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Flagship TCI takes a close look at engine performance data.

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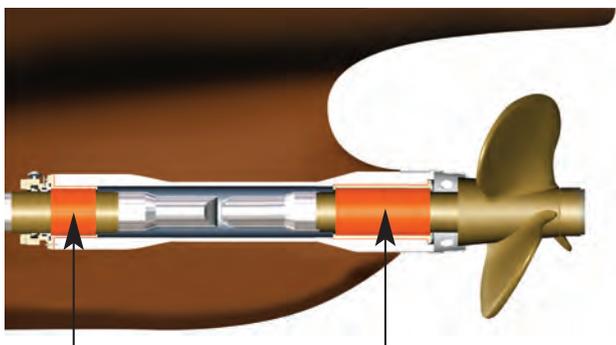
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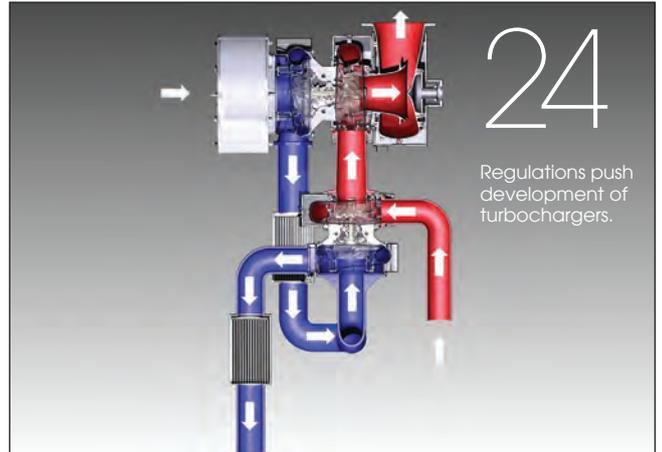
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On-line Edition

The Royal Institution of Naval Architects is proud to announce that as of January this year, *Shiprepair and Conversion Technology* journal has gone digital. We are very pleased to inform the maritime industry that each issue will be published online, on the RINA website. Visit www.rina.org.uk/srct and click on the issue cover you wish to view. This means that the entire publication, including all editorials and advertisements in the printed edition, can be seen in digital format and viewed by members, subscribers, and (for a limited time) any other interested individuals worldwide.



The Royal Institution of Naval Architects

DESIGN AND OPERATION OF TANKERS

8 - 9 June 2011, Athens, Greece

Second Announcement

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In recent years the industry has been through a commercially unprecedented period and been subject to major regulatory change. Both commercial and regulatory influences have presented many technical challenges and many more lay ahead.



Operators are looking to future-proof their new designs for potential new technologies, but this later benefit must be traded against initial cost outlay. The level of automation on board is also an area of development, how much should the crew be directly responsible for? Concern for the security of the ship, its crew and cargo is also now becoming a major design driver. Environmental regulation is also moving forward with the revision to MARPOL Annex VI placing further restrictions on emissions of NOx and SOx. The development of the IMO Energy Efficiency Design Index is aimed at stimulating technical innovation in propulsive efficiency as the industry strives to reduce its CO2 emissions.

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RINA invites papers from designers, operators, class societies, suppliers and builders on all aspects of tanker design and operation including:



- Cargo Handling
- Energy Efficiency
- Coatings
- Rules, Regulations and Standards
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Innovation is the key

The wooden model made by Ernst Vossnack in his back garden clearly displaying the layout for its cargo cylinders.

Bo Cerup-Simonsen, Maersk's VP of marine technology, told a gathering of industry experts that when he speaks to friends, family "even my wife... they say that shipping hasn't really changed for many years".

Such is the perception of the industry that many outside it, while they do not get visions of the *Mary Rose* when shipping is mentioned, have certainly only taken the historical journey in their mind's eye as far as the *Titanic* or possibly to the *Queen Mary* for some of the more advanced laymen.

Image is important and when old and dilapidated vessels sink and pollute the seas and coastlines, the image of the industry is affected for all those within it. Imagination is, therefore, crucial for those who work within the industry. To have the imagination to innovate and create in order to improve the industry and ultimately its image to those whose perception comes from the outside.

This is why Ernst Vossnack's Cylinder Tanker is as important today as it was when he was in his back garden designing his new tanker using (full) beer cans and wooden models. He took a simple idea, that of the transportation of juice in cylinders and expanded on that idea to create an entirely new concept.

Mr Vossnack was creating his design at a time when the pollution from tankers that ran aground and or sank was the key environmental problem facing the tanker industry. Today all ships now must be cleaner, reducing airborne emissions, and safer than ever before.

It is designers like Mr Vossnack who have the courage to think laterally and create that will improve the shipping industry and its image to outsiders. They also inspire others to pick up the mantle and drive designs forward. Hence this month's article from Helge Kringel.

If collaboration was the art that has moved the Cylinder Tanker design forward then that collaboration within the industry was high on the agenda at Lloyd's Register's (LR) excellent technology days on *HMS Belfast* last month.

The Naval Architect will reproduce excerpts from a number papers read on these two days in the coming months. We start this month with Peter Filcek, senior principal surveyor within Lloyd's Register (LR's) technical investigation department. Mr Filcek presented four scenarios on the day. Alas we have room for only two both investigating excessive noise and vibrations aboard liquefied natural gas (LNG) tankers. Each case had a different cause, but in sharing information such as this LR does the industry a great service.

Papers on tanker corrosion, gas fuelled ships and the Energy Efficiency Design Index (EEDI) were all delivered over the course of this conference. It is surely the mark of a truly mature industry that can share information in this way with a view to improving safety and efficiency. Of course this journal for the last 40 years (this year) and this institution for the last 150 years have set excellence through collaboration as its mission. Those that doubt the industry's ability to adapt need only look as far as the development of the diesel engine.

This month's issue outlines further developments to diesel engine technology, with news of scrubber technology that will make ships cleaner, new Hybrid Shaft technology that will improve vessel efficiency and yet more collaboration even between competitors, Wärtsilä and MAN Diesel and Turbo, who along with other commercial bodies and European Union (EU) government to further develop the mainstay of maritime propulsion so that the industry will meet its immediate commitments to reduce emissions.

Rudolf Diesel, himself was not even a twinkle in his father's eye when this institution was formed, but innovation and creativity in this industry pre-dates The Royal Institution of Naval Architects (RINA) and is as alive today as it has always been.

Collaboration is the key for this creativity and again Maersk has placed itself at the forefront of developments by engaging in a host of collaborative ventures with a number of industry partners, not least the Green Ship of the Future.

Mr Cerup-Simonsen explained the thinking of the company that lay behind its willingness to trial new technology. Customers are looking for cleaner vessels as their customers demand consumer goods that are delivered by and from sustainable sources. Delivering ships that can offer timely, safe, clean and cost efficient services is a challenge that this industry has demonstrated in the past it can deliver.

Collaboration and innovation displayed by those in the industry today show that the creative spark remains alive and kicking. *NA*

Newbuilding

Maersk throws down the gauntlet

Danish container ship operator Maersk Line has thrown down the gauntlet to its competitors with the order for 10 ships of 18,000TEU from Daewoo Shipbuilding and Marine Engineering of Korea.

The US\$5.7 billion order for 10 ships, with 10 options to be taken up by the end of this year and a further 10 options available later, Named the Triple-E, the new ships will be the longest on the water at 400m in length and will have a 59m beam with a deadweight of 165,000tonnes, a reefer capacity of 600 boxes and a 23knot maximum speed.

Draught of the new vessels is a comparatively shallow 14.5m due to the new U-hull shape which fills out the usual V-shape of the hull and offers most of the extra space for the increase in cargo capacity, although the ship is an extra row wider, 23 rather 22, compared to the 15,550TEU *Emma Maersk*.

The hull was optimised to create the greatest space for cargo while limiting the effects of drag on the vessel and the ship had to conform to the latest super post-panamax crane sizes, quay lengths and turning circles at terminals around the globe.

Other design features include the moving forward of the bridge and accommodation block with the engine room moved further back creating more space for cargo on deck. Maersk admitted, however, that they had not yet decided whether the ships would have two propellers or one. The two screw solution would allow the vessels to have smaller propellers, preventing them from rising above the water when the ship is operating light. This solution offers more efficiency and is expected to be the way Maersk chooses to go.

The company also claims that the vessels will be 50% more fuel efficient than existing ships and emit 35% less

pollutants than any ships currently on order. Although the ships will have a space for SOx scrubber technology to be added at a later date, because the company believes the current technology does not meet its requirements. A US\$30 million waste heat recovery system will also be added to the ships, bringing the total per ship cost to US\$190 million. Maersk says that the Triple-E with its advanced technology will have a 26% slot cost advantage to a 13,100TEU ship, based on a bunker price of US\$600/tonne.

Market outlook

Specialist ships boost industry

A change in the mood music has seen a more upbeat Wärtsilä claim a definite upturn in maritime markets which have provided a fillip to shipbuilders and equipment suppliers.

Although over-capacity means that some sectors of shipping remain stagnant, particularly merchant vessels, orders are still being delivered and new orders were strong in 2010, said the Finnish company. Offshore and specialist ship markets were particularly strong and Wärtsilä expects them to show continue to grow this year.

“In 2011, the prevailing conditions will continue to affect competition and price pressure among shipbuilding suppliers. Wärtsilä expects that its Ship Power order intake in 2011 will be moderately better than in 2010,” a company statement said.

The company added that the number of vessels contracted in 2010 represented an increase of 75% compared to 2009.

“This was a much faster and more significant recovery than expected. The improvement was backed by a recovery in trade and ship owner earnings, as well as by attractive new building prices.”

Cleaner by design, Maersk's Triple-E boxship incorporates much of the latest green technology and fuel efficient design.





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In the first half of 2010 contracting for bulk carriers was high, but the second half year container ships saw similar increases in contracting activity.

However: "The offshore segment continued strong throughout the year and demand was good especially for floating production units. In the fourth quarter demand for more specialised vessels was good."

Wärtsilä expects that a sustainable recovery in the marine service market will begin during 2011.

China has emerged an overall winner following the recession having secured a majority of new building orders, Korea followed in second place while both Japanese and European yards lost market share.

"Growing shipbuilding nations, such as Brazil, were active throughout the year and secured a good share of orders.

"In 2010, Chinese ship owners were the most active, ordering more than 20% of all vessels ordered. German owners, traditionally strong in shipping, were slow in ordering whereas Greek owners continued to be active," said Wärtsilä.

Newbuilding

Dockwise orders Type-0 from HHI

Dutch heavy-lift company Dockwise has ordered the world's largest semi-submersible vessel the Type-0 which it says is around 50% bigger than its next largest class, the 73,000tonne Type-1.

The Type-0 will be delivered by Hyundai Heavy Industries (HHI) in the latter part of 2012 and, the company says it will exceed the revenue that they had originally planned for in the first year. Weighing in at 110,000tonnes the 275m long ship will have a beam of 70m and will meet the demand for extra capacity in the fast moving offshore sector.

At US\$240million the Type-0 does not come cheap, but the company will pay for the vessel in two installments, 45% this year and 55% during 2012



and is fully financed through a previous rights issue and a revolving debt facility.

André Goedée, chief executive, Dockwise, said: "We have been particularly encouraged by clients' reactions since we announced this investment decision. It is our expectation, based on latest discussions with clients, that we will surpass our initial revenue assumptions for the first year of operations. Clients have grasped the game changing potential of the vessel and have made a valuable contribution to our thinking around the detailed design.

Final design specifications for the Type-0 are currently being considered through a consultation process with Dockwise clientele and HHI's offshore design division.

Design

Greek owners like Triality concept

The Union of Greek Shipowners (UGS) which was presented with the DNV's Triality tanker last month said the concept ship was "very interesting". A UGS spokesman said the tanker concept solved many issues, but that there were still some questions that needed to be resolved, "Still it is a way forward," he said.

The positive reaction for DNV's design by the UGS is a boost for the class society which had come under fire from some quarters for developing its concept vessels, the Quantam container ship was also designed by a DNV team.

The Norwegian class society has always said that the concept vessels were unlikely to be built as designed but the group believe that some of the elements of each design could be incorporated into newbuildings.

That was a view shared by the UGS who said that the long term savings for owners were attractive, but the Triality design would be for larger ships due to the ship being ballast free, meaning that it could have stability issues on its unloaded voyage.

Bunkering was also considered a problem for the LNG powered tanker design, but these were issues that could be resolved if the design became a reality, said the UGS and there is a long way to go before that happens.

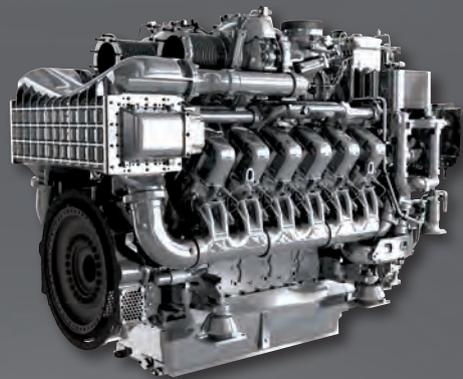
Correction: In February's news pages we incorrectly spelt the name of FKAB. *The Naval Architect* would like to apologise to FKAB for this error.

A 3D model of the 110,000tonne semi-submersible heavy transportation vessel (SSHTV).

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Engines

MAN cracks out Opcon Powerbox

MAN Diesel & Turbo has signed a co-operation agreement with Swedish energy and environmental technology company, Opcon. The agreement aims to explore the possibilities arising from the merging of Opcon's 'Powerbox' waste-heat-recovery (WHR) technology with MAN Diesel & Turbo's market-leading diesel engines for cutting fuel consumption and reducing emissions.

A marine installation that utilises waste heat for electricity production, is currently underway. The Opcon Powerbox is being integrated with a two-stroke MAN B&W 8S60ME-C8 engine aboard a newbuilding owned by Wallenius, the Swedish shipping group.



Opcon Powerbox produces fuel-free, emission-free electricity from waste heat.

Opcon Powerbox is a waste-heat recovery unit is an energy-recovery heat exchanger that recovers heat from hot streams with potentially high energy-content. The Opcon Powerbox is a stand-alone power plant that transforms waste heat from diesel engines to emission-free electricity. In recovering waste heat, both from exhaust gases and engine-cooling water the system is suitable for both newbuildings and retrofits.

The Opcon Powerbox is unique in that it caters for low-temperature applications and uses robust technology. It can also be integrated with smaller engines in contrast with existing WHR units that are targeted at higher-temperature applications and larger engines.

The Opcon Powerbox directly influences the performance of ships by reducing the amount of fossil fuels they consume during operation by 5-10%. It significantly reduces consumption and directly cuts carbon, NOx and sulphur emissions.

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Ancillary equipment

It's a gas for Crowcon Xgard

Crowcon's Xgard IR infrared (IR) gas detector has been approved to the latest amendment of the Marine Equipment Directive (MED, 96/98/EC). This means the detector can be used to detect flammable gases and vapour hazards on tankers, drilling ships, FPSOs, dive vessels, coastguard vessels, ferries and other marine vessels.

