritime Innovation Programme agendas attuned accordingly.

This publication provides a good first impression of the activities TNO is developing in the maritime and offshore sector. It addresses the various market areas that TNO serves. These include short-sea vessels, superyachts, offshore, inland shipping vessels, dredging vessels, and harbour activities. Also covered is the range of possibilities offered by TNO. These include laboratory facilities for experimental tests and trials, the facilitation of alternative solutions within prevailing regulations and the development of new technologies. At the back of the publication you will find a compact overview of the sophisticated trial and test facilities available to industry.

This publication presents a clear picture of TNO and our activities. That is something we are proud of and something we are always trying to improve and modify. TNO, always moving forward. Innovation for Life.

Would you like to know more? If so, click on TNO.NL/MARITIME or simply get in touch with us. We are always pleased to help you.

Arnold Stokking
Managing Director
Industrial Innovation

Wouter Kruijt
Director of Innovation
Maritime and Offshore

EXTREME TESTING OF LNG HOSE

Offshore transfer of LNG using hoses by Gutteling, courtesy of Exmar

Gutteling, a manufacturer of flexible hoses for the transport of liquid chemicals, has become the first to succeed in producing and qualifying a hose suitable for pumping offshore liquefied natural gas (LNG) from ship to ship. Worldwide there is significant demand for such a hose because it provides the key to expanding the LNG sales markets in a quick and flexible way. TNO carried out a series of extreme tests to prove the safety of the hose in accordance with stringent international requirements.

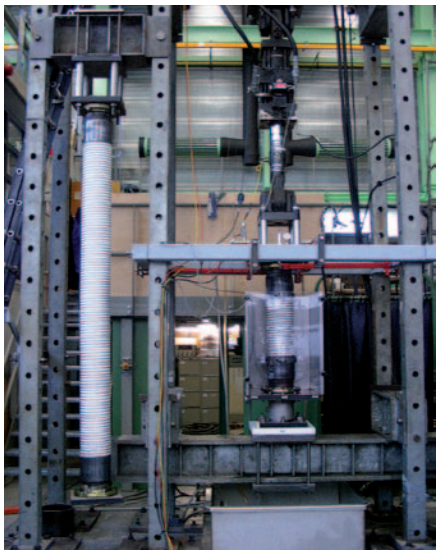
CHEAPER AND FLEXIBLE

Other parties involved in this project were the Belgian shipping company Exmar, which operates a fleet of LPG and LNG tankers, and Excelerate Energy, an LNG importer. Natural gas becomes liquid at a temperature of –162° C. At this temperature, the volume is 600 times less than the volume of natural gas at ambient temperature and pressure. The low volume and the low pressure make LNG the logical state for shipping gas to onshore terminals. There, the LNG is converted back into natural gas in special installations to distribute it to companies and consumers. Such land-based LNG installations require high investment. A cheaper and flexible solution is to convert LNG into natural gas while onboard a vessel moored on the coast. Such gasification vessels are already operational but a proven way of transferring LNG from the transport vessel to the gasification vessel was lacking. This need prompted Gutteling to develop a new type of hose. Prior to going into service, the hose had to undergo extensive testing. Det Norkse Veritas, the classification body, subsequently assessed whether the test results satisfied the standard (EN 1474-II). Generally, the development of a new product and its qualification take many years. In happy contrast to this, Gutteling and TNO managed to starkly reduce the necessary time. The entire test program was complete within 18 months and it led to the necessary DNV certificate.

Cryogenic bending test of the hose

ROBUSTNESS DEMONSTRATED

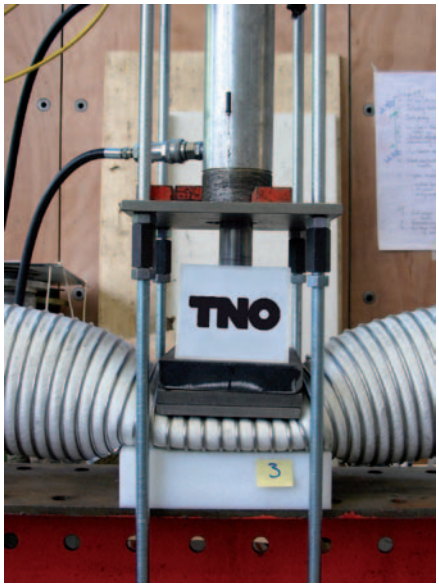
The features TNO tested included stiffness, flow resistance, insulating resistance and bursting strength of new and extremely damaged hoses. For safety reasons, the bursting tests were carried out in an explosion-proof bunker. Owing to the movement of vessels, the bending fatigue strength had to be demonstrated for a minimum of 400,000 loading cycles. A special set-up was built to continuously test the hose in fatigue at cryogenic temperature for a five-week period. In addition, TNO used a test site in Las Vegas where the hose was tested with LNG. 'Understandably, there was some initial scepticism in the market about the robustness and safety of the hose. By demonstrating that in several respects the hose performs many times better than the standard requires, this sentiment changed to general acceptance of the product. This turn-about has significantly boosted the market position of the SME Gutteling in a field with major suppliers of alternative systems. Gutteling will be the first party to launch this certified product on a market that is awaiting it.'



Test arrangements for torsion and tension

TESTING TO DESTRUCTION

'Much of the testing was carried out at cryogenic temperature (-196° C) and under high pressure,' explains TNO's Gerard van der Weijde, the project leader. 'No LNG was used at this stage, just liquid nitrogen. That is even colder and carries no risk of explosion. Yet it does have other risks, certainly when you do what we did: test the product till it fails. We utilised the multiplicity of knowledge fields and facilities present at TNO to carry out the broad testing program. This breadth, our knowledge of how to demonstrate a product's safety and performance and the good partnership with Gutteling were the keys to this success.'



Inflicting extreme damage; the severely damaged hose still fulfill the bursting pressure requirement of a new hose

THE HOSE WAS PULLED ON, TWISTED, BENT FOR A HUNDRED THOUSAND CYCLES, COMPRESSED, SQUEEZED AND SUBJECTED TO PRESSURE, AND ALL AT ROOM TEMPERATURE AND EXTREME COLD (–196° C)

UNIQUE KNOWLEDGE ON CORROSION BY MICRO-ORGANISMS

View of refuge harbour at Bruinisse

They were supposed to last for 50 years or more but after five years they were already at the end of their lifetime. It was evident that many of the steel mooring posts in the refuge harbour of Bruinisse, in the municipality of Schouwen-Duiveland, were severely damaged due to extreme rapid corrosion. Two of the eighteen mooring posts had even broken in half, a completely unexpected turn of events. Unacceptable and hazardous. Neither the municipality nor the contractor could explain it. And so outside help was called in: the TNO experts of the Maritime Materials Performance Centre in Den Helder.