Applications for the Xgard IR include pump rooms and monitoring leaks in storage tanks, pipes and valves. It provides fast early warning of gas accumulations before concentrations reach flammable levels. Detection is in the range 0 – 100% LEL.

Unlike conventional sensors (such as catalytic pellistors) the Xgard IR's sensor is immune to being poisoned or inhibited by other substances. Infrared sensing has other benefits such as being able to detect flammable gas in inert backgrounds and are also not damaged by high gas concentrations.

The Xgard IR is available with a 316 stainless steel enclosure for maximum corrosion resistance in the most extreme marine environments. The sensor, which has a life expectancy of over five years, is a plug-in module that makes replacement quick and easy. ATEX, IECEx and UL approved for use in hazardous areas, the Xgard IR is also Exd flameproof rated.

The standard junction box is designed for both wall and ceiling mounting, and four cable gland options ensure compatibility on any site. The detector takes a range of accessories for harsh or wet conditions and for remote sampling.

Contact Crowcon Detection Instruments Ltd, 2 Blacklands Way, Abingdon Business Park, Abingdon,

Crowcon's Xgard IR infrared gas detector.



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Ancillary equipment

ESAB strikes a cord

UK-based welding supplies manufacturer ESAB has introduced its latest rutile corded wires, for welding of high strength steel, on to the market.

Dual Shield 55 and Dual Shield 62 are ESAB's latest all positional rutile, low hydrogen flux-cored wires for the welding of high strength steels, giving weld metal yield strengths of minimum 550 and 620 MPa respectively and good toughness down to -40°C. They have excellent weldability and produce flat beads with good wetting and smooth appearance. Both wires are designed for use in Ar/CO₂ shielding gas.



ESAB's latest rutile cord wires for welding.

These 'welder-friendly' wires have a soft, spatter-free arc that always operates in the spray arc mode. It is easy to obtain flat welds with a good penetration and smooth wetting onto the plate edges. The brittle slag is easily removed leaving behind a smooth weld appearance. Typical positional welding defects such as lack of fusion and slag inclusions are avoided, due to the spray arc operation. The wires have a good tolerance for fit-up variations. High quality one-sided root runs are made economically on ceramic backing.

The wire formulation provides a fast freezing slag that supports the weld pool well in positional welding, enabling deposition rates which cannot be equalled by stick electrodes or solid wires. Deposition rates in vertical up welding can reach up to 4kg/h (100% duty cycle), making it the most productive consumable available for manual welding position. Welding parameters are optimised per welding position for maximum productivity, but one

single setting can be selected for all-positions (230A), making it ideal for fit-up work.

Contact ESAB, Hanover House, Queensgate, Britannia Road, Waltham Cross, Hertfordshire, EN8 7TE, UK.
Tel +44 800 3893152
www.esab.co.uk

Software

MESPAS launches version 5.13

Mespas AG has released version 5.13 of its fleet management software mespasR5. With more than 80 new functionalities and modifications, this software upgrade is the most complex and largest ever released by mespas. The most important innovations relate to the mespas Cube and mespas Reporting Engine.

The mespas Cube, which is installed onboard the ships, is a small offshore server, which acts as the hub between the vessel's PCs and the central database ashore. With the Cube, the vessel client architecture was changed from a "single user/single PC" to a "client/server" architecture, which is fully network and multi-user capable. The software can be run on multiple PCs onboard the ship, without impinging on the software's ability to synchronize and work with the central database ashore.

The mespas Reporting Engine was developed with this need in mind. The overviews, comparisons and analyses can be run on single vessel level as well as across products or even the entire fleet, thanks to the centralized database. With the mespas Reporting Engine, the huge amount of data that is recorded and documented every day can be analysed and made viable to relevant internal and external stakeholders.

In addition new features include a complete redesign of the Planned Maintenance System (PMS) – now called Asset Management System, which further improves the system's architecture as well as the functionality and look & feel of the user interface. Additional enhancements were implemented in part management, procurement, and maintenance. Also, enhancements in simplified recording of jobs; enhanced part management functionalities including location history; easy categorisation of recurring jobs; and many others.

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The devil's in the data

Securing robust data from a ship's engines is a major part in establishing a performance management system. However, ensuring that the data is correctly presented to the crew is where the maximum value can be added. Ornulf Jan Rodseth, Marintek's research director, discusses how the part-European Union (EU) funded FLAGSHIP-TCI project secures robust engine performance data.

Recent changes in market conditions including reduced margins, the relatively high cost of bunker fuel and the focus on reducing emissions have brought the need for vessel efficiency into the spotlight. Many ships currently in service were built before these issues were ever considered. However, for a vessel built in the late 20th century which has perhaps 20 more years of service life, the need to improve its efficiency and reduce its emissions is imperative to meet commercial and legislative requirements.

Furthermore, changes in crewing arrangements combined with advances in technology have led to a situation where ship-board systems are now extremely complex, but there are fewer people on board to manage them. With this in mind and in order to ensure that a ship's technical systems are working at maximum efficiency it is now desirable to provide a vessel's crew with a mechanism for co-operating more intensively with shore-based experts.

FLAGSHIP's Technical Condition Indicators (TCI) sub-project has developed a framework of data capture, transmission, analysis and advice utilising a collaborative platform. In developing a framework to fulfil this brief, the FLAGSHIP TCI team identified a number of value-adding opportunities that could be implemented by utilising the enhanced onboard data acquisition and data communication between the ship and shore to build a repository of performance data that can be used for long term performance and efficiency.

FLAGSHIP is a consortium of more than 40 European maritime organisations



Shipboard systems are now more complex with fewer people to manage them. (Courtesy of Teekay)

digital gauging



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collaborating in a part EU-funded project which is focused on improving the safety, environmental friendliness and competitiveness of European maritime transport. The project was designed to further increase the capacity and reliability of freight and passenger services and to further reduce the impact from accidents and emissions. The emphasis of the overall FLAGSHIP project is focused on onboard systems and procedures, ship management systems on shore, the impact of new technology on present ship-, owner- and operator organisations, effective and efficient communication interfaces and the impact of standards and regulations.

The FLAGSHIP-TCI sub-project was led by MARINTEK in Norway and was supported, delivered and trialled in conjunction with NTNU in Norway, Teekay Shipping, and Rolls Royce in the UK; Danaos Shipping Co Ltd and ASME of Greece; Containerships in Finland and the class society RINA in Italy.

Measuring overall vessel efficiency is a huge challenge simply because there are so many factors involved. While it is possible to introduce proprietary measurement systems and devices with the required level of accuracy and repeatability there is major expense involved and consistency is not yet guaranteed. By focusing on acquiring data from main engines, auxiliary engines and thrusters it is possible to improve the



Orulf Jan Rodseth, research director at Marintek.

efficiency of each individual piece of plant while obtaining a comparative overview of the performance of the whole ship.

With the aim of delivering long term measurement and analysis the FLAGSHIP TCI team developed a framework utilising instrumentation that is currently used aboard the vast majority of vessels.

The concept behind Technical Condition Indicators utilises performance information in a manner similar to the way key performance indicators (KPIs) are used.

Measurement data taken in service is used to assess the performance of important mechanical equipment onboard a vessel. The efficiency and degradation of equipment can be assessed from the dynamic properties of equipment, taken in its operational condition.

By recording validated performance information in a single digital log it is possible to take a far more homogenous view of reviewing performance over time and identifying trends. Whether an engine is being run at 70% load or 90% load there are relationships between performance parameters that can be compared over time to measure performance and act as a catalyst for improvement.

In order for any analysis to provide valid and valuable results it is imperative that

“it would be possible for ship owners to review trends across sister vessels and address mechanical or reliability issues before they became problems”

By focusing on information from main and auxiliary engines and thrusters it is possible to improve the efficiency of each element and get a comparative view of the whole ship.

(Courtesy of Teekay)



the raw data is complete and accurate as possible. Repeatability of measurements is particularly important on equipment where external variables had a major impact. For example, instrumentation that indicates cylinder pressures is totally dependent on correct timing of top dead centre. One degree wrong in the timing variable can introduce 10% error in the calculation. In order to ensure that the raw data being used was valid the FLAGSHIP TCI defined a set of measurement procedures including ensuring that sets of complementary data were recorded. Wherever possible, FLAGSHIP TCI utilises measurement data taken by the vessel's crew as part of their normal mechanical inspection regimes. By aligning the process with one that the crew's members were familiar with, it added very little to their workload.

Once collected, the data is input manually to a PC via an Adobe form which provides a basic level of data validation. The data is automatically converted into XML format and sent ashore via an email application as a standard attachment. The system uses powerful data exchange formats but the user interface is deliberately basic, accessible and intuitive making it easy for the crew to use. The methodology and IT architecture that the FLAGSHIP TCI team has used makes it technically possible for data to be collected automatically in the future. With further development the system could be upgraded so that readings are taken directly from key sensors and the data automatically imported as XML data.

When the data is received onshore it is extracted from the message, processed, analysed, and compared to trend, benchmark and reference data. An automatic analysis is undertaken and a report generated and sent to the crew or to the shore-based specialists as appropriate. While FLAGSHIP TCI has not been designed as a diagnosis system it does have the capability to provide an advisory warning if an issue is identified. By normalising and correcting data, the system can detect potential issues over a range of temperature, pressure and speed parameters. An aggregation of indicators in the same area is used to address the challenges with instrumentation and support one high-level indication. In order to make the advice as accessible as possible to all parties, the reporting takes the form of text and a red-yellow-green, traffic light indicator system.

The FLAGSHIP TCI has been developed to provide several layers of decision support. Not only will automatic functions in the land based server pick up the main trends and identify any negative results the electronic analysis and distribution can be programmed to send each report to individual specialists depending on the results. Furthermore, the owners shore personnel and the crew can use the same report to discuss the issues and the best way to address them. FLAGSHIP TCI has created an easily accessible platform for facilitating co-operation between the crew, the ship owner and a range of different experts. Furthermore it would be possible for ship owners to review trends across sister vessels and address mechanical or reliability issues before they became problems. By engaging



Technical condition indicators can be shared with data repository on shore and used for long term performance monitoring. (courtesy of Teekay)

a range of specialist knowledge, FLAGSHIP TCI makes it possible to co-operate to find valuable solutions to problems that are not directly obvious.

One of the key value-added elements provided by adopting the FLAGSHIP TCI framework would be access to valuable performance data stored as part of a collaborative database. With the potential for an independent organisation to collect data from a range of ships, meaningful benchmarking would become viable. With

more data available in the future it would be possible to compare a broader range of ships, compare your data to a ships reference values, as well as looking at global trends for a particular ship.

The FLAGSHIP TCI project has taken a major step forward in improving the management and ultimately the efficiency of ship's engines and thrusters without the need for major investment in sensors or other new technology. The work done by the Flagship TCI team has demonstrated that it is possible to successfully measure and record robust data that can be used to improve efficiency without a lot of additional instrumentation, or workload for the crew. By deploying a standardised platform that encourages co-operation between different experts, FLAGSHIP TCI makes it straightforward for a range of experts with different specialisms, in different locations to engage with a technical problem and provide a solution. While still in its infancy, the data comparison and efficiency improvement opportunities offered by the Flagship TCI project will be very important for the shipping industry in years to come. **NA**

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Success of industry collaboration points to further funding

Although the use of public money to fund technological research by private organisations has its critics within the European maritime community, various European Union (EU) and national programmes have attracted greater participation by the industry over recent years, writes David Tinsley.

A perception of the increased practical relevance, improved structures and new opportunities presented by publicly-sponsored R&D initiatives has helped swell involvement by manufacturers, technology specialists, and ship owners, often partnering academia and the classification sector. The pragmatism permeating national R&D that has long been displayed by Germany, in particular, is far more in evidence today in the EU Framework Programme than it was some years ago.

The need for companies to maintain the R&D momentum, with all its associated costs in man-hours and resources, and irrespective of fluctuating market conditions and profit margins from year to year, has no doubt increased the attractions of participating in joint projects that typically have upwards of 50% in financial support.

The large, integrated projects beloved of the European Commission (EC) as a means of stimulating pan-industry collaboration, are expressed more clearly than ever before in the current Seventh Framework Programme, the EU's main instrument for funding R&D. Europe is well known for the development of innovative technology and processes. Arguably, though, the approach has been fragmented. One of the main planks of the Framework Programme has accordingly been to foster an integrated, cooperative approach to pre-competitive technological research, and thereby channel strengths to potentially greater global effect.

Although the manufacture of large two-stroke diesel engines is now almost wholly the province of eastern Asian producers, Europe retains market-leading strengths in both two-stroke and four-stroke marine engine technology. A raft of major R&D projects part-funded



Turbocharger technology forms an important element of the Hercules-B co-operative research project. Wärtsilä's photo here shows a prototype two-stage turbocharging system on the company's RTX-4 laboratory engine.

out of EU and national coffers is contributing to new endeavours to consolidate that position through further advances in engine and energy efficiency, and operational and environmental performance.

"EC funding for R&D is an excellent instrument for focusing on practical science, and maintaining and improving technological leadership and competitiveness," stated Trudy Schoolenberg, Wärtsilä's Vice-President responsible for global R&D. In a recent article in the company's stakeholder magazine *Twentyfour7*, Ms Schoolenberg observed that "It takes 5-10 years to develop a new marine technology product, and

demands the involvement of a large number of experts. EC funding mechanisms help in gathering together the best expertise and creating the necessary research facilities. They accelerate the launching of innovative products, which proactively address the demands set by environmental and other legislation. Without public funding, it would be impossible to carry out research on this scale."

Despite being arch-rivals in the global business of supplying engines and propulsion systems, Wärtsilä and MAN Diesel & Turbo have found merit in selective collaboration within the EU-sponsored, multi-phase Hercules programme.

The Hercules-A project, undertaken between 2004 and 2007, set a new benchmark for co-operation in marine engine technology research, drawing in some 40 participants from 10 countries. The follow-on Hercules-B project, initiated in 2008 with a 36-month timescale, is attributed with a raft of achievements to date by the 38 partner-consortium. This prompted MAN and Wartsila in December 2010 to propose a further phase, Hercules-C.

Hercules-A received EU funding to the tune of €15 million under the Sixth Framework Programme, plus the equivalent of €2.5 million from the Swiss government, towards total budgeted costs of around €33 million. Hercules-B was implemented with a similar level of EU funding under the Seventh Framework Programme, but for a smaller overall budget of €26 million.

If Hercules-C gets the go-ahead in 2011 for financial support within the terms of the Seventh Framework Programme, the

new phase will run from 2012 until 2015. The continuation project has a targeted budget of €19 million, which would bring the total combined budget of the Hercules programme to around €78 million.

The principal aim of the current, Hercules-B phase is the development of new technologies to reduce gaseous and particulate emissions from marine engines. A secondary aim is to improve both engine efficiency and engine reliability, since this reduces specific fuel consumption, carbon dioxide (CO₂) emissions, and lifecycle costs. The multinational project consists of 54 sub-projects grouped into 13 task packages and seven work packages covering the entire spectrum of marine engine technology.