CORROSION MEANS HUGE LOSS

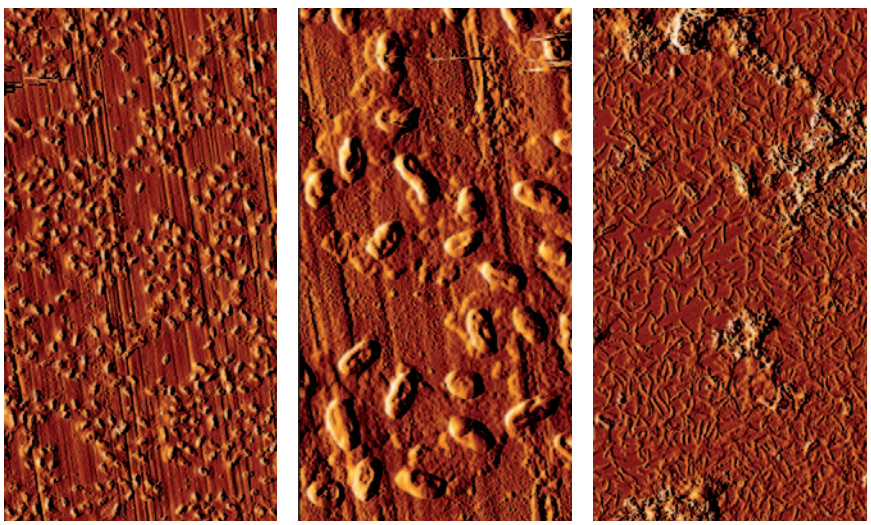
In 2001 the former refuge harbour in Bruinisse acquired from Rijkswaterstaat (the implementing body of the Ministry of Transport, Public Works and Water Management) was partially refurbished to create a fishing port for the mussel fleet. Landing stages were built with steel mooring posts. It looked robust, solid until five years later two of the posts spontaneously fell over. An initial inspection revealed that a number of mooring posts were so corroded that an immediate investigation into the cause was required. Following the investigation by TNO, the council decided in 2009 to have the posts repaired using the method advised by TNO. 'Biocorrosion', the technical term for which is microbiologically influenced corrosion (MIC), has been gathering attention in recent years. In the Netherlands alone, the phenomenon costs trade, industry and government tens and probably even hundreds of millions of Euros each year. This form of corrosion is highly problematic because it often occurs completely out of the blue and spreads rapidly. Micro-organisms corrode all sorts of materials: steel mooring posts, quay walls, vessels, water pipes, oil and gas installations. Often, preventive measures currently in use against corrosion offer insufficient protection against MIC. This is why we've become highly specialised in this field,' explain Peter Willemsen and Harald van der Mijle Meijer, two TNO experts.

Felled mooring post and the appearance of corrosion near the break

WIND FARMS, OIL AND GAS EXPLORATION AND PRODUCTION INSTALLATIONS, FIRE EXTINGUISHING SYSTEMS AND VESSELS ALL SUFFER FROM THIS FORM OF EXTREME CORROSION

GLOBAL PROBLEM

TNO is working on the early detection and prevention of this problem. This is being achieved using electrochemical and microbiological measurements. The techniques itself are not new but TNO has broad multidisciplinary expertise and a database of commercial and experimental coating systems that is unparalleled. TNO has accumulated this knowledge by charting all the relevant micro-organisms and by conducting thorough research into the underlying biological processes and corrosion reactions that occur on all sorts of materials. The Netherlands is by no means the only country generating a demand for TNO's applied knowledge of MIC. The problem is widespread. The corrosion by MIC of steel infrastructure in ports is a major problem worldwide. In many cases, the often unprotected quay walls and mooring posts fall prey to this corrosion. In Bruinisse, TNO showed incontrovertibly that the problem was not due to the welding or the properties of the steel, but that it was a question of accelerated corrosion just below the low-water line where certain bacteria were causing a chain reaction. TNO's research also showed why and in which situation coatings and cathodic protection are effective in combating MIC. Willemsen and Van der Mijle Meijer believe that the risk of MIC causing substantial damage to industry, in particular offshore industry, is huge. Wind farms, oil and gas extraction installations, fire extinguishing systems and vessels: they all suffer from this form of extreme corrosion and need the protection of customised solutions.



Depiction of bacteria on steel surface

MAKING LIFEBOATS SAFER

Courtesy of StatOil

Quickly evacuating the staff of drilling platforms and tankers usually means using lifeboats. But these lifeboats are not always safe enough. Under some conditions the international regulations cannot guarantee the safety of the passengers. The boats are drop-launched from around 20 metres above the water and the force of the impact can cause severe injuries.
In cooperation with a couple of Norwegian parties, TNO analysed the safety of more than 20 types of these free-fall lifeboats in some 10,000 scenarios.

CRASH TESTING ON THE WATER

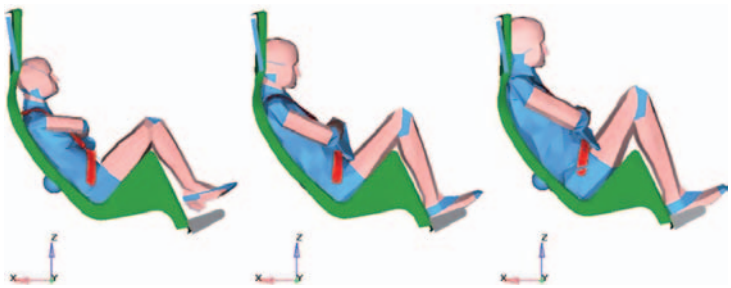
Statoil, the Norwegian oil company, knew of TNO's reputation in the field of crash testing. The automotive industry has a long history of drawing on this expertise. Could this TNO expertise be relevant to lifeboats? 'Oil companies hold exercises regularly. This involves dropping lifeboats into calm water from a height of 15 metres. Unfortunately, these aren't likely to be the conditions in a real emergency. When a calamity occurs, the sea is likely to be rough and the waves very high. With the swell, the boat may drop some 30 metres. Our initial tests showed that the potential problems were much greater than had been thought,' explain TNO's experts Lex van Rooij and Joëlle van den Broek.

CATALOGUING THE RISKS

Clients call in TNO to demonstrate scientifically that a system or procedure they have devised is safe. In this case, the results of the first test with a dummy and measuring equipment that TNO carried out gave Statoil sufficient cause to alert colleague companies and the government to the potential risks. This brought two new parties into the research: OLF, the coordinating organisation of the Norwegian offshore oil and gas industry, and Marintek, the Norwegian marine technology research institute. An inventory was compiled of all the free-fall lifeboats used on the drilling islands under OLF's control. Subsequently, TNO was asked to devise and implement test methods.

Installation for free-fall lifeboats

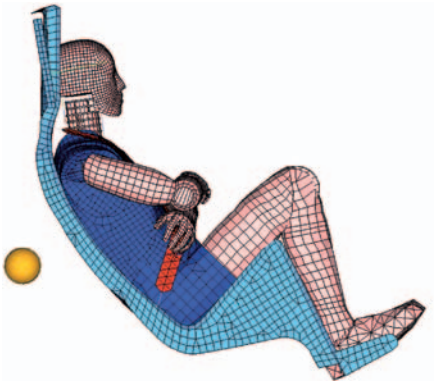
TNO ANALYSED THE SAFETY OF MORE THAN 20 TYPES OF FREE-FALL LIFEBOATS IN 10,000 SCENARIOS



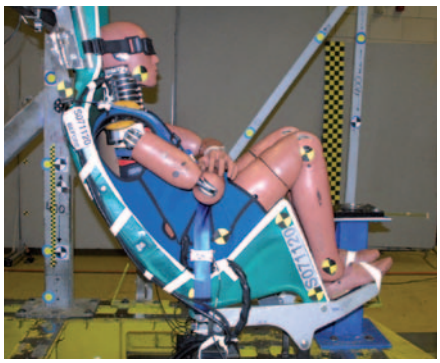
Simulations using various body lengths

COMBINING TESTING AND SIMULATION

'Our starting point was the launching of lifeboats in representative situations. For these tests in our lab, we use dummies equipped with hypersensitive sensors. The sensors measure numerous factors such as force, pressure, speed, acceleration and more under all conceivable conditions. We process the measurement data in our computer models, so that this virtual test environment simulates reality as far as is possible. Subsequently, using these models, we can establish accurately for each type of lifeboat how a human body reacts to such forces in various scenarios. Our method, in which we combine real-life testing with simulations, has the advantage of enabling us quite easily to include various parameters. I'm thinking of, say, wave height, launch height, the position at which the boat enters the waters, seatbelt system, the effect of evacuation clothing, and the passenger's weight and size.'



Computer animation



Testing forces on a sled

TNO METHOD ADOPTED AS THE STANDARD

TNO's research has opened the eyes of not only oil and gas companies in Norway. Det Norske Veritas, the classification body, has since elevated the TNO method to a provisional standard for the design of free-fall lifeboats. Worldwide, parties are showing great interest due to the scientific underpinning of the tests carried out by TNO.

'We have published our findings. You can't change all the lifeboats overnight. But boats are already being adapted to reflect our recommendations. Without a doubt, in time the passenger safety of new boats for use on the drilling islands in Norwegian waters will be tested using the TNO method,' says Lex van Rooij.

The knowledge gained in the free-fall lifeboat assessment has been used by lifeboat manufacturers during the design of new lifeboats, resulting in free-fall lifeboats with a higher level of occupant protection.
Using the experience gained during the evaluation of free-fall lifeboats a similar assessment for davit-launched lifeboats has been performed, showing the potential risk of injury during evacuation with davit-launched lifeboats.

NEW METHOD FOR PILE-DRIVING IN THE SEABED

Anchor piles

It started with research by TNO; it resulted in a completely new method for pile-driving in seas and oceans. Operating company IHC Hydrohammer® owned by IHC Merwede, one of the world's largest builders of vessels and installations for the dredging and offshore sector, created a craze with a unique product. Never before had anyone managed to use seawater as hydraulic fluid rather than oil. And the advantages are numerous.

NO ONE THOUGHT OF THE IDEA

IHC Hydrohammer® put a question to TNO: could piles be driven into the seabed in any way other than the traditional method. The issue at stake here is the solidity of the foundations of installations ranging from drilling platforms to wind farms. Traditionally, oil is the fluid used to drive hydraulic machinery.

IHC Hydrohammer®

Conductors

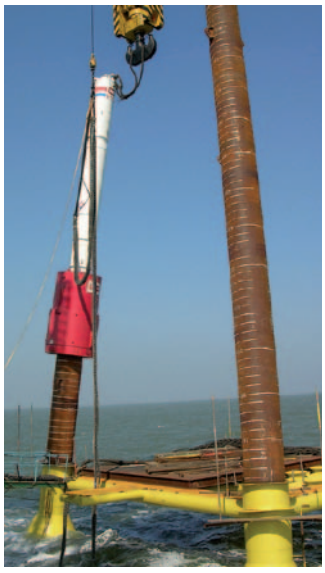
IHC Hydrohammer® refers to itself as the 'technology innovator' and delivers on this commitment in various ways, including by breaking new ground. Why is oil always the hydraulic fluid? The practical disadvantages are familiar enough, such as the regular occurrence of pressure losses in the pipes. But possibly even worse than that is oil leakage. Oil in the sea is a severe environmental hazard. In short, a safer and more intelligent method is needed.

Templates

FROM THREE TO SIX KILOMETRES

TNO's research into the alternatives was thorough. Could seawater really take the place of oil? Is that technically feasible? Does that, in turn, have other disadvantages, such as corrosion? The TNO expertise that IHC Hydrohammer® was keen to use lay in the field of tribology: friction, lubrication and wear in mechanical machines.

'Besides the advantage of any leaks being not oil but seawater, there is another great plus: whereas until recently the maximum depth for pile-driving was three kilometres, now it is six kilometres, thanks to the new method,' explains Henk Slot, an expert at TNO. 'The reason is very simple. Hoses are let into the sea to operate the hammer. Oil flows through these hoses to maintain sufficient pressure for pile-driving. The longer the hose, the harder it is to maintain the pressure. By using seawater at great depths, this problem is solved.'



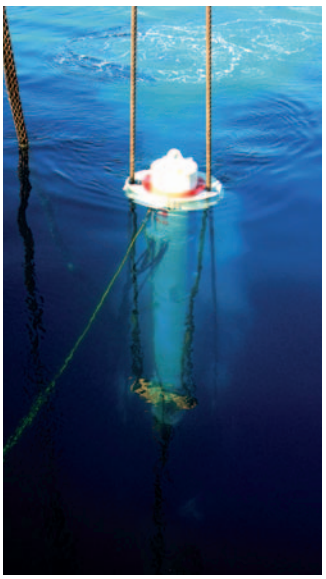
Jackets

JAN ALBERT WESTERBEEK, IHC HYDROHAMMER®:

'OUR COOPERATION WITH TNO IN THE FIRST RESEARCH PHASE WAS USEFUL. IT HELPED US CHOOSE THE RIGHT DIRECTION. NOW, IN THE CURRENT TEST PHASE WE CAN CONTINUE TO REFINE AND CAN STILL RELY ON THIS FUNDAMENTAL KNOWLEDGE.'