Hercules-B has produced valuable test results with regard to two-stage turbocharger technology. This technology is viewed as a groundbreaking advance which could lead to a new era of environmentally sound solutions and competitive lifecycle costs for large marine

diesel engines. Other important results of Hercules-B so far have been the design and production of research tools, such as a spray combustion chamber and a camless (no camshaft) research engine. The spray chamber was developed to support the mathematical modelling of fuel spray patterns and combustion processes in diesel engines.

One of the main arguments for Hercules-C is the need for integration of the multitude of new technologies identified under Hercules-A and Hercules-B, and for the preparation of optimal solutions. Other proposed research areas are the factors affecting engine reliability and engine lifetime.

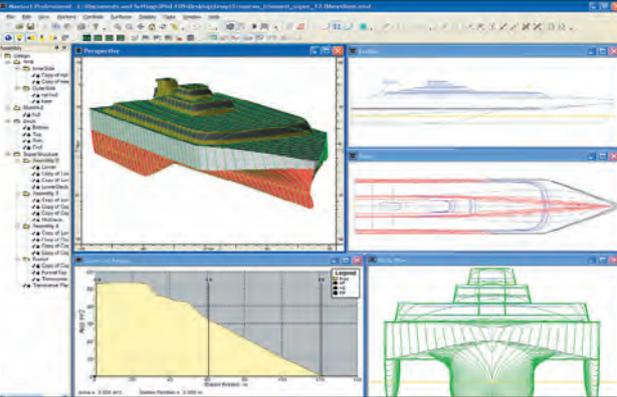
MAN and Wartsila created a joint subsidiary, Augsburg-domiciled ULEME, to provide management and coordination for the Hercules programme.

Wartsila is also heavily involved in the Ultra Slow Ships (ULYSSES) project, launched at the outset of this year under the Seventh Framework Programme,



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in keeping with the Commission's environmental goals. The research partners have a remit to demonstrate that the efficiency of the world fleet can be increased, through a combination of ultra slow speeds and complementary technologies, to a point where major reductions can be achieved in the industry's CO₂ emissions.

The initial target is a 30% cut by 2020 in greenhouse gas emissions, compared with 1990 levels, towards the aim of securing advances that will result in 80% less emissions than 1990 by the middle of the century.

ULYSSES is focused on bulk carriers and tankers, as these categories account for 60% of CO₂ from all ocean-going vessels. Since bulkers and tankers are already relatively slow ships, the technical challenges of reducing design speed are greater than for other ships. Therefore, it is expected that the project will address not only engine and propulsion technologies, but also directional stability and seakeeping issues.

Besides Wartsila's subsidiaries in Finland and the Netherlands, the research consortium includes Bureau Veritas, which is also acting as project coordinator, Germanischer Lloyd, SSPA Sweden, TNO of The Netherlands, Newcastle University, the Technical University of Denmark, Chalmers University of Technology, Belgian ship owner Euronav, and others.

An EU-sponsored, three-year research project with the ambitious target of reducing pollutant and greenhouse gas emissions from ships by 15%-35% was due to start in January 2011 under the title of Technologies and Scenarios for Low Emission Shipping (TEFLES). The study is expected to cost €4 million, and €2.6 million funding has been sanctioned under the Seventh Framework Programme.

A central area of study will be how to raise ship efficiency on each voyage, including sailing time, docking, and cargo loading and unloading. The objective is to identify and develop the best technologies that can reduce environmental impact and yield savings in operating costs.

The project partnership comes from six European countries, but includes substantial representation from the Galicia region of north west Spain, which has a strong maritime and shipbuilding

industrial base. Galician members of the project account in total for €1 million of the EU funding.

Vigo-based technology innovation consultancy Inova is project manager for TEFLES. Another Vigo company specialised in shipping technology and research, VICUS Desarrollos Tecnológicos (VICUSdt), is overall technical coordinator as well as leader of two of the work packages. VICUSdt will focus on the development of hybrid drive technology and energy storage, including its potential application to support ships in harbour. A further two organisations from the same area, shipbuilder Hijos de J.Barreras and port operator Autoridad Portuaria de Vigo, are also partners in TEFLES.

MAN Diesel & Turbo is coordinating the HELIOS project, implemented last September with the goal of developing a research platform based on a low-speed, two-stroke gas Diesel marine engine. The objective is a new generation of high-pressure gas injection engines operating on compressed natural gas (CNG) and/or LNG, using both Diesel-type and partly pre-mixed combustion principles.

HELIOS has qualified for EU Seventh Framework Programme funding of €2.98 million, towards a total budget of €5.11 million, on the strength of the environmental technology goals. Compared to current marine diesel engine technology, the research engine platform is to have an emissions footprint that is 20-30% lower in CO₂, 10-15% lower in NO_x (nitrogen oxides), 90-100% lower in SO_x (sulphur oxides), and 60-70% lower in PM (particulate matter). Besides installations in newbuild ships, HELIOS is also intended to provide for retrofitting of gas diesel technology into existing ships.

Among the particular technical challenges are the development of reliable gas injection systems, the combustion system layout including ignition control, engine monitoring/diagnostics, and combustion chamber materials. The project must also address issues relating to the onboard storage and transfer of CNG and LNG.

MAN's partners in the three-year project include compatriots TGE Marine Gas Engineering, Germanischer Lloyd

and Friedrich-Alexander University, plus participants from Sweden and Switzerland.

The need for new propulsion concepts that can deliver a step-change in efficiency is the driving force behind the STREAMLINE project, implemented last year under the Seventh Framework Programme. This 48-month project has a budgeted cost of €10.91 million, of which €7.95 million is being publicly-funded.

The first task of STREAMLINE's research partners is to investigate radically new propulsion concepts that have the potential to increase efficiency by at least 15% relative to the current 'state-of-the-art'. The concepts will be designed for maximisation of energy conversion, combined with low levels of cavitation, and low levels of noise and vibration.

The second objective is to study methods of fully optimising current state-of-the-art propulsion systems, including those based on conventional propellers, podded propulsors, and waterjets. The third goal of STREAMLINE is to develop advanced CFD (computational fluid-dynamics) tools and methods to optimise the hydrodynamic performance of the new propulsion concepts. The final objective is to present the operational, economic and classification aspects of each of the new propulsion concepts.

STREAMLINE will demonstrate solutions for a wide range of applications, although there will be a particular focus on short-sea shipping and inland waterway transport.

The project is one of the most extensive to have been launched in 2010 as regards the number of participants and the four-year timescale. The research consortium is led by Rolls-Royce Power Engineering of the UK and has 30 partners from eight European countries, including equipment makers, research institutes, technology specialists, universities, and the classification sector.

EU and national funding for the foregoing and other initiatives, however, should be seen against the backcloth of European companies' considerable, ongoing commitments to R&D from their own resources. **NA**

HSG-Concept shaft takes to the waves

Technicians from Rolls-Royce Marine have developed a system that avoids the need to run shaft generators at a constant frequency. A patent is pending for the Hybrid Shaft Generator, also known as the HSG-Concept. By David Tinsley.

Shaft generators supply electrical current for ship systems in an economical manner by using the rotational energy of the main engine to turn an alternator. However, a ship's electrical system normally requires a fixed frequency, which requires a constant engine speed, or a very limited variation.

By contrast, the Hybrid Shaft Generator, or HSG-Concept, conditions the power from a shaft generator so that a constant voltage and frequency is received at the switchboards, and so that the correct phase angle is achieved, to match other generator sets running in parallel.

This makes it possible for more flexible use of the engine and propeller speed variations, so that both the engine and the propeller can be run at their design points, improving efficiency



The Rolls-Royce hybrid shaft generator (HSG-Concept) drive system, seen here in application on an NVC design of tanker, confers greater running flexibility and efficiency.

and reducing exhaust emissions. In addition, the HSG-Concept system can control the generator so that it acts as an electric motor, to feed power to the shaft (PTI, or power take-in) to drive the propeller.

The main candidates for the HSG-Concept

are vessels with medium-speed engines driving controllable pitch propellers or main thrusters through reduction gears. Engine and shaft speed can be set to give the required power in the most economical way, so that the propeller operates at its maximum efficiency, speed and pitch for the given conditions. The shaft generator continues to function down to very low shaft speeds, feeding the main switchboard and supplying the ship's electrical load without the need to run auxiliary generator sets.

The new HSG-Concept drive is also suitable for merchant ships with direct-coupled low-speed diesel engines and fixed pitch propellers. The HSG allows the generator to follow changes in engine running speed, while still providing the normal voltage and frequency to the electrical consumers. **NA**

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Turbocharging boosted by new regulation

Advances in turbocharger technology are pivotal to improvements in diesel engine performance, efficiency and environmental compatibility. David Tinsley reports.

Recent and forthcoming step changes in mandatory emission standards, coupled with ever-more pressing concerns over specific fuel consumption, have given considerable impetus to research and development endeavours focused on turbocharging. Innovation is clearly expressed in the product development process and in the crafting of new solutions.

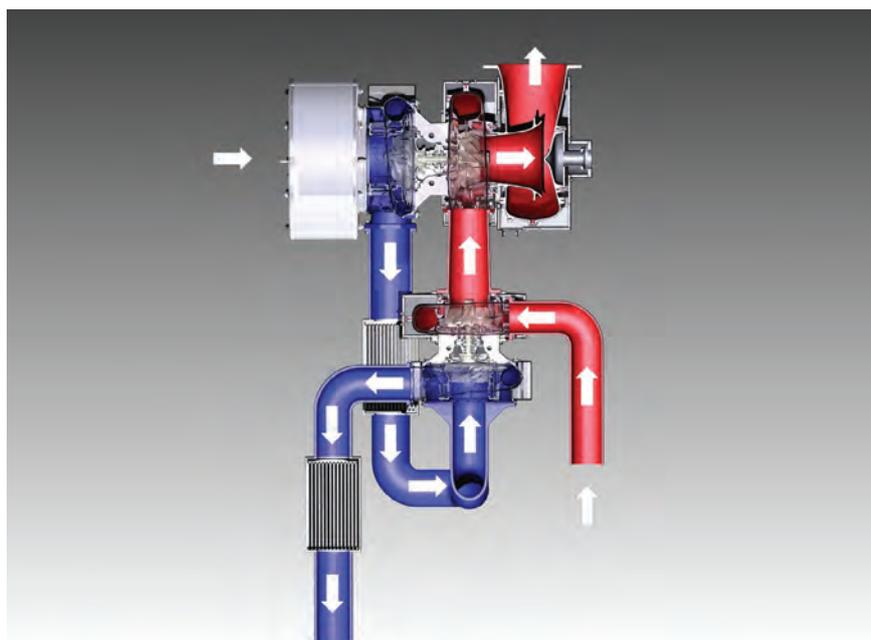
In particular, two-stage turbocharging is regarded as a seminal technology, which could lead to a new era in environmentally sound solutions and competitive lifecycle costs for large marine diesel engines.

It enables charge-air pressures to be increased substantially, raising engine mean effective pressure, and consequently reducing exhaust emissions despite increased engine specific power output. The requisite charge-air pressures are of an order that cannot be achieved through single-stage turbocharging.

The key point of interest is the potential offered by two-stage turbocharging in helping the industry reduce oxides of nitrogen (NO_x) emissions to the much lower limits to be mandated in 2016 under International Maritime Organisation (IMO) Tier III edict. The system facilitates the use of a different type of combustion process, the so-called Miller cycle, which has the effect of lowering peak temperatures within the combustion chamber, thereby producing less NO_x.

The basic principle underlying the Miller process is that the effective compression stroke can be made shorter than the expansion stroke by suitably shifting the inlet valve's timing. Since the inlet valves are open for a shorter period than normal, less air will be drawn in to the combustion chamber. By applying two-stage turbocharging, however, the high boost pressures force sufficient air into the chamber to realise the full benefits of Miller timing. As a consequence, the two technologies form an optimum combination.

One of the drawbacks cited is the potential for poor low-load running as a result of



MAN two-stage turbocharging with intermediate cooler (Suction air/charge air side shown in blue, exhaust gas side in red).

comparatively low in-cylinder temperatures. Therefore, attention is being paid by engine and turbocharger manufacturers to new means of controlling valves so as to permit variations in valve timing to suit the load demand on the engine across the operating profile.

Last year, Wartsila and the Swiss company ABB Turbo Systems announced a joint programme to develop two-stage turbocharging for large diesel engines. Wartsila's objective is the combination and integration of two-stage turbocharging with advanced engine technology to optimise engine performance, benefiting fuel efficiency and emissions.

In the new technical solution introduced into the Wartsila four-stroke engine portfolio, two turbochargers are arranged in series to generate increased charge air pressure, increased airflow, and a more efficient turbocharging effect. The increased

combustion air density conferred by the arrangements, together with the adoption of advanced engine technology, offers power output improvements up to 10%. At the same time, both fuel consumption and carbon dioxide (CO₂) emissions are reduced.

Testing of the two-stage turbocharging concept has been carried out using four-stroke Wartsila 20- and 32-series engines at the company's Vaasa test facility in Finland. It is planned to extend the technology to two-stroke engines.

Prior to its agreement with Wartsila, ABB Turbo Systems entered into a collaboration with engine component specialist INA Schaeffler of Germany for the joint development of ABB's new Valve Control Management (VCM) system. VCM has been designed to allow the variation of both valve timing and valve lift on four-stroke diesel and gas engines of more than 400kW.

A prototype of VCM underwent tests

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during 2010. ABB regards VCM as a method of facilitating the application of advanced Miller cycles to engines to meet future IMO Tier III limits on NOx emissions. With this objective, VCM could complement ABB's Power2 two-stage turbocharging system.

The VCM system achieves variation in valve timing and valve lift by the use of a high-pressure oil chamber located between the engine valve and its mechanical actuation system. A solenoid valve varies the filling of the chamber with engine lubricating oil delivered under pressure by a camshaft-actuated pump. This enables the timing of the opening and closing of the engine valve to be varied, and also enables the distance the valve opens to be varied.

The Power2 two-stage turbocharging system under development by ABB consists of two turbochargers of different, tuned frame sizes. These are connected in tandem on the compressor side via an intermediate air cooler. Power2 is being tested at ABB Turbo Systems' technical centre in Baden,

Switzerland, and on two-stroke and four-stroke engines from major designers.

MAN is ready to bring two-stage turbocharging to the market through the introduction of the TCX generation of turbochargers for large-bore diesel engines.

The TCX series is based on the proven design philosophy of the TCA and TCR series, with uncooled casings and durable plain bearings. However, while the TCA types use axial turbines and the TCR types use radial turbines, the new TCX turbocharger series has a novel, diagonal turbine. This is best suited to the lower-pressure ratios.

Two-stage turbocharging creates a number of challenges not exclusively related to the turbochargers but also to the nature of the engine's charging system. In addition to the space and piping requirements that an additional(second) turbocharger stage requires, an optimised intercooler is included in the MAN solution. The compact solution also has the two turbochargers arranged at 90 degs to each other.