PATENT FOR COMBINED SOLUTIONS

During the research TNO had to overcome many technical hurdles. The use of protective coatings turned out to combat corrosion. It was possible to prevent wear by using carefully tested materials. And that's just to mention two problems that can occur in any part of the 'water hammer'. This combination of solutions, which delivered an operational, environmentally friendly hydrohammer, has resulted in a patent for TNO.



Subsea structures

IMPACT-RESISTANT SIDE WALLS

Gas tank in a hull with impact-resistant side walls

Also in 2010 vessels chemical tankers will enter service on European rivers, equipped with impact-resistant side walls. Thanks to this protection, inland waterway tankers, which carry hazardous materials such as liquid gas and chemicals, can have tanks on board that are twice as large as regulations previously permitted. TNO took the lead in the development of a safety assessment method, did calculations based on unorthodox models and carried out full scale collision tests.

TNO METHOD ELEVATED TO STANDARD

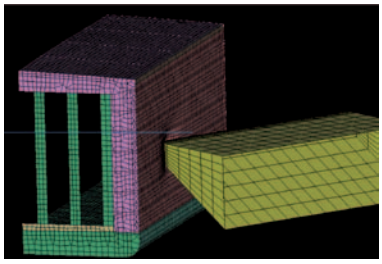
The result: the 'TNO assessment method' has been elevated to the standard for guaranteeing the safety of inland shipping vessels fitted with crashworthy side walls. The bodies responsible for this are the Central Commission for the Navigation of the Rhine (Strasbourg), which sets the rules for the European inland waters, and the Economic and Social Council of the United Nations (Geneva), which is responsible for the regulations governing the transport of hazardous loads through Europe. Years ago, various shipping companies were already asking themselves how they could increase the hazardous loads they were carrying on European inland waters. Greater load means more profitable transport. But the requirements of the regulators were strict. The maximum tank capacity allowed was 380 cubic metres. In response to this, the number of tanks per ship gradually rose from averaging ten to around thirty. In TNO's estimation, an increase in the number of tanks meant a proportional increase in the risk of equipment failure or human failure. This prompted the question: can you make tanks twice as large without increasing the risk? Is this technically feasible without exposing the ship, crew and the environment through which the ship travels to added risks?

EQUIVALENT SAFETY

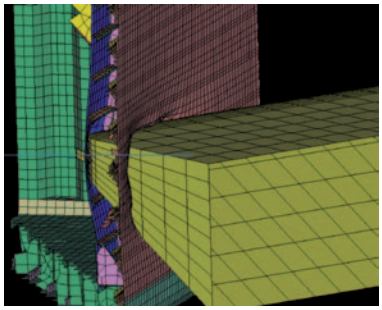
'Safety is the common thread running through all our activities,' says Alex Vredeveldt, senior scientist and naval architect of the TNO Centre for Mechanical and Maritime Structures (CMC). 'At TNO we cluster specialisms in the fields of mechanics, thermo-dynamics, human behaviour and mathematics in order to make vessels safer. Traditionally, legislation is based on existing and thus proven structures. But at TNO we take the concept of equivalent safety as our conceptual starting point. 'You start with an existing design and you calculate its safety levels in all conceivable ways. You adopt the same approach when analysing a new concept. For that, too, you calculate all the safety levels. If the safety level turns out to be greater than or equal to that of the existing system, you take the idea further. It has equivalent safety. This TNO idea is now internationally accepted.'

COOPERATION WITH THE MARKET

To answer this question, TNO first carried out research in cooperation with interested parties like Chemgas, De Schelde and VOPAK. The results were encouraging and in recent years they have been presented at international conferences. The conclusion in brief: tanks twice as large are not a problem provided the inland shipping vessels are equipped with impact-resistant side walls. Next, this theory, substantiated by exhaustive scientific research, had to be tested in the field. TNO has long-standing contacts with all conceivable parties in the maritime sector. The matter was raised in discussions with shipowners. For a long time now, TNO has been doing research for the Royal Netherlands Navy into ship walls that provide improved protection against external hazards. This sowed the seed for a spin-off into the civilian sector.



Penetration of the bow of a flat-bottom craft



Penetration of the bow of a flat-bottom craft (detail)

Full-scale testing of impact-resistant side walls

NUMBER WORK AND TEST

For years Chemgas, one of the largest transporters of liquid gas on the inland waters of western Europe, has been ahead of the field with new techniques and concepts. It became the lead customer and made material available so that TNO's number work could be tested in the field using impact tests. It was evident from the tests that TNO's findings were correct. 'It was a win-win situation,' explains Arie van der Ven, Manager of Maintenance and Projects at Chemgas. 'Fewer tanks with more load means not only reduced investment, but also improved safety. The fewer the tanks, the less there is to go wrong. The impact-resistant side walls are a major step forward; six of our vessels are now equipped with them. Another advantage for us is that the design of our seagoing short-sea vessels, some of which are also allowed to navigate the inland waters, is now better suited to the seagoing market.' The results of the computing work and the field tests were presented to the Central Commission for the Navigation of the Rhine, the classification societies and discussed with sister organisations of TNO in France and Germany. The 'TNO guideline', as the method was then christened, has since been embraced internationally and translated into European regulations for the transport of hazardous loads by water.

CHEMGAS:

'FEWER TANKS CARRYING MORE LOAD MEANS NOT ONLY REDUCED INVESTMENT, BUT ALSO IMPROVED SAFETY.'

MONITORING PILE-DRIVING AT SEA

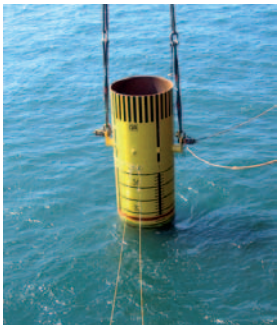
Preparations are taken to up-end the piles

Pile-driving at sea to create the foundations for drilling platforms is highly specialised work. Minuscule deviations can have huge consequences and so the builders of these platforms like to be the safe side. TNO is regularly called upon to watch intently every second of the pile-driving.
Over very many years, TNO experts have been involved in numerous projects all over the world.

CRITICAL PROJECTS

One of the companies with which TNO works closely is Conewel, part of the Dutch Geomet group. Conewel works worldwide on studies into the feasibility and installation of pile foundations for offshore platforms. In critical projects it is vital to keep a close eye on the pile-driving process so that decisions can be taken on the spot. In this situation, pile instrumentation is the solution. Conewel provides this, with TNO's assistance as sub-contractor.

Above-water sensor, mounted on the pile



Positioning the pile

Underwater sensors, mounted on the pile

OWN HARDWARE AND SOFTWARE

‘We do projects of this nature a number of times a year for various customers, such as Conewel, Geodrive and Heerema,’ reports Peter van der Meer of TNO. ‘A project may be anywhere in the world. New oil and gas fields under seas and oceans are always being discovered, and new wind farms are springing up. Before starting any pile-driving project, we collaborate with the customer on a thorough study. The expertise is continuously moving forward. Extraordinary projects require different instrumentation, for which we develop sensors, hardware and software. ‘We collect all our data real-time. For every impact of the rammer, we measure the energy that is released, speeds, the resistance of the seabed and more. Everything is very finely adjusted. As soon as any damage occurs in one of the piles, we spot it. Every deviation, however small, is noticed within a second. The data enables our customer to give immediate advice about the load capacity of the piles and, when the work is done, to report back to their client. Moreover, the data is valuable for future pile-driving projects.’

The SSCV Hermod (Heerema) in rough weather

The piles to be monitored lie alongside

EXCELLENT BOND FORGED

‘We have been working with TNO for years in this field to our complete satisfaction and that of our clients,’ reports Dirk Pluimgraaff of Conewel. ‘TNO provides all the necessary measuring equipment and software, sensors, cabling and more. ‘Together with TNO, we measure and record the pile’s response to every impact. Few parties worldwide are as highly specialised in this as TNO. Over the years we have forged an excellent bond with TNO. ‘TNO offers not only expertise, but also flexibility. That’s important because every project has its own very specific requirements.’

Overview of the deck on board the crane vessel

‘TNO OFFERS NOT ONLY EXPERTISE, BUT ALSO FLEXIBILITY. THAT’S IMPORTANT BECAUSE EVERY PROJECT HAS ITS OWN VERY SPECIFIC REQUIREMENTS.’

IHC MERWEDE OFFSHORE & MARINE DESIGNS COMPACT DRILLING VESSEL

Reducing the size of a drilling vessel smaller brings all kinds of advantages: reduced weight, reduced installed power, reduced fuel and thus reduced emissions. IHC Merwede Offshore & Marine, architect and designer of the compact drilling vessel, wanted to have the advantages quantified and to see the profit calculated over the long-term. Environmental experts at TNO performed a life cycle analysis (LCA).

CONVINCING CUSTOMERS

'We've known TNO a long time and have made use of their various expertises. But I must say, this was the first time we had called on their sustainability discipline,' tells Peter van der Hoek, Naval Architect and Head of the Design Agency of IHC Merwede Offshore & Marine. This TNO research has been of great value to IHC Merwede Offshore & Marine.

Not only have they succeeded in making a compact drilling vessel, and been one of the world's first shipbuilders to do so, they are also keen to use concrete evidence to convince potential buyers in the oil and gas industry of its advantages. And now they can. More than ever before, sustainability is the issue that has the customer's attention.

Green designs are the future. 'TNO examined the complete life cycle of the ship for us, from the extraction of the minerals to the final recycling and, between these bookends, its use. This creates an honest picture. To put it briefly, the finding was that our new ship has 20% less impact on the environment than conventional drilling ships. That this finding was proven by the independent TNO is a valuable factor for us in our competitive edge.'

SURPRISING INSIGHTS

Calculating all the elements that impact the environment throughout the total life cycle is the only way to create an accurate picture, in TNO's view. For a ship that is continuously on the move, propulsion is a determining factor; for a vessel that is almost always stationary, most environmental gain is to be had by optimising its main activity, in this case drilling. 'Many parties fall prey to misunderstandings and false assumptions about sustainability,' explains Marieke Head, a TNO expert. 'As an independent scientific institute we examine carefully all aspects in an LCA: the materials used, fuel, emissions, construction, operation, maintenance, recycling, everything. This often gives rise to some surprising insights.'

'OUR NEW SHIP HAS 20% LESS IMPACT ON THE ENVIRONMENT THAN CONVENTIONAL SHIPS.'

RAINBOW WARRIOR III: AN ENVIRONMENTALLY-FRIENDLY SHIP

Greenpeace applied TNO's LCA knowledge to the design of the sailing ship Rainbow Warrior III. This was achieved via the architect Dijkstra & partners in Amsterdam. The third of the Greenpeace ships is the first new-build. Thus the perfect opportunity arose to make the ship environmentally friendly.

'We computed all sorts of conceivable scenarios from production via operational use to the ship's scrapping,' says René van Gijlswijk, a TNO researcher. 'It was immediately obvious from the first scan which of the ship's properties were a strong influence on the environmentally friendliness. We also saw that things that seemed important had little effect, and vice versa. That Greenpeace has chosen primarily to sail the ship means great fuel savings and no emissions. At a stroke this justifies the construction of a new ship that has been optimised for sailing.'

'The question arose during the design phase whether it would be better to make the hull from aluminium or steel. Aluminium has a higher environmental impact in production than steel but is also lighter so less energy is required to power the ship. As this ship primarily sails, the environmental benefit of a light hull is not so great. This is how it was; constantly thinking of pros and cons. Ultimately, the exchange of ideas and knowledge between TNO, Dijkstra and Greenpeace resulted in an environmentally friendly ship.'

SHORE SUPPORT

The Alana Evita van Wagenborg, one of the participating ships in Shore Support

Twenty-five 'short-sea vessels' as they are called belonging to three Dutch shipowners have been plying the seas of Europe since the summer of 2008 with a Maritime Officer on board instead of an engineer. Discretionary permission to do this has been granted by the Ministry of Transport, Public Works and Water Management. It's all in aid of an experiment lasting over a year in which the crews receive onshore assistance. TNO is recording continuously the workload on board, the safety, the crew's tiredness and their enjoyment of their work.

OPTIMISING TASK DISTRIBUTION

Once TNO has processed the huge quantity of measurement data by the end of 2010, it should be evident whether this new way of seafaring offers proven safety and, at the same time, whether the working conditions on board have improved. The scientific substantiation provided by TNO will enable the Dutch government to adapt laws and regulations, if necessary. The same applies to the UN's International Maritime Organization (IMO). The shipowners' interest lies in soon being able to crew the coasters more efficiently and being able to optimise the task distribution on board. The solution devised by shipowners and TNO is to use Maritime Officers, abbreviated to 'Marofs'. These are merchant navy officers who have been trained in navigation and engine maintenance and who can take over the job of the engineer. This is still prohibited by international rules. As a consequence, there is some imbalance on board between the captain and the navigating officer, on the one hand, who each work 12 hours alternately in a 24-hour period, and, on the other hand, the engineer, who is hard at it for no more than three hours when deployed an a vessel of the current generation.

QINETIQ:

'WE ARE VERY PLEASED WITH TNO'S EXPERTISE, THE QUALITY OF THEIR WORK AND THEIR TIMELY DELIVERY OF THE END PRODUCT.'