Two turbochargers of different sizes, connected in series, are used in the two-stage turbocharging system. The exhaust gas from the engine drives the turbine of the smaller,

high-pressure turbine(the first stage). This in turn drives the turbine of the larger, low-pressure turbocharger(the second stage).

The low-pressure turbocharger's compressor draws in ambient air and sends it via an intermediate cooler to the high-pressure turbocharger's compressor. Here, the air is compressed once again and then sent, via a further charge-air cooler, to the engine. The system adapts to varying operating conditions, either through controlled turbine bypass, or by variable turbine area(VTA) technology variable nozzle rings.

MAN has successfully introduced VTA technology to turbochargers with both axial and radial turbines for installation on large diesel engines burning heavy fuel oil(HFO), probably the most technically challenging engine fuel in daily use. **NA**

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Ferries ripe for scrubber offer

The operating patterns of short sea ships and ferries in particular, offer an ideal opportunity to apply exhaust gas scrubbing technology, according to Hamworthy Krystallon.

While operators of deep sea tonnage consider their options with respect to the fuel burnt inside and outside the International Maritime Organization's (IMO) fast expanding Emission Control Areas (ECAs), those operating short sea ferries on routes spending the majority of their time within ECAs will be afforded no such luxury.

Already, the Baltic Sea and the North Sea/English Channel are defined by IMO as ECAs. On 26 March, 2010, IMO designated the same status to specific portions of USA and Canadian waters, with entry into force due from August 2012. Further ECAs are being considered for such areas as the Mediterranean and Japan.

The ECAs defined within IMO's revised MARPOL Annex VI have capped the maximum sulphur content in fuels used by ships in such zones at 1% from this year, moving on to a tighter 0.1% from 2015. Under European Union (EU) Directive 2005/33/EC, meanwhile, a 0.1% limit on sulphur content in fuels for ships in EU ports was imposed from January 2010.

Both provisions permit exhaust gas cleaning as an alternative, allowing ships to continue burning low cost, easily available residual fuel oil.

For operators of coastal tonnage and short sea passenger vessels, in particular, the effect of the ECA will simply be a straight choice between a shift towards currently scarce and costly distillates that achieve low emissions after combustion, or investment in the type of after burn technology that achieves similar emissions levels.

Taking a lead

It was the performance of the Hamworthy Krystallon shipboard exhaust scrubber applied to an auxiliary engine during trials on board the P&O Ferries ship *Pride of Kent* that led both IMO and the EU to



It was the performance of Hamworthy Krystallon's exhaust scrubber during trials on an auxiliary engine aboard P&O Ferries' *Pride of Kent* that led both IMO and the EU to conclude regulations limiting emissions were feasible.

bring emissions abatement technology into the legislative framework.

Trials of the company's seawater scrubber, with an engine burning residual fuel oil with sulphur content of 3.5%, showed that those emissions were cut by as much as 98%.

The solution has subsequently been trialled on the Holland America Lines cruise ship *Zaandam* and on two land-based installations (in Europe and Asia).

It is no coincidence that the first ever commercial order for any exhaust gas scrubber was thus placed with Hamworthy Krystallon, from Italian owner Ignazio Messina & C. The order was made so that four new 45,000dwt ro-ro ships burning residual fuel oil can meet rules demanding sulphur emissions equivalent within EU ports. The ships, under construction at Daewoo Shipbuilding and Marine Engineering, South Korea, will principally operate between Italy and the east and west coast of Africa.

A similar seawater scrubber was also recently fitted on the *APL England*,

a 5500TEU container vessel trading between Asia and the USA. The exhaust gas cleaning system will allow APL to continue using low-cost residual fuels for their auxiliary engines, as per the IMO ECA rules. Additional environmental benefits are expected from reduced emissions of particulate matter and NOx.

In the context of short sea ferries, Hamworthy Krystallon Managing Director Sigurd Jenssen pointed out: "Even at today's price differentials, these ships would see very short pay-back times on an investment in seawater scrubbers. Once the 0.1% requirement comes into force in 2015, pay-back would be less than one year based on today's price differential between residual fuel oil and distillates of US\$250. If the price differential moves to US\$500, as is widely expected, the pay-back will be less than six months."

Where today 1% sulphur content fuel or equivalent gas scrubbing technology is permissible in ECAs, Mr Jenssen said that the pay-back for installing the seawater exhaust scrubber would be in the range of only three years. "So a ferry operator

installing today would have recovered the investment by 2015.”

Ferry companies operate in an intensely competitive environment, with rail and road transport operators vying for their business, while hotels offer different leisure/conference options.

“There is clearly, therefore, little room for manoeuvre when it comes to increasing prices to compensate for higher fuel costs,” said Mr Jenssen. “Many would simply be put out of business: no known ferry operator achieves margins to cover a 50% higher fuel cost, much less a 100% increase.”

Furthermore, it might be noted that, when short sea operators on the Irish Sea raised rates by 2%-3% in 2006-2007 to compensate for higher fuel costs, the move translated into news copy.

“On that basis, for a growing number of ship owners, the question is not why fit a scrubber, but when,” said Mr Jenssen.

New commitments

In the current economic climate, ship owners are understandably wary of investing in new technology, Mr Jenssen said, which was why Hamworthy itself was looking into the possible avenues for financing solutions. This could also provide a way for operators to hedge their fuel exposure.

However, he added that exhaust gas scrubbing offered significant other benefits worth considering. “For example, the technology cuts particulate matter

emissions by 70%-80%. Not only is this particulate removal ‘for free’; it provides a degree of future proofing, as regulations on particulate matter are expected.”

The adoption of gas scrubbing technology offered more than just a means of raising an environmental profile, and a way of getting rid of the cosmetic problems of soot on the deck, Mr Jensen said, even though these were increasingly important factors in ship owner thinking.

Looking at the broader environmental picture, he noted that distilling diesel and/or de-sulphurising to the levels required needed 10%-20% more energy to drive the process. The overall CO₂ footprint and demand for energy for shipping would, therefore, grow by 10%-20%

“Switching to low-sulphur diesel will actually also make the particulate matter problem worse,” he added. “Burning diesel generates more of the small, harmful particles than burning HFO.”

Multi-inlet scrubbers for auxiliary engines could provide a cost-efficient means of complying with both EU and ECA rules, Mr Jenssen emphasised.

Space matters

Mr Jenssen conceded that there was a concern in the market that wash-water regulations would themselves be tightened, and that local port-specific requirements may be introduced. “This is probably unfounded, but our system is modular, and can easily accommodate such changes, if they happen,” he said. “So

rather than installing a system with all the bells and whistles from the start, we supply one that does the job now, but still allows for upgrading if that is required later.”

For any ship owner, the space occupied by shipboard equipment is always an issue and owners have also been understandably concerned that space that might otherwise be occupied by freight or passengers is not taken up by sea water scrubbing equipment.

Hamworthy Krystallon’s is an open loop abatement technology that neutralises scrubbed acid gasses using the carbonate/bicarbonate naturally occurring in sea and brackish water. Fitted into the ship’s funnel space, the design is suitable for slow and medium speed diesel engines and oil fired marine boilers.

While auxiliary equipment is also needed in the engine room, Mr Jenssen said that the company was continuously developing systems with smaller foot-prints. He added that cruise ships and ferries typically had limited space in the funnel casing, but plenty of space in the engine room. Scrubbers can be fitted anywhere between the turbocharger and the funnel outlet.

He said that Hamworthy Baltic Design Centre (the company’s specialist ship design and consultancy firm based in Poland) had developed installation lay-outs specific to ferries, car carriers, tankers and containerships, where both the regulatory regime and the ship type had consequences for seawater scrubber installations in the funnel and for supporting systems in the engine room.

One further by-product of scrubber installation was that the silencing effect of a scrubber is similar to, or better than a conventional silencer, so that the conventional silencer could be removed, saving some space.

Those following the steps taken by P&O in the Channel and Messina in the Mediterranean should consider the following, said Mr Jenssen, as they weigh up whether it will make sense to switch to distillates or seawater scrubbing and continues to burn residual fuel oil, he will get an immediate operational cost benefit over his competitors.” **NA**

APL England has also been fitted with the Hamworthy Krystallon scrubber technology that will cut NOx and SOx emissions and reduce particulates, regulations on particle emissions is expected in the near future.



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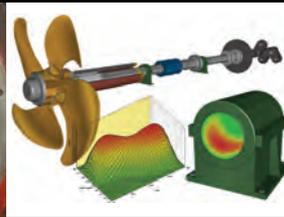
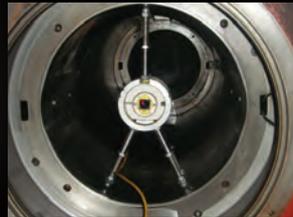
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The Vossnack Cylinder Tanker

Bremen, naval architect, Helge Kringel, explores the feasibility of building Ernst Vossnack's innovative tanker. In the first of a two part story the design and structure of the Vossnack design is considered. Part two will look at the tanker's systems and will be published next month.

This article was written to honour the late Ernst Vossnack, who was chief designer for Rotterdam Lloyd and Nedlloyd for more than thirty years. He was an extremely modest, creative, and experienced naval architect blessed with team spirit. After retirement he remained engaged in his profession until he passed away on 3 October 2006.

One of his many ideas was the concept of a triple-hull tanker with large, vertical, membrane-type crude-oil tank cylinders with a smooth inner surface, arranged in a conventional double-shell hull. Mr Vossnack expected more corrosion problems in double-hulls than in single-shell hulls, due to their more complex steel structure. The steel surface of the ballast tanks in double-hulls is more than two times larger than in single-hulls. He also proposed to abandon the practice of using double-scrubbed flue gasses to inert



Ir. Ernst Vossnack. 1985.

void spaces in favour of the more-costly method of using N₂, because corrosion can occur from both the residual sulphuric compounds and CO₂ of the flue gasses. Mr Vossnack had published his idea of a cylinder tanker by 2001.

He originally conceived a vessel with containerised stainless steel tanks which could be transferred ashore and replaced by empty containers. This principle had been used for fruit juice tankers by his son Jan Gert's company, but for huge VLCC's it is not feasible. Mr Vossnack first experimented with empty beer cans and wooden models in his garden. He settled on a three-row arrangement of cylinders.

Mr Vossnack envisaged a lengthy service life of the cylinder tanker due to easier and less maintenance and also expected a minimisation of oil spillage in case of collisions, because in the event of penetration of the side tank, the striking vessel would hit one cylinder on-centre or

off-centre. The bow would intrude into a cylinder or into the void space, thus more energy is absorbed by further deformation of the side structure and with the buckling of the cylinder wall. He was aware that the loss of usable space surrounding the cylinders would adversely impact the economics of the vessel, and that the additional net steel, required for the cylinders would require more investment compared to a double-hull tanker of the same size.

Mr Vossnack has inspired this author to design a large crude-oil cylinder tanker. He followed the design work with interest and contributed his ideas until the summer 2006. The author fondly recalls the co-operation with this venerable shipbuilder feeling deep gratitude and devotion.

The author decided to design a 280,000dwt cylinder VLCC and to use a two-row concept (with 20 cargo tanks plus two slop tanks which is normal for double hulls of the same size). This approach was also made due to the systems' cost.

TECHNICAL PARTICULARS	
Vossnack Tanker	
Deadweight:	286,350tonnes
Cargo:	272,800tonnes of 0.85t/m ³
Capacity: 2.1 Mio bbl =	334,000m ³
Slop:	7,400tonnes,
Ballast Water (B.W.)	54,875tonnes
LPP	= 324.2m D = 31.1m
B	= 65.0m T = 21.4m
2 x 10 cylinders,	
Diameter CD	=23m,
Height CH	= 43.2m for cylinders 2-9
Power:	2 x 15,500kW MCR,
	restricted to 2x 14,000kW
	at 88 (1 / min)
Speed:	Full load: 16knots (on trials);
	14.9knots (sustained sea speed)
Ballast:	17.9 (on trials);
	17.0 (sustained sea speed)
Complement:	40



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Energy absorption in case of a collision

The void space between neighbouring cylinders favourably influences energy absorption in case of collisions when the striking vessel intrudes into it, because more energy is absorbed by further deformation of the side tank. The midship section of the vessel is conical up to a height of 17.5m, where the side tank becomes 7m wide. The great width of the side tank contributes predominantly to the vessel's energy absorption capacity. Table 5.2 of [1] confirms this for all draft constellations of the colliding vessels. After deformation of the side tank, residual kinetic energy of the striking vessel is absorbed by deformation of a cylinder.

Investigations by Germanischer Lloyd (GL) [2] show that the energy absorption of a structure can be substantially increased by using steel of higher ductility. If austenitic steel 1.4404 were used, [1], [2], the absorption capacity would be roughly doubled. GL investigations refer to material elongation during the tensile test. This is for austenitic steel about three times higher than for mild steel. The author assumes that Sharpy-V impact energy is also a significant parameter for energy absorption. The fine-grain, thermo-mechanically-rolled P 355 ML1 steel will probably yield higher energy absorption than D36 steel.

If this can be proven, more margin against oil spillage is possible by using TM-steel for the cylinder shell up to the main deck, because a cylinder buckled by the striking vessel then will crack later. The TM-steel cost is 6% higher than for D36. Cargo oil displaced by the cylinder's deformation will be pressed into the void space of the ullage zone. If the energy of the striking vessel is so high that a cylinder cracks, oil will first pour down into the large void spaces. Outflow will occur quickly due to the high pressure head between the cylinder's top and the leak. The negative pressure which then occurs in the ullage zone can slightly impede the outflow.

The double-bottom height shall

be 4m. This is more than the International Maritime Organization (IMO) threshold level for penetration of the inner bottom in case of a grounding. A cofferdam structure 1m high is provided between the inner bottom and the cylinder bottom. All cargo-oil piping is situated above the inner bottom. Probability-based oil outflow calculations have not yet been performed, but it is likely that the results for the described design would be favourable.

Further design features are twin-fixed-blade propellers with stern bulbous skegs, independent twin-rudders and separate, autonomous, main diesel engine rooms and diesel tanks. The heavy fuel-oil bunker is located between the engine rooms, separated from the shell by a cofferdam.

The vessel's systems are designed for accommodating three grades of crude oil. The cylinders have to be either entirely (98%) full or empty. Partial filling of the cylinders will be permitted, provided it does not cause significant sloshing loads. The described concept may be applicable not only for crude oil tankers but also for product tankers.

The crude oil cargo shall be distributed as follows:

Grade 1: cylinders Nos. 1+5+7+10

Grade 2: cylinders Nos. 2+4+8

Grade 3: cylinders Nos. 3+6+9

The vessel's anticipated service life time is 45 years. For twin-hull tankers of high standard, e.g. [4] the 442,000dwt ULCCs of Hellepont, a 40-year fatigue-life was used as the structural design basis. Forty-five years of service life for a three-shell cylinder tanker, designed to minimise maintenance costs, is felt to be a reasonable expectation.

Figure 1 shows the geometric midship section of the vessel with the principal arrangement of main piping. The three main cargo pipes are stacked above the cylinder bottom at CL. One string of the ballast water-ring system is located in the double bottom

only. Figure 4 represents the general arrangement Plan of the vessel.