CHANGES FOR THE GOOD

One of the participating shipowners is Wagenborg Shipping in Delfzijl. Engineering/ nautical staff worker Izak van Rhijn, who is also a member of the steering group of the Shore Support project, explains the situation. ‘On our ships the reactions have been positive. Thanks to the shore support, the Marof can perform these tasks perfectly well. In the hours remaining, he may, say, take over responsibility for the bridge watch. This relieves the captain and the navigating officer. It also helps the atmosphere on board. And there is another favourable effect. Marofs who have been trained as navigating officer/mechanical engineer specifically for small ships have very little scope to progress to chief engineer. This prompts many of them to leave the shipping industry. In the new situation, this changes for the good. This is what our sector needs.’

Work in the engine room

Joint Operations Room on board of RNLN landing platform dock ‘Johan de Witt’

TNO COOPERATES ON NEW US NAVY SUBMARINES

Not until the year 2080 will they be written off and they won’t take to the water until around 2030, yet already the new generation of submarines belonging to the US Navy is in development, and TNO is closely involved. And is the only non- American party to be invited. With some regularity, Jan Maarten Schraagen and Wilfried Post visit the US Navy in Washington DC or Orlando. There, officers, scientists and companies are collaborating on new concepts.

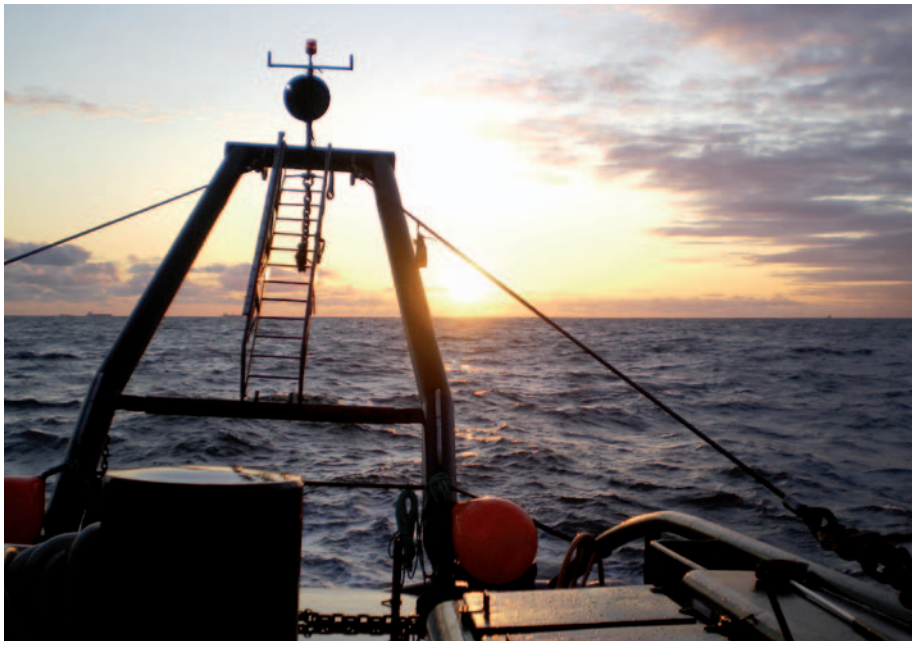
‘We are applying ourselves to the question of whether it is possible to operate submarines with a reduced crew. This has radical consequences for the sub’s interior design. For the Royal Netherlands Navy we have demonstrated that the crew can be halved. It requires an intelligent approach to organisation, a different approach to the ship’s operation, totally new concepts for cooperation and the organisation of space. This impressed the US Navy. We are now working with the Americans to make the concepts we have developed applicable to their situation.’

For QinetiQ, a player in the British defence industry, TNO developed similar concepts . ‘We are very pleased with TNO’s expertise, the quality of their work and their timely delivery of the end product’, QinetiQ.

EVERYONE BENEFITS

TNO’s measuring goes on 24 hours a day. All crew members have been equipped with a special PDA on which they answer a stream of questions; their answers are sent via internet to TNO’s computers. ‘Even the initial results were encouraging. The study is still underway, but if an unsafe situation had arisen, we would have intervened immediately,’ says Wilfried Post, a TNO expert. ‘Everyone is participating fully. Shipowners and crew members have been made fully aware of its importance. In many respects, the new seafaring will be more enjoyable and more efficient, while the safety level will be maintained. Everyone benefits.’

MEASURING UNDERWATER NOISE IS RARE SPECIALISM



Sunset seen from the 'Mon Desir' during the TNO baseline measurement/background measurements in 2008

The environmental impact statement (EIS) for Maasvlakte 2 weighs in at over 6,000 pages. It describes the possible environmental consequences of building this artificial peninsula. Thus, for example, the Rotterdam Port Authority has been required to demonstrate to Rijkswaterstaat, the implementing body of the Ministry of Transport, Public Works and Water Management and the licensing body in this case, that the dredging work has no detrimental effects on sea life. Time to call in the help of TNO's noise experts.

SOPHISTICATED COMPUTATIONAL MODELS

'Measuring underwater noise and the ability to relate that to possible harmful effects on sea life is a rare specialism, even when you cast your net globally. It was our good fortune that right here in the Netherlands TNO has acoustic experts and knowledge of how to prevent underwater noise causing harm to sea mammals. Moreover, it turned out that TNO was able to make sophisticated computational models to predict how noise travels under water,' says Albert Gerrits, one of the Maasvlakte 2 project organisers at Rotterdam Port Authority

GROWING DEMAND DUE TO LEGAL OBLIGATIONS

Demand is growing for the expertise of measuring underwater noise. This knowledge has long been of importance to the navy and it is in this context that TNO has been researching this field for the past 50 years. Today, the interest of other parties is being awakened. Ever more frequently, industry is being required to have experts identify the effects of noise on the environment. A licence to build a wind farm, for example, will not be issued without such a report.
The European Commission's Marine Strategy Framework Directive (MSFD) came into force in 2008. With its introduction, the member states are working towards the Good Environmental Status (GES) of all Europe's seas in 2020. One of the stipulations of the MSFD is that underwater noise may not cause harm to the marine environment.

Dredging work on Maasvlakte 2 during the second TNO measuring campaign in September 2009

‘FORTUNATELY, TNO HAS ACOUSTIC EXPERTS AND KNOWLEDGE OF HOW TO PREVENT UNDERWATER NOISE CAUSING HARM TO SEA MAMMALS.’

COMPARING MEASUREMENTS

Over the course of 2008 TNO drew up an initial plan for carrying out the measurements in a responsible way. This involved close consultation with the Port Authority. In September TNO carried out the first baseline measurement, ahead of the dredging work. From a small boat close to the planned development area, hydrophones, which record noises under water, were placed at two depths. The exact locations were agreed in advance with ecologists and biologists. For over a week the equipment registered all the background noise under the water.
As well as noise, TNO also charted wave motion, wind speeds and the movements of vessels. ‘This provided a huge quantity of data, which we correlated to the movements of vessels with the aid of a model,’ says Eric Heemskerk, TNO project leader. ‘Subsequent readings, taken while dredging was in progress, for example, are then easy to compare with these background levels.’

INTERNATIONAL INTEREST

Once again, in September 2009, another week’s worth of measurement data was gathered. Again at various sites, but now while dredging was underway. This time, TNO put its own in-house SESAME system to work at a fixed location. A mobile version was mounted on a small boat working at location close to the various dredging activities.Now, as well as gaining a comparison with the measurements taken in 2008, it was also possible to determine which noises travelled through the site from which sources. This work relies on TNO’s propagation models.
The findings are expected in summer 2010. The Port Authority will then be able to submit the requested data to Rijkswaterstaat. ‘This will give us the source terms, which is what the government asked us for,’ explains Gerrits. ‘In future these source terms can be used to determine the impact on sea life.
At present little is known about the effects of work at sea. Rotterdam is one of the world’s busiest ports; the North Sea one of the busiest seas. This explains the considerable international interest in this research.’

NEW GENERATION OF BLAST WALLS FOR OFFSHORE

Floating production, storage and offloading (FPSO) owned by Bluewater

For years now, the same relatively simple technique has been used to drill for oil at sea. Now that fossil fuels are becoming increasingly scarce, oil companies are having to drill at ever more difficult sites. Often these are areas in which gas is released or where gas has collected above the oil sources. What's more, the extraction of natural gas for its own sake is really taking off. In situations like these, the risk of explosion and fire is greatly increased. The present generation of blast walls cannot deal with explosions involving large quantities of gas. Worldwide TNO is an acknowledged leader in research into this problem and its solutions.

ACCEPTABLE WEIGHT AND COST LEVEL

In the EXROS project TNO cooperated closely with two companies, Bluewater and Van Dam. Together the partners sought innovative solutions for a new generation of blast walls capable of withstanding high pressures. The work was guided by the need for an acceptable weight and cost level. Bluewater Energy Services B.V. designs, develops and operates floating production storage and offloading (FPSO) vessels. These vessels not only search for oil and gas, they also store it. Van Dam B.V. specialises in the design and construction of explosion and fire-resistant walls and doors for the oil and gas industry and for Defence. As its starting point, TNO used its own Auto-Reagas code to carry out a study of explosions involving large quantities of gas. This revealed that the pressures involved were much higher than those covered by existing regulations. Drawing on a brainstorming session and research into existing technologies, TNO experts collaborated with Van Dam and Bluewater to draw up a list of more than 30 potential concepts for a new generation of blast walls. Following more research, some 20 of these looked promising. Ultimately, four concepts including joints and fire protection were worked out in greater detail using sophisticated simulations to study each structure's failure.

BLUEWATER:

'TNO'S PRO-ACTIVE APPROACH COMBINED WITH THEIR EXTENSIVE KNOWLEDGE OF STRUCTURES SUBJECTED TO BLAST MADE THEM AN INDISPENSABLE PARTNER IN THIS PROJECT.'

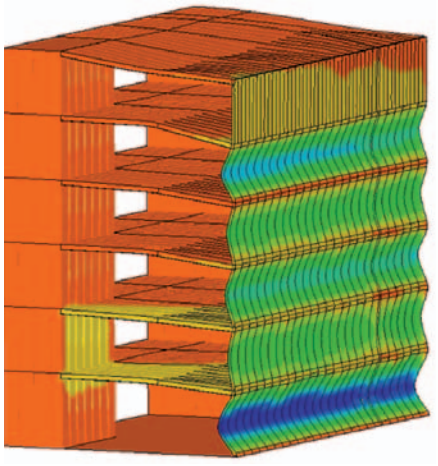
MINE OF USEFUL KNOWLEDGE GENERATED

‘There are various ways of resisting the pressure of an explosion,’ relates André van Erkel, a TNO expert in the protection of maritime platforms. ‘You can absorb or resist the pressure that is released. To learn more, in recent years we have been studying numerous materials in all sorts of structural shapes and have tested them in practice. For instance, flat plates, ridged plates, egg-box shaped plates and double plates, some filled with certain materials, others not. We have also looked at new types of joints and at combinations of materials. These have been based primarily on the membrane principle. This has generated a mine of scientific data, which we put straight to work in the EXROS study.’ Bluewater and Van Dam will be using the results of the research to convert the new concepts into products. Helping companies to innovate: this is what TNO does.

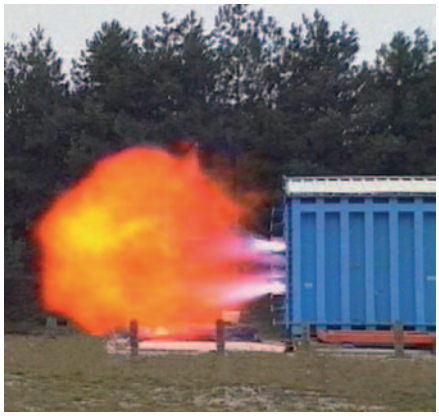
Test on a light-weight and affordable explosion-resistant structure

VAN DAM:

‘TNO HAS MANAGED TO CONVERT SOMETHING THEORETICALLY PROFOUND INTO SOMETHING PRACTICAL.’



FEM simulation of a blast wall for an FPSO facility



Gas explosion in the TNO test lab

YACHT BUILDING: COMBINING LUXURY WITH SUSTAINABILITY

The Ethereal

The Ethereal: it is being widely hailed as one of the world's most energy-efficient superyachts. The customer Bill Joy, co-founder of Sun Microsystems, wanted a large yacht that pushed the boundaries of what was technologically possible. This wish brought him naturally to the Royal Huisman shipyard in Vollenhove. But some challenges had to be faced before the efficient on-board use of electricity was assured.

LATEST TECHNOLOGIES

'Our reputation as an innovative shipyard is global. Our customers come from all corners of the world. External parties help us with some aspects of our projects since we cannot do everything alone. When our customer asked us to make the Ethereal an energy-efficient yacht, using the latest technologies, we called in TNO. They have unparalleled expertise in house,' relates Erik van Hulst, project manager with Royal Huisman.

The question was simple but the issue at its core was complex. Naturally, the yacht has electrical systems on board for navigation and communication. Diesel generators provide back-up in the event of failure and help manage the peaks in consumption. Could a more efficient system be devised? Could energy somehow be stored?