High walkways, starting at the navigation bridge, connect the top of the cylinder ceilings on P and S. The bridge is supported by two towers. The space between them is shaped like a nozzle. The air flow through the nozzle will enhance the helicopter landing conditions, because the turbulence zone in the aerodynamic shadow of the deckhouse is reduced.

Five groups of double-bottom ballast water tanks are provided. For trim reasons, a ballast water tank is located at the transom. The ballast water capacity has been minimised since IMO-approved, ballast water treatment plants with sufficient capacity for a VLCC are still under development. The installed ballast capacity will be sufficient for full propeller immersion in the B.W. arrival condition. Two 2-lobe slop tanks are located between cylinders 5 and 6 below the vessel's manifold. Their capacity is 360tonnes of slop from tank washing per cylinder.

Stability and trim

The light ship of the vessel was established by reference to a single-hull VLCC and a double-hull tanker both of approximately the same size. The GM at full load is departure / arrival 1.67m / 1.42m. The author trusts that the righting levers due to the trapezoidal shape of the midship section will be favourably high. The dynamic stability as well as the rolling and heaving behaviour are still to be evaluated.

The trim at full-load is slightly by the bow, i.e., departure / arrival -0.27m / -1.22m. Thereby the transom ballast water tank is full. Due to twin-skeg lines the author sees no danger with regard to yaw instability. After discharging grades 1 and 2 crude oil, a trim by the stern of 5.7m occurs.

Structural design

For cylinders, longitudinal members, and bulkheads, steel HTS 355 is anticipated. The double-bottom is supported at CL by a non-watertight, longitudinal bulkhead which above the double-bottom consists of a

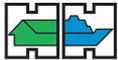


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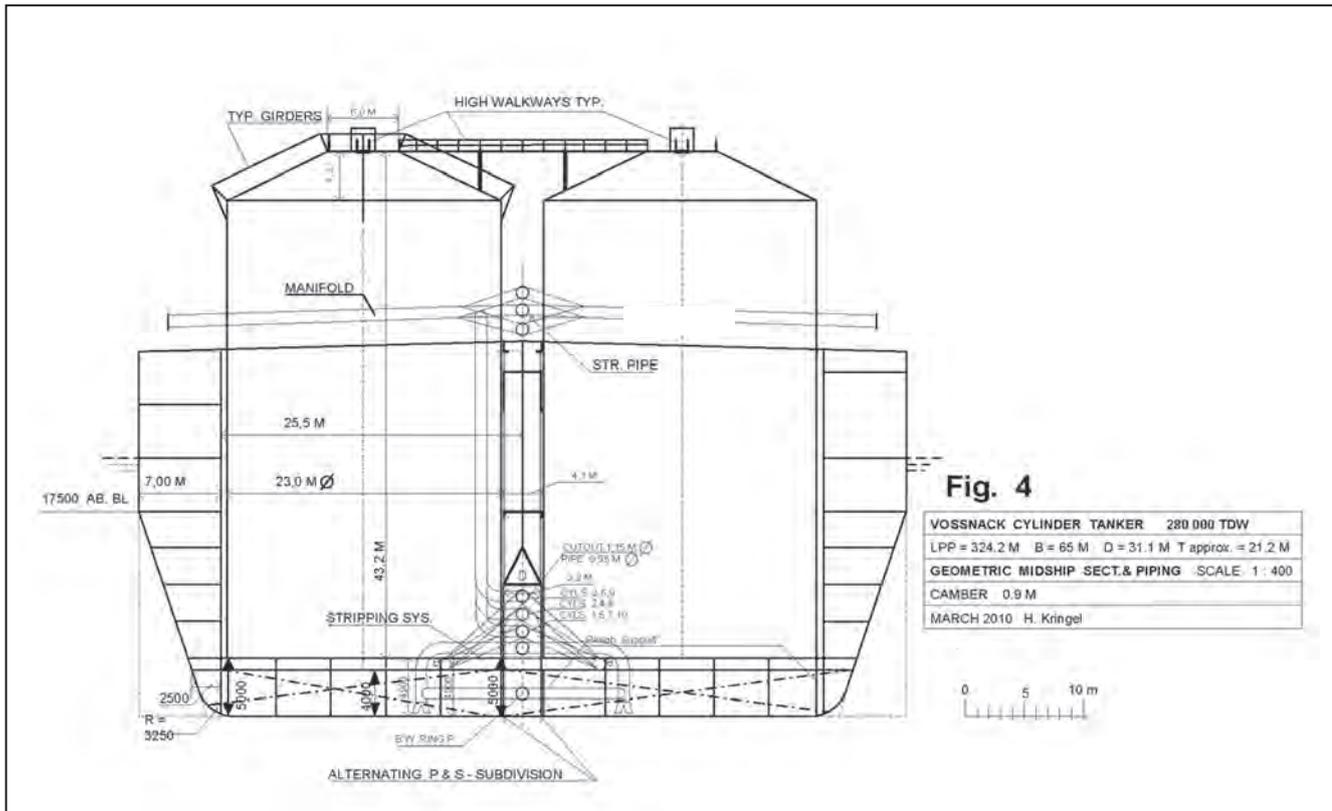


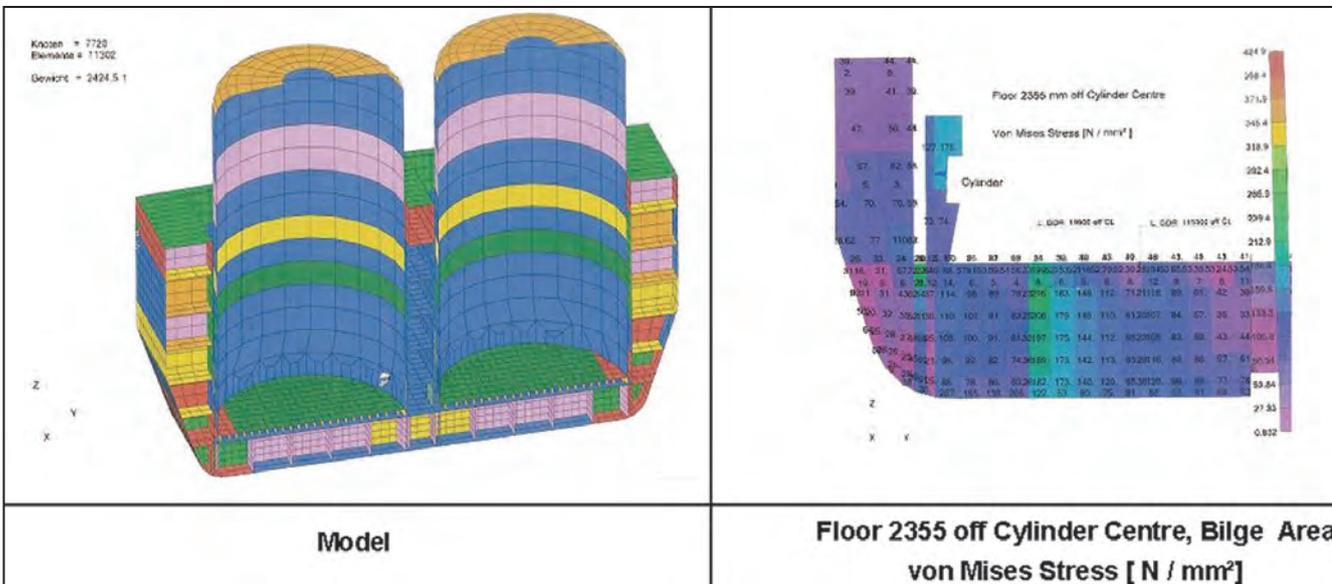
Figure 1. Geometrical midship section with main piping.

longitudinal box with openings at the sides, in which the cargo pipes are located. Above that box, a single-plated bulkhead with vertical webs and stringers up to the main deck is installed. Figure 1 shows the geometry of the midship section.

The primary structure under the cylinders consists of four floors and longitudinal girders each. In line with the cylinder shell, a strong peripheral girder between cylinder bottom and the outer bottom is needed to provide structural continuity between cylinders

and the double bottom. Furthermore, for reasons of continuity, the cylinder bottoms P & S will be connected, and they are extended towards the side shell. The transverse bulkheads shall preferably be alternating watertight and non-watertight, provided this can

Figure 2. Static FE-calculation.



Model

Floor 2355 off Cylinder Centre, Bilge Area von Mises Stress [N / mm²]

HIGH-TECH VESSELS FOR ARCTIC EXPLORATION FROM ADMIRALTY SHIPYARDS



In the second half of XXI century reserves of oil and, partially, of gas in such traditional regions of production as Western Siberia or Persian Gulf will be depleted. At the same time the demand for energy resources worldwide in this period will be multiplied. One of priority economic tasks of the near future will become development of hydrocarbon resources of the Arctic area, where, according to estimates of American scientists, are contained up to 30% of the world reserves of gas and 13% of the world reserves of oil.

However, in order to avoid energy famine after 2050 it is necessary right now to select keys for arctic marine storehouses. Accordingly for development of the arctic shelf - technically complicated activity which demands enormous financial outlay, it is also required unification of efforts of all the countries which have modern technologies.

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"Admiralty Shipyards" takes up its niche in production of technically complicated, unique vessels for research and development of areas of the Arctic and the Antarctic. Beginning from the year of 2000 and up until today JSC "Admiralty Shipyards" delivered to the Customers 5 tankers of arctic class with deadweight of 20 000 tons, Project 20070 and 20071, 2 shuttle tankers of double action with deadweight of 70 000 tons, Project P70046, built in international cooperation with design company Aker Arctic Technology, Finland. At present a research and expedition vessel is being built for research and development of areas of the Antarctic. The vessel is to be delivered to the customer in September of this year.

A special place among the delivered ships is occupied by two shuttle tankers of double action. These vessels are destined

for carrying of crude oil from the Prirazlomnoye field, they are equipped with high voltage diesel-electric propulsion plant of total power of 25 MW. This vessel is able to move bow ahead in clear water and stern ahead in strong ice. At the same time onboard the vessel has been fully implemented the concept of double navigation bridge, one bridge is intended for movement of bow ahead while its complete analogue - for movement of stern ahead. The vessels are equipped with dynamic positioning system of class DP AA1. During period of the sea trials was confirmed the accuracy of keeping of the vessel in automatic mode within 40 cm from the given point of keeping.

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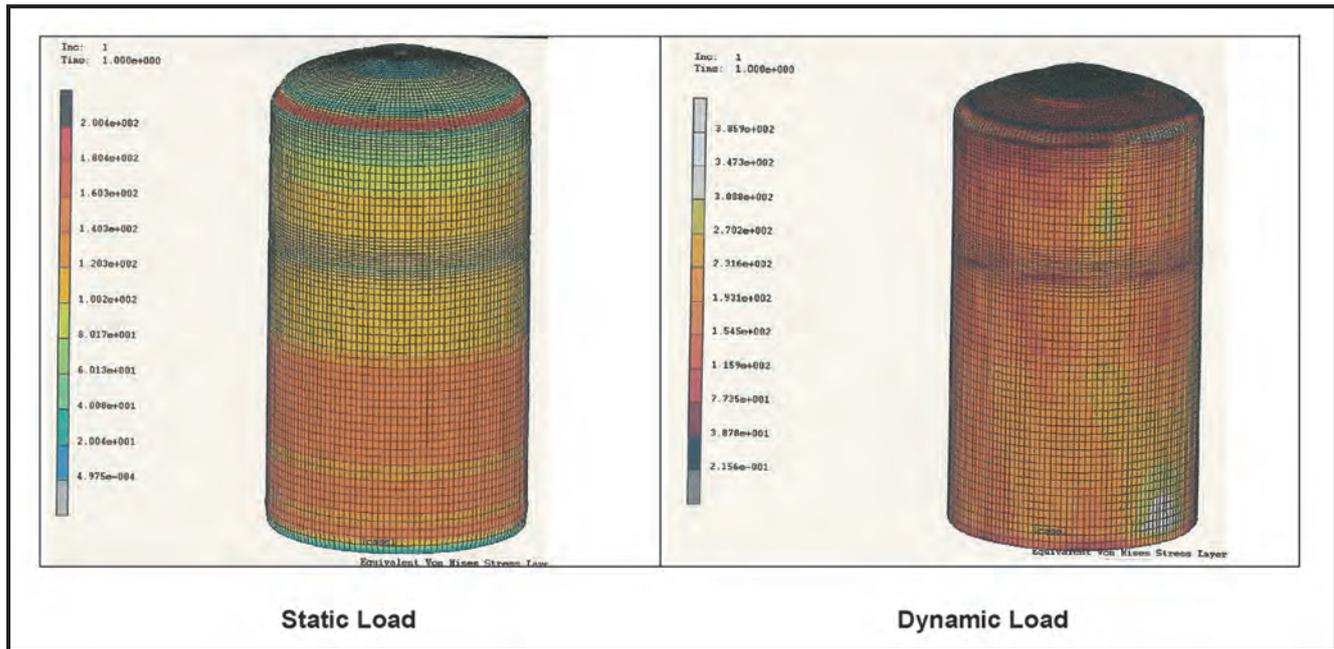


Figure 3. Dynamic FE-calculation with ring stiffener at main deck.

The additional net steel needed for the cylinder tanker amounts to:		22,210
Main components thereof are:	cylinders	15,695
	transverse bulkheads	4,660
	stronger and higher double bottom	4,815
	sum of various deductions and additions	-2,960

be confirmed completely or partly after damage-stability calculations.

The bulkheads are not of the usual single-plate, high-stringer design, but of a cofferdam type. No doubt these will be very heavy, but otherwise, the vessel's length had to be increased substantially with much more additional weight. An advantage of the cofferdam bulkheads is that no horizontal surfaces exist where standing fluid collects and in which corrosion can start. Following Mr Vossnack's preference for nature's, light-weight, bamboo-tube structures, the author designed sectored cylindrical shells for the plating of the bulkheads which saves some bulkhead weight. The twin-lobed cylindrical slop tanks are internally smooth. Access to the slop tanks is direct from the weather deck via a trunk and a ladder below.

The width of the cylinder strakes is

3m (thickness 13 - 45 mm). The inner surface is smooth. The ceiling has a central plane working area. Though in [3] a ceiling with an elliptical section is proposed, due to cost, a conical structure was designed. To withstand the internal over- or negative pressure of the PV-valve setting the primary support consists of four radial quarter girders. The high stresses at the transition from the cylinder shell to the ceiling will be controlled by soft-toe, peripheral brackets supporting the knuckle in the bi-sectored angle.

Strength Calculations

The structural design was developed using an existing 280,000dwt, double-hull VLCC as a basis. To the extent possible, the scantlings were established based on GL-regulations. The objective of strength investigations was to demonstrate that Mr Vossnack's

concept is feasible.

IGN (Ingenieurgesellschaft Nord - acknowledgement 1) performed a static finite element method (FEM) calculation for a pair of cylinders including surrounding hull structure in the upright, light-draft condition of the vessel. Figure 2 presents on the left the finite element (FE)-model, and on the right, von Mises stresses of the floor aside from the cylinder centre towards the bilge. The results of this calculation show local hot spots at the restraints of floors and girders, where thicker plating had to be provided.

Dynamic FEM calculation

TUHH (Technical University Hamburg-Harburg [3]) performed dynamic FEM- calculations for one cylinder in seaway as defined by GL without surrounding structure but fixed at the bottom. The maximum rolling angle was 20degs. The cyclical dynamic pressure is moderately uneven in peripheral sections of the cylinder.

This leads to significant additional bending and shear stresses superimposed onto the membrane stresses of the cylinder shell which amount to 40% - 45% of the total peripheral stress and require substantially thicker cylinder plating.

Figure 3 shows, on the left the von-Mises-stresses under static load, and on the right that under dynamic load. Under static load the constant peripheral membrane stresses are displayed by regularly-distributed colours, while the irregularity of colours shows the influence of superimposed bending stresses. Furthermore, the 60% higher stress level can be seen. The meridian stresses within a rolling period alternate between tension and compression. In the lower strakes, near to the bottom, shear stresses up to 100N/mm^2 can be expected.

The dynamic calculations were performed for the following four structural design alternatives:

1. Cylinder, fixed at the bottom only;
2. Fixed cylinder, with a peripheral ring stiffener at main deck level. This only reduced the peripheral stress of the strake on which it is fitted;
3. Fixed cylinder, with transverse bearings at main-deck fore and aft at tank CL. The bearings reduced the stress level locally. Furthermore the meridian stresses at the bottom were reduced by 8%;
4. Cylinder with transverse bearings and a peripheral ring-stiffener. This reduced the peripheral stresses of the reinforced strake. Also, the meridian stresses at the cylinder bottom were reduced by roughly 30%.

Considering the cost of main-deck bearings plus ring reinforcement and the achievable reduction of meridian stresses near the cylinder bottom, the author decided not to provide these. The maximum transverse, dynamic, elastic deformations of the cylinders amount to $\pm 275\text{mm}$. These are mainly caused by the cylinder's cross-sectional deformation. The ship's staff must become accustomed to the permanent, elastic deformations in heavy weather which are of the same magnitude as dynamic, longitudinal hull-bending.

Buckling analysis

The cyclical, meridian stresses required a buckling analysis for the combination of meridian compression with peripheral membrane-tension. This was performed in two ways, at first, according to

Germanischer Lloyd (GL) rules which are based on DIN 18800 and secondly, by application of the original DIN 18800. While the GL rules refer to shell structures under external pressure, DIN 18800 considers also cylinders under internal pressure which support their shell thus increasing the buckling strength by approximately 10% as compared to GL rules. In both cases, shear stresses contribute substantially to the total sum of safety terms.

The disappointing result of the buckling analysis was that the compressive meridian stresses required outer-ring stiffening of the cylinders at a narrow spacing of 600mm.

Joint evaluation of the static and dynamic FEM calculation

Since the FEM of TUHH was investigated for both static and dynamic conditions, the results of the two independent FEMs could be compared, and were found to be in agreement. Contrary to the meridian membrane stresses the plate-bending component has no direct influence on the dynamic, double-bottom load. The dynamic meridian stresses were evaluated from the von-Mises stresses of the cylinder shell above inner bottom. Then, they were referenced to the meridian stresses of the static calculation.

The result was an incremental factor of 1.67. This factor, representing the dynamic influence, was applied for correcting the basic scantlings of floors and girders used in the static calculation. Substantial reinforcement of the bottom girders, especially at their restraints was necessary. For the shear stresses, it has been assumed that their ratio versus the bending stresses is the same for both the dynamic and the static load cases.

Differential Steel weight calculation

In parallel to the structural calculations, plus/minus weight calculations for net steel were performed with reference to a conventional, double-hull tanker.

Due to additional net steel weight, the light ship of a cylinder tanker compared to a conventional, double-hull tanker is approximately 41% higher. An increase in weight had been expected, but this result, in fact, was disappointing. Nevertheless,

it should be considered together with the advantages, which Vossnack's concept offers as compared with double-hull tankers.

Tonnage

Very large containerships, meanwhile, are built with up to nine tiers of deck containers partly filled with cargo. According to the practice of the 1969 London Convention, the volume of deck containers above the hatch coamings is not part of the gross tonnage. The cylinder volume of a Vossnack tanker above main deck would be included in the gross tonnage, because it is part of the hull structure and not containerised. The contradictory practice of tonnage calculation for huge containerships on one hand, and for LNG-tankers with spherical tanks and for a cylinder tanker on the other is not logical. Mr Vossnack fought in his last years against this illogical practice. **NA**

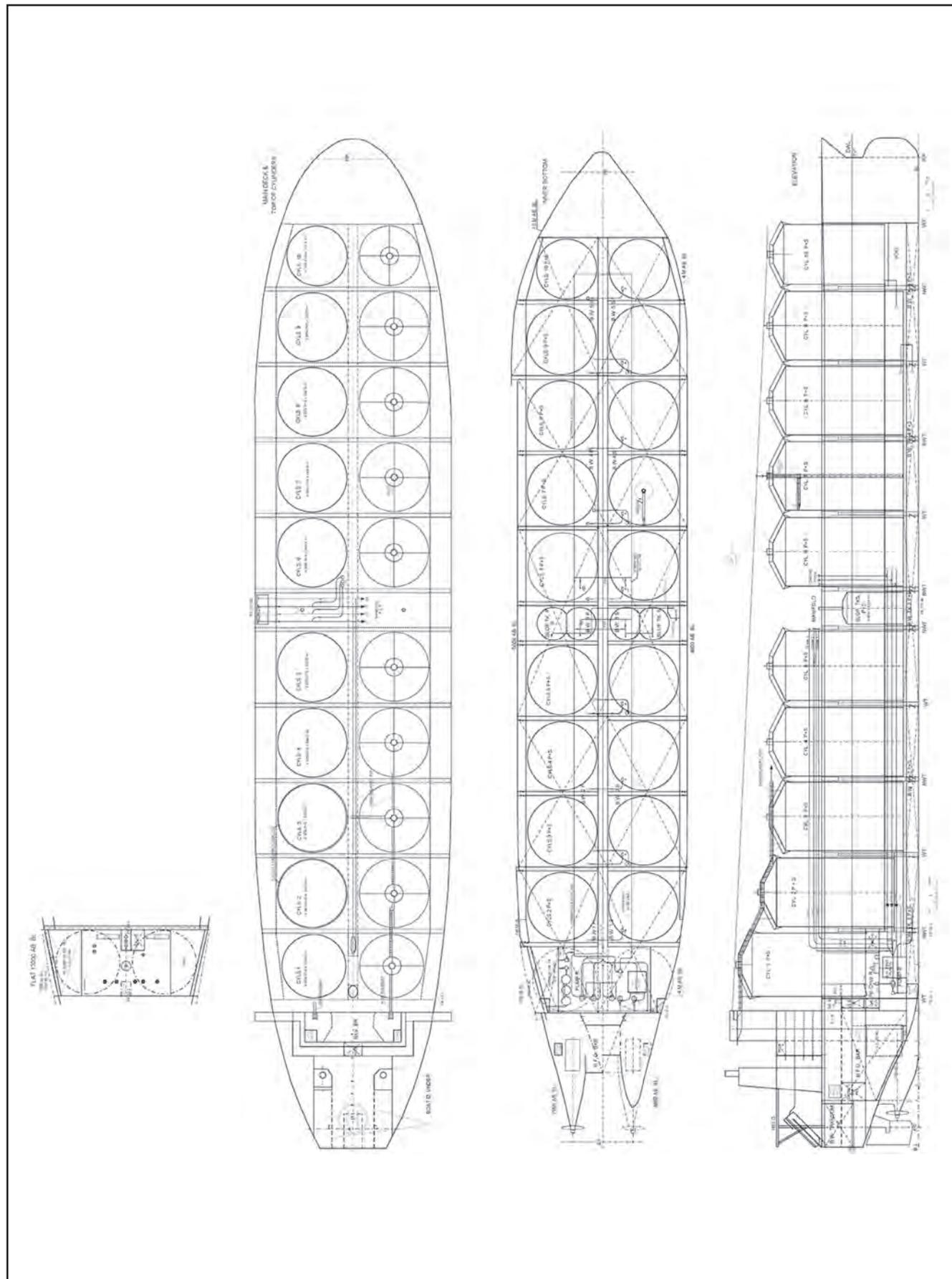
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2. Professor W.Fricke of Technical University Hamburg Harburg (TUHH), contributed design ideas to the cylinder concept and his student M. Melzer, performed a dynamic FEM study of one cylinder. The author deserves thanks to both.
3. Frank Tiedemann from Blohm +Voss Nordseewerke supported the author with regard to steel material.

Figure 4. General arrangement plan for the Vossnack Cylinder Tanker with piping.



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Innovative Power Transmission

Tanker structural vibration investigations

Lloyd's Register's (LR) Technical Investigation department (TID) has taken a closer look at the effects of vibration in two shipping case studies. Peter F.G. Filcek, technical manager and senior principal surveyor, TID describes the investigations carried out on these types of vessels.

The Technical Investigations department has built up a considerable expertise by investigating a wide range of ship vibration problems over many years. The staff consists of a mixture of mechanical and marine engineers, hydrodynamicists and fluid dynamacists, civil and structural engineers and instrument specialists who combine to provide a consultancy service to Lloyd's Register and the marine industry.

This paper presents the results of two vibration investigations carried out by TID. The emphasis is on the fact that reducing the excitation at source is the best option.

135,000m³ LNG Carrier

In the first investigation, a 135,000m³ liquefied natural gas (LNG) tanker with a

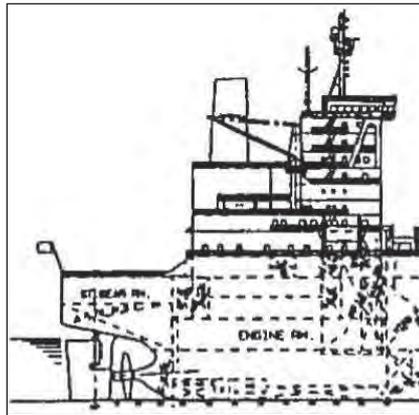


Figure 1: Vessel 1, general arrangement aft end.

service speed of 19.5 knots (Figure 1), the vessel has the traditional LNG steam turbine main propulsion machinery. This consists of one set of two cross-compounded steam turbines and a double-helical tandem-articulated double-reduction gearbox developing a maximum continuous rating of 28,700kW at 93rpm, and a five-bladed fixed pitch propeller was fitted.

The vessel was reported to have high vibration levels during sea trials, especially at the aft end and transversely on the bridge. Before TID's attendance several attempts had been made to reduce the vibration levels, but without success. A vibration compensator had been installed on the steering gear flat, but it was later removed. The number of propeller blades was increased from four to five. Local structural reinforcements were made to the aft end region, including additional pillars on the steering gear flat and stiffening of the fresh water tank bulkheads. These were ineffective, and more fractures occurred in the fresh water tanks and around the steering gear flat and machinery spaces after fitting the five-bladed propeller.

The initial investigation by TID included measurements of the hull surface pressures generated by the propeller, as well as measurements of hull, machinery and accommodation vibration response, intermediate shaft torsional vibration and propulsion shaft lateral movement.

The trials, which involved several progressive measurements through the operating speed range, identified several minor hull-girder natural frequencies and other globally resonant responses. The measured amplitudes were not excessively high. The increase in bridge transverse vibration at the propeller first blade rate of 91rpm, corresponding to 7.6Hz, suggested that the measured levels were on the rising

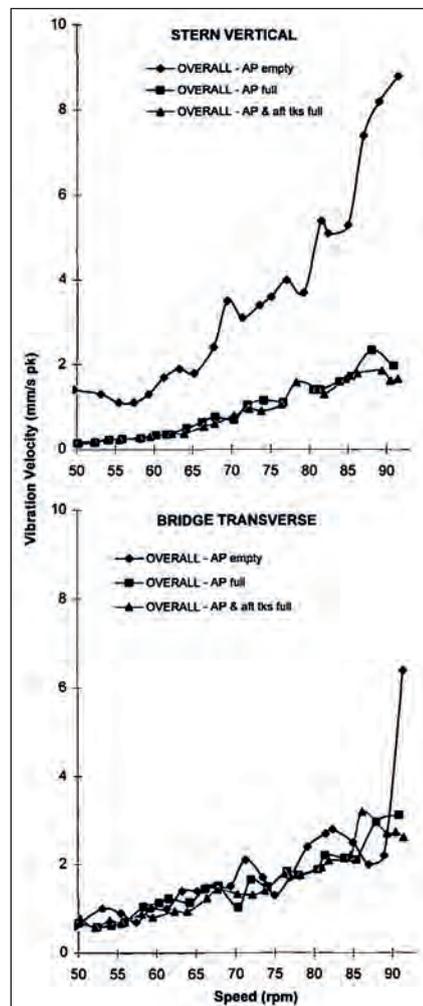


Figure 2: Vibration at the stern and on the bridge.

The basic philosophy used in structural vibration investigation work can be summarised as follows:

Measure – it is only an opinion until measured

Have a working hypothesis

Measure throughout the speed range to identify global modes

Identify local responses

Identify and measure excitation sources

Measure in ballast and laden draughts

Use theory to explain measurements and provide solutions.

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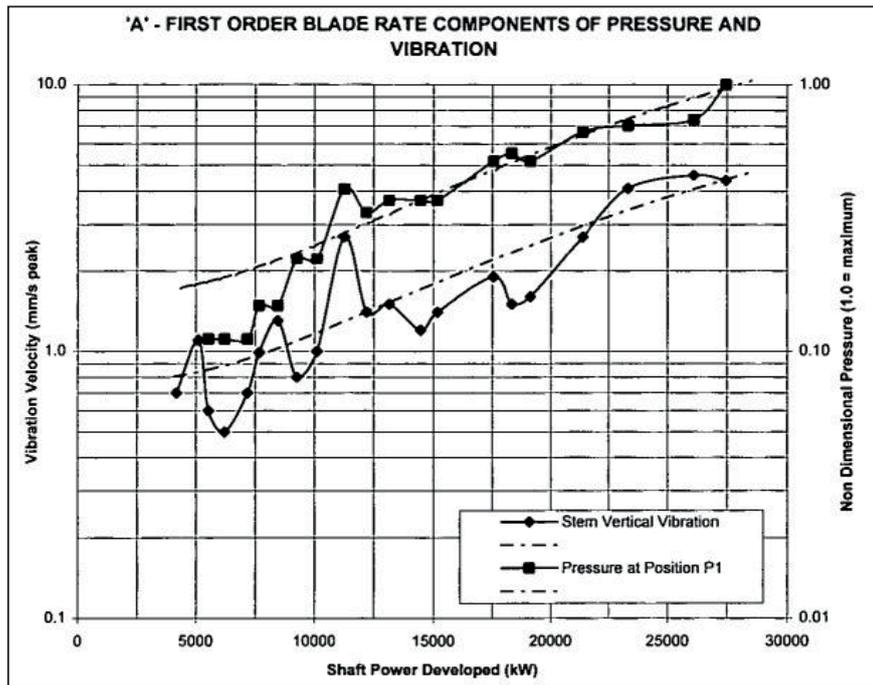


Figure 3: Forced response of aft end vibration.

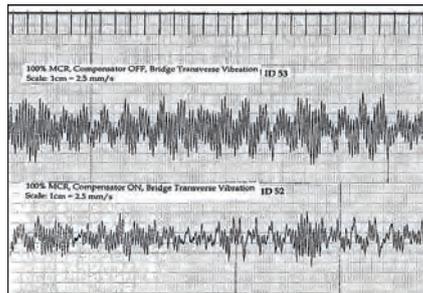


Figure 4: Performance with compensator off (upper trace) and on (lower trace).

flank of a resonant transverse response of the accommodation structure (Figure 2). This response mode had been predicted by the shipbuilder to occur at 8.09Hz. No significant vibration excitation was identified from the main engines or the shafting system.

For the purposes of identifying vibration excitation sources it is convenient to refer to the order of vibration, where:

$$\text{Order} = \frac{\text{frequency of response}}{\text{Engine or shaft speed}}$$

High overall vibration velocities were measured adjacent to some of the local structures in the vicinity of the fresh water tanks. The frequencies were at the higher harmonic components of the propeller blade passing frequency vibration (blade-rate). Impact tests confirmed that the natural frequencies of some of the most excessively

vibrating structures coincided with the harmonics of the propeller blade passing frequency. At these frequencies local structures are subjected to a large number of stress cycles in a short period causing rapid fatigue cracking at positions of stress concentration such as welds at bracket ends.

The vibration response of the aft end over the speed range was more characteristic of forced excitation. The nature of the response was confirmed by comparing the hull pressure excitation force and the vibration response of the stern at blade passing frequency against the shaft power curve (Figure 3). The vibration and pressure curves correlate closely and have similar gradients indicating that forced excitation is predominant. It was also possible to deduce whether a response was forced or resonant by deriving the exponent of the ratio of the amplitudes at any two shaft speeds.

Hull pressure was measured in the aperture above the propeller. Analysis of the signal identified the first six propeller blade rate harmonics with their magnitudes decaying monotonically with increasing harmonic number. At low propeller speeds (50 to 63rpm) first order blade passing rate pressures were the only dominant component but at speeds of 65rpm and above, second to sixth order blade passing frequency became apparent. A response in a broadband spectrum was noted at considerably higher

frequencies. All of these characteristics are indicative of significant cavitation on the propeller in the slipstream.

Attention to the propulsion hydrodynamics of the vessel was considered necessary. The possible alternatives considered were:

- Introduce air into the tip sheet and vortex cavities, by external means, in order to cushion the collapse process and hence attempt to reduce the occurrence of higher harmonic excitation
- Fit a partial tunnel, or stern-wing, in the aperture above the propeller to modify the wake field
- Modify the propeller design to reduce the loading distribution at the propeller tips. This was expected to reduce the volume of sheet cavitation collapsing on the blade and in the immediate slipstream. This would reduce the hull excitation forces but at the risk of face cavitation leading to blade erosion and lower amplitude broadband excitation at a higher frequency.

A stern wave was observed to form ahead of the propeller on the port side only and some thought was given to the possible contribution of the main turbine condenser cooling water outlet discharge. This was an interesting observation.

Air injection was tried, but with only limited success in the next sea trials. Some reduction in vibration amplitudes at higher frequencies was measured. There was no reduction of the high levels of transverse vibration of the bridge.

At this stage one of the other parties insisted on fitting an electrically driven mechanical compensator on top of the deckhouse. This was ineffective at coping with the varying amplitudes and phasing of propeller generated excitation which occurs in a seaway. (Figure 4).

Eventually a stern-wing and significant external steelwork were added to the bridge to alter the response in the transverse direction. This was somewhat unsightly but subsequent measurements confirmed that vibration levels on the navigation bridge deck had been reduced to within the range where “adverse comments are not probable” [1].

140,000m³ LNG tanker

Cracking of all four domestic and distilled water tanks both on port and starboard sides, located at the forward end of the steering gear

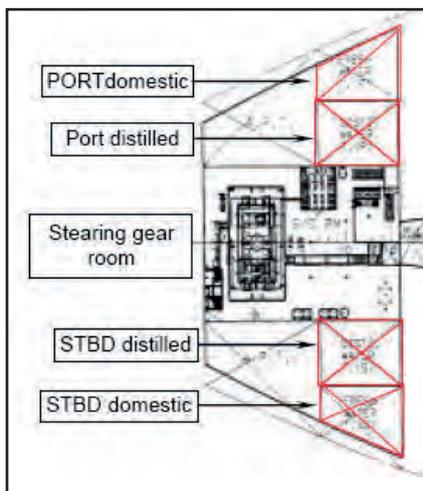


Figure 16: Location of fresh water tanks.

flat, occurred within the first year of service of a 140,000m³ LNG tanker.

It was concentrated in or around the transverse bulkhead at frame 7 and web frame 11. Cracks had been repaired and brackets added to the tank structure where it



Figure 17: Crack in tank bulkhead.

was thought necessary (Figure 16).

The ship's staff had not complained about ship vibration, but had observed that higher vibration occurred in the upper speed range.

The vessel's main propulsion is provided by two cross-compounded steam turbines and a double reduction gearbox delivering a maximum continuous rating of 29,032kW at 90rpm to a single fixed pitch propeller with six highly skewed blades and a diameter of 8250mm. Normal continuous rating is at a

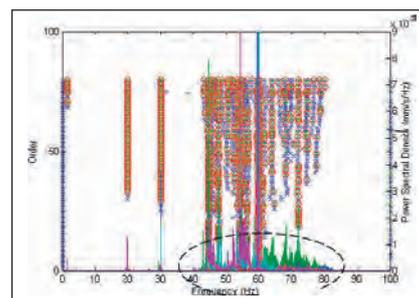


Figure 18: Stability diagram for forward bulkhead of the starboard domestic fresh water tank. shaft speed of approximately 83rpm.

Overall peak vibration amplitudes of over 30mm per second (mm/s) between 5Hz and 100Hz were measured on the domestic and distilled tank bulkheads at shaft speeds over 65rpm. At normal service speed of 83rpm peak, amplitudes exceeded 100mm/s. Vibration levels in excess of the 30mm/s overall peak limit are expected to cause damage to steel panel structures. This was the cause of the repeated cracking of the water tank structures [1].

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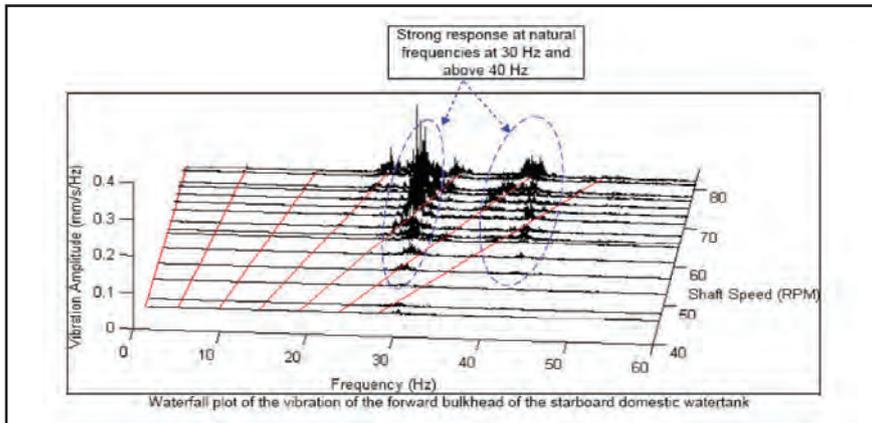


Figure 19: Waterfall plot of the vibration of the forward bulkhead starboard domestic fresh water tank.

The technique of operational modal analysis provided information about the natural frequencies and mode shapes of the structure. The modal analysis of the forward bulkhead of the starboard domestic tank is shown in Figure 18. This shows a large number of modes present between 40Hz and 80Hz. The spectral spikes and columns

of red circles at approximately 20Hz and 30Hz are from external sources such as the four engine room fans at 1170rpm and the steam turbine main alternator and the two electrical generators running at 1800rpm. Differences were measured according to the amounts of water stored in the tanks. Water adds effective mass to the tank bulkhead and

thus tends to lower the natural frequencies of the tank wall.

The vibration response through the speed range of the forward bulkhead of the starboard domestic tank is shown in Figure 18. The shaft rate and blade rates are shown as red lines. The starboard domestic tank had 127m³ of water during this run-up compared with the 14m³ of water it contained when the modal analysis was conducted. It may be seen that there is no substantial vibration of the bulkhead up to about 25Hz. Two areas of high energy are also seen around 30Hz and 40Hz. These areas correspond to frequencies at which the aft peak is passing energy through. The highest peak in the waterfall plot of the forward bulkhead of the domestic tank is present at 73rpm at 28.9Hz. At this frequency the hull is excited by the fourth blade order. The aft peak tank has a mode at this frequency and thus a large amount of energy is passed from the hull to the water tanks at this frequency. This explains why the largest peak value, 180mm/s, occurs at 73rpm rather than at the maximum shaft speed when the propeller excitation is highest.

A complicated picture of the vibration characteristics of the water tanks emerged from analysis of the measurements. The water tank bulkheads had a number of large number local modes between approximately 20Hz and 80Hz, whose natural frequencies varied with tank content level. The lowest local mode in the water tanks was above the first and second blade harmonics at 8.4Hz and 16.8Hz at 84rpm, but below the third, fourth and fifth blade passing frequencies orders at 25.2Hz, 33.6Hz and 42.0Hz. The largest excitation at a particular frequency in the tank bulkhead occurs when the third, fourth or fifth order of the blade rate coincides with a local natural frequency of the aft peak tank and a local natural frequency of the tank bulkhead.

The overall amplitude of the hull pressure measured above the propeller was evaluated between 4Hz and 100Hz to exclude low frequency components resulting from seaway and high frequency components from fast, but less energetic, cavitation collapse events. The overall

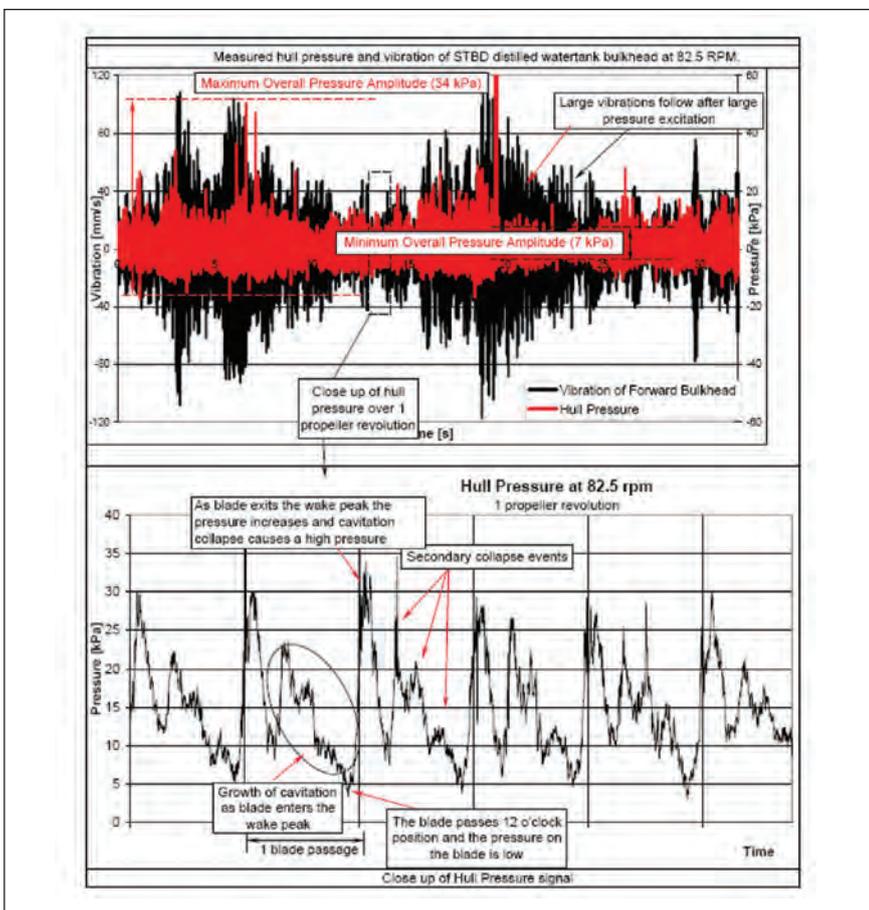


Figure 20: Maximum overall hull pressure (top) and close up view of hull pressure characteristics.

root mean square pressure amplitude at 82.5rpm is 4.5kPa and the overall peak amplitude of 20kPa is very high compared with other measurements. The peak value exceeds the limit of 16kPa at which fatigue cracking may be expected in the aft peak and the 10kPa which is considered a safe limit from Lloyd's Register's experience [1]. The relatively large ratio between peak values and root mean square values is, in this instance, an expression of the impulsive and unstable nature of the signal, with high energy pressure bursts and relatively calm periods.

A 30 second sample of recorded hull pressure is shown in Figure 20 and is characterised by several bursts of high-amplitude pressure impacts. The overall maximum amplitude is 34kPa with minimum overall amplitude of 7kPa. Such a strong amplitude modulation has not been recorded on other vessels. This was attributed to variations in the propeller inflow, possibly due to turbulent components in the wake. No correlation was observed between ship motions and these bursts of high pressure. The shape of the hull pressure signal for each blade passing (Figure 20) shows features normally observed on such signals. There is an underlying blade rate pressure fluctuation resulting from the non-cavitating pressure field around the blade. Superimposed on this

is the contribution of the pressure caused by cavitation. This pressure consists of a cavitation growth phase as the blade enters the wake peak, possibly causing a gradual reduction in pressure, which is followed by a high pressure peak resulting from the sudden collapse of the main body of sheet cavitation. The three secondary pressure pulses have been observed on other vessels and could be related to tip vortex activity.

The magnitude of the hull pressure at two and three times the blade rate and at the same order of magnitude as the blade rate component is significant since natural frequencies of local structures can be typically found at, or around, the frequencies of the higher blade orders. Hence, large amounts of energy at higher harmonics are likely to cause high amplitude vibration in local structures.

It was concluded that the combination of the impulsive high pressures emanating from the propeller and the spread of tank natural frequencies would make it difficult to add enough stiffening to move the tank these frequencies above the propeller fourth and fifth blade rates.

The preferred route, again, as always with vibration, was to reduce the excitation from the propeller. The high level of propeller excitation was due to poor flow around the aft ship. There are several wake modification

devices available but it was considered in the first instance that a reduction could be achieved by fitting vortex generators upstream of the propeller. These mix the high energy flow, away from the ship, with the low energy boundary layer flow. Propeller blade cavitation and the radiated pressures at the hull are reduced. An added significant benefit of this strategy would be the reduction of vibration levels in other parts of the ship, particularly in the higher decks in the accommodation where resonance with a mode at 8.4Hz was identified. *NA*

Reference

1. *Ship Vibration and Noise*, Guidance Notes. Revision 2.1. Lloyd's Register. 2006.

Acknowledgements

The author wishes to thank the owners and managers of the vessels onboard which the investigations were undertaken. Thanks go to the surveyors who undertook the investigations, in particular: Mr. Anne Boorsma, Dr. E. Peter Carden, Mr. Patrick Fitzsimmons, Mr. Dan Griffiths and Mr. Stewart Whitworth. Acknowledgement should also be made of the work done by the staff of the Lloyd's Register TID Laboratory who maintain the measurement equipment and ensure its proper use.

Beating the Drum

In recent times requirements regarding noise and vibration onboard mega yachts have got more demanding. One major source of noise and vibration are the propellers. This article deals with procedures to control and reduce propeller induced noise and vibration.

Noise that is unwanted sound is generally understood to relate to acoustic, airborne, disturbance. The distinction from vibrations is such that the latter are structure borne. Vibrations will excite the bodies of those onboard who get in direct contact with a piece of structure. As far as the "total annoyance level" is considered, the effects of noise and vibration in concert, cause mutual aggravation.

Noise and vibration are closely related, either phenomenon will cause discomfort, fatigue and increased stress levels. In

the context of megayachts, owners will invariably demand the highest possible comfort levels. Exceeding specified noise and vibration parameters may result in disappointed clients, loss of yard reputation and severe pecuniary losses. Therefore, it is an obvious risk reduction exercise, to control, manage noise and vibration as much as possible from the very early stages.

Generally, it is the best idea to "design it out", by reducing the excitation of the yacht's structures and tuning the structure to frequencies that are different from those

of the actuator. In this way, the application of sound damping material can be minimised, improving the overall performance and cost of the yacht. While the focus has traditionally been with the machinery, today noise and vibration experts also target the major hydrodynamic source of noise and vibrations, the propeller.

The path of noise and vibration

The operating propeller will cause general flow noise and varying levels of pressure pulses. The latter may quite possibly excite

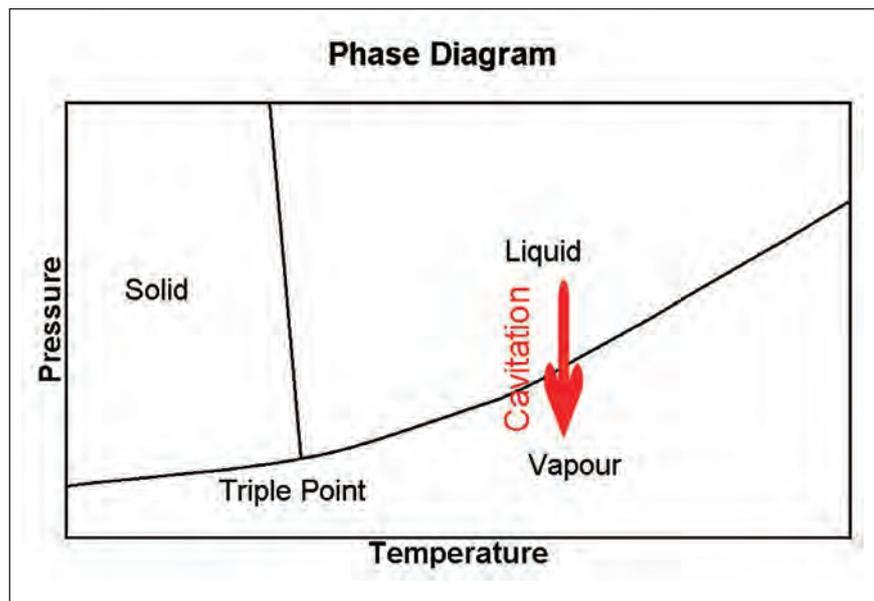


Figure 1: Phase Diagram.

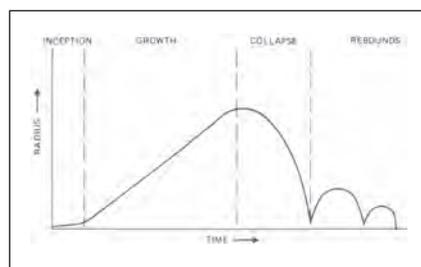


Figure 2a: Radius of a cavity over its lifecycle.

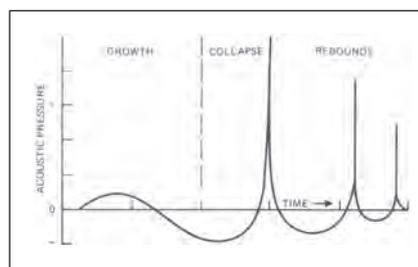


Figure 2b: Modulation over the lifecycle of a cavitation bubble. Source (2): Ross

the hull structure. In fact, in this way, the prop may cause all sorts of parts of the vessel to vibrate quite badly, causing rattling and discomfort.

The most basic consideration is that structures should be tuned in a way that their respective Eigen frequencies are different from that of the most common blade passing frequencies. The blade passing frequency (or blade rate) being the number of times a propeller blade passes the top dead centre per second. It is, of course, nearly impossible to tune every constituent of the vessel's structure so that it will not resonate at any conceivable frequency. This in fact obviates the importance of low propeller related pressure pulses. Luckily, pressure pulses tend to be less at lower speeds and the vessel's top speed is normally taken as the design case.

Pressure fields

Generally, pressure fields surrounding

the propellers of the yacht will result in some sort of excitation on the side of the hull because the pressure differential is what produces the propulsive force. Unfortunately, these pressure fields are located on a rotating body. Further, they are ultimately not constant, but tend to fluctuate since the wake of the yacht in which the propeller operates is inhomogeneous. Since these pressure fields rotate in the vicinity of a rigid body, the latter is prone to being excited. Whilst there is no way to completely avoid this problem, there are ways to cope with the propeller's pressure pulses.

Cavitation: microscopic level

If the pressure in a fluid is lowered as indicated by the red arrow in the Phase Diagram (Figure 1), the fluid will vaporise, even though temperature remains unchanged.

If the resulting vapour bubbles are carried to a region with increased pressure, they will

suddenly collapse. The surrounding fluid will very suddenly rush into the previously void region. However, the bubbles may not entirely collapse, but their remains may in fact rebound. It is obvious that this sudden and repeated change of volume (see Figure 2a) will result in an energy rich modulation of the surrounding medium (see Figure 2b).

Cavitation may not only be present on the propeller itself, but also in the propeller wake (see Figure 3). The helix, or tip vortex, is due to the highly loaded propeller tips. At the blade tips, a rotational motion is initiated within the fluid, which remains intact, even though being swept downstream, as the vessel advances. Tip vortex cavitation occurs, because the local pressure within a rotating fluid is lower than that of a fluid at rest (Bernoulli's Law).

These vortices may twist, bend or neck. Recent research indicates that this could be the reason, why a vortex is prone to cause a stronger modulation of its environment, than one would expect. The resulting so-called "broadband excitation" is so difficult to handle because an enormous amount of energy is being transferred into the environment, covering a large frequency range (see Plate 7). Therefore, it is very difficult to avoid a response from the yacht's structure and constituents.

Cavitation: macroscopic level

On most modern propellers, there will be stationary clusters of cavities (see Plate 3), which are typically situated on the low pressure side of the prop. Since the wake is not homogeneous, the inflow velocity into the propeller plane (or velocity of advance, see Plate 4) will alternate through the course of the revolution of the prop. As the rotational velocity stays constant, the resulting velocity, and therefore the angle of attack at each blade, will change during the course of each revolution (see Figure 3).

The higher the angle of attack, the lower the pressures on the lifting surface. As a result, a propeller blade is likely to experience more cavitation when entering the hull boundary layer, the shadow of shaft struts or a skeg, where the velocity of advance is comparatively low. The presence of the resulting cavities increases the amount of water that will be displaced by the blade itself, thereby increasing or even being more dominant than the pressure pulse caused by



Figure 3: A propeller in a cavitation tunnel displaying the back skew and the three distinct types of cavitation present: On the back of the blade surfaces, the helical tip vortex and the central hub vortex.

Courtesy: HSVA

pure displacement action of the blade alone. As a consequence of this gradual growth and decay, there will be a modulation of the surrounding medium. This pressure alternation will be experienced by the hull (see Plate 5), which could subsequently lead to vibration onboard.

Propeller selection

The blade rate will have to be out of tune with the vessel's structure. First of all, it is important to select the right gear box ratio. The faster the propeller rotates the more likely the occurrence of cavitation will be. Therefore, lower rates of propeller revolutions, n , are recommended.

Further Z , the number of blades per Propeller, will have to be decided upon. Z , in combination with n determines the frequency at which the yacht will be excited. The number of blades are not only important for propeller - structure tuning, but the strength of the individual pressure field surrounding each blade will reduce with the increase in Z , which literally helps to reduce the impact of the passing blades on the hull. This is the primary reason why there has been a trend to higher blade numbers in recent years. This trend persists, even though each additional blade will slightly reduce the propeller's propulsive efficiency through tip losses and blade interference effects.

Finally, the propeller diameter and propeller clearance (closest approach of the blades to the hull, expressed in percent of propeller diameter) will have to be determined. The impact of pressure pulses reduces exponentially with distance. Thus, it may be possible to increase propeller clearance by tunnelling the hull for the obvious cost in displacement. Though this may help, tunnelled propellers suffer from high wake due to the thick boundary layer inside.

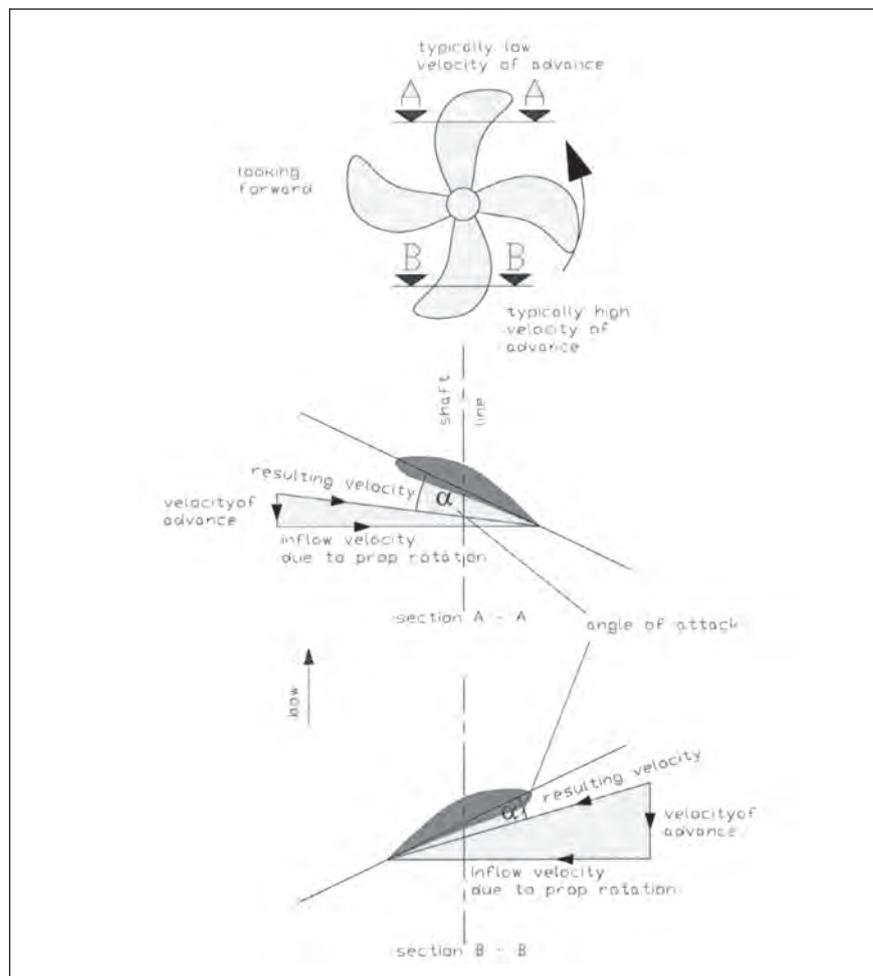


Figure 4: The Effect of changing Inflow Velocity into the propeller plane on Angle of Attack α at constant rate of rotation. The marked increase of α at lower velocity of advance will notably increase the risk of cavitation.

Note that the inflow into the prop in fact occurs from abaft. The vessel's bow would be at the top, the stern at the bottom.

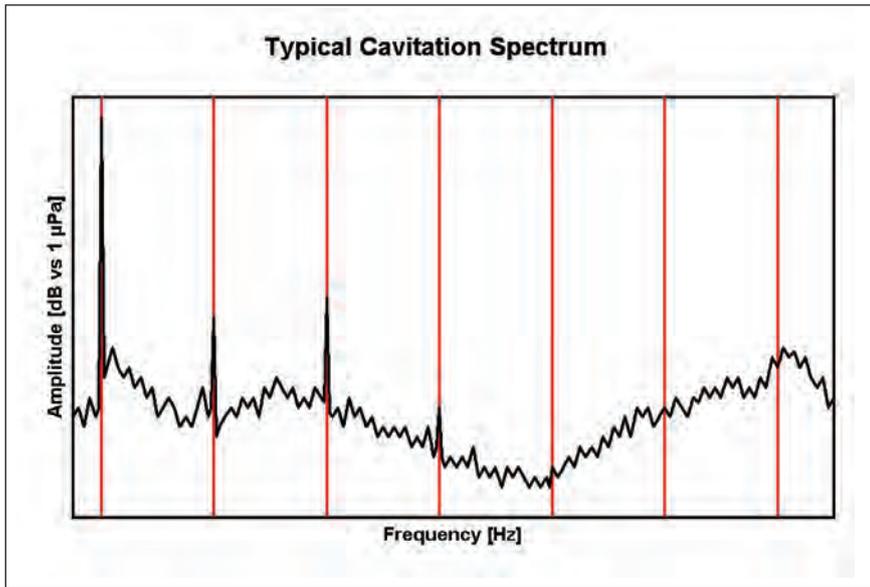


Figure 5: Typical Cavitation Spectrum.
Red bar (far left): Blade Rate. Other bars: Blade rate multiples.

This would imply a small propeller diameter. However, the smaller the propeller, the higher the pressure differential per unit area on the prop will have to be, to achieve the thrust necessary to reach contract speed. Lowering pressure may in fact lead to an increase in cavitation. This classic “catch 22” situation requires careful balancing of design variables. One may be tempted to increase propeller shaft inclination to increase propeller clearance. Note however, that this will reduce overall propulsive efficiency of the vessel.

Cavitation Control

- **Wake:** Keep as low as possible, i.e. the inflow velocity into the propeller plane should be as uniform as possible, thus reducing the tendency of alternating cavity volumes. A low and homogeneous wake will be achieved by means of fair buttock lines. This includes shaft struts which are carefully aligned