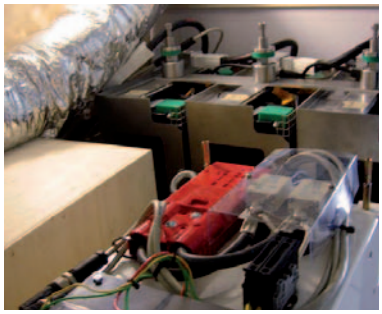
'TNO'S EXPERTS NOT ONLY DELIVERED SCIENTIFICALLY SOLID WORK, BUT THEY WERE ALSO ABLE TO TRANSLATE THEIR FINDINGS INTO PRACTICE SO THAT WE COULD BUILD IN THIS REVOLUTIONARY ENERGY SYSTEM.'

THOROUGH RESEARCH

Royal Huisman carried out its own research and quickly concluded that storing energy in batteries was the answer. Only there are limits to the space available and how much weight the yacht can haul around. Huisman scanned the market and settled on the latest lithium-ion technology; it offered good prospects. At the time the technology was still fairly new. So, in the first instance, Huisman asked TNO to carry out scientific research into the safety of the lithium-ion batteries.

'TNO did that in close cooperation with our suppliers,' reports Erik van Hulst. 'TNO studied how hot the batteries could get, whether fire could break out and the explosion risk. Stories were circulating that in mobile phones these new batteries could explode. For us, safety comes first. We wanted TNO to give us a definite answer.'

Calculating the efficiency of the new system was the second job for TNO. The aim was to demonstrate to the customer that the batteries were indeed efficient and had a long life. Plenty of knowledge about these technologies is available from manufacturers, suppliers, engineering firms, universities. Why consult TNO? 'Independent and scientific,' says Van Hulst. 'Their research was extraordinarily thorough. We are shipbuilders, craftsmen, people in the field. The great thing was that TNO's experts not only delivered scientifically solid work, but they were also able to translate their findings into practice so that we could build in this revolutionary energy system.'



Battery system test arrangement for the Ethereal

A FIRST FOR ROYAL HUISMAN

With its delivery of the Ethereal, Royal Huisman has entrenched its reputation worldwide as an innovative yacht builder. It is the first shipyard to succeed in delivering a completely new and efficient energy system on board a yacht. 'The storage of electrical power on board ships is still in its infancy, but it's going to soar,' says Berend Evenblij, an expert with TNO. 'The vessel in question here is a yacht but our research extends to everything that travels by water: cruise ships and dredging vessels, naval frigates. This garners attention worldwide. 'This knowledge is like gold dust and TNO, in other words the Netherlands, can use it to conquer the world with innovative concepts.'

SALVAGING THE KURSK

Rear of the Kursk

When major interests are involved in a project, discretion can be vital. TNO is often called upon to participate in such projects. Only much later, once the project has been completed, can details be published. A good example of this approach is provided by the salvaging of the Kursk, the Russian nuclear submarine.

Cable saw detail

MECHANICAL CHALLENGE

The people charged with salvaging the Kursk faced a series of hurdles. One of these was the mechanical challenge of working at a depth of 108 metres to separate the first compartment of the sunken sub, containing torpedoes, from the main section containing both the victims and the nuclear reactor. This would take too long if flame cutting torches were used. While another proven technology, the use of light explosives, would be much quicker, it is was similarly discounted due to the presence of life torpedoes.

ALTERNATIVE: CABLE SAW

There was, however, a third option, but it had never been proven: a cable saw. This system consists of a ‘beaded cable’ made up of hardened ‘beads’ drawn in a cyclical motion in the direction of the cable along the hull, thereby cutting through the steel. Before you start cutting through a submarine at depth using any such system, it’s obviously good to know that it will work. TNO was asked to supply the necessary technical evidence, to be gained experimentally. The role TNO played was crucial, in particular in finding the correct instrumentation to demonstrate that during each stroke enough steel would removed and to establish that the cable forces would be manageable.

WORKING DISCREETLY

The necessary discretion related not only to extensive experiments in TNO’s laboratory, but also to field tests in which the system was used to saw through scrap vessels. As the final check, a piece of submarine steel was shipped specially from Russia for TNO’s saw tests. As well as TNO’s technical expertise, this final check test also required TNO’s discretion as information about the composition of the hull material has strategic value. The media had a field day with the final result: once again Dutch industry had delivered work of global prominence. TNO is proud to have contributed.

TNO RESEARCH AND TEST LABS FOR THE MARITIME AND OFFSHORE SECTOR

1 WIND TUNNEL

Among others the TNO Wind tunnel can be used for measuring the aerodynamic drag (moments and forces) on ships and other marine constructions, the dispersion (and optimisation of the discharge) of fumes from exhaust pipes and flight deck wind tests in order to advice safe helicopter operations on board.

Laan van Westenenk 501
7334 DT Apeldoorn
T +31 88 866 2212
E rene.koch@tno.nl

2 MARITIME MATERIALS PERFORMANCE CENTRE

Test arrangement for research into the behaviour of materials in seawater, various forms of corrosion, antifouling and composites; electrochemical measurements.

Bevesierweg, MML building
1781 CA Den Helder
T +31 88 866 25 19
E corina.prent@tno.nl

3 MOVEMENT SIMULATION

Ground-breaking research lab with disorientation trainer, flight, seafaring and driving simulator. Capable of simulating the extreme movements of, for example, combat planes, helicopters, ships, cars and roller-coasters.

Kampweg 5
3769 THE Soesterberg
T +31 88 866 58 52
E peter.rasker@tno.nl

4 UNDERWATER NOISE

Basin measuring 8 × 10 × 8 metres (depth) in which underwater noises can be measured: where is the noise coming from, how is it propagated? Valuable to Defence, offshore and wind farms.

Oude Waalsdorperweg 63
2597 AK Den Haag
T +31 88 866 80 12
E frank.vandenberg@tno.nl

5 CLIMATE CHAMBER

Engines and complete vehicles are tested under extreme conditions in the climate chamber. Large offshore machines can also be accommodated. Temperatures can vary from –45° C to +55° C; the pressure can be reduced to a level consistent with an altitude of 4,000 metres.

Steenovenweg 1
5708 HN Helmond
T +31 88 866 84 86
E peter.vangompel@tno.nl

6 SHOCKS AND VIBRATION

Research lab for measuring shocks and vibrations, for example as a consequence of underwater explosions. The space industry, transport sector and civil infrastructure have tests performed here.

Van Mourik Broekmanweg 6
2628 XE Delft
T +31 88 866 30 21
E peter_paul.vantveen@tno.nl

7 EXPLOSIONS

Research and test lab for conducting tests involving explosions and for studying the effects on equipment and structures.

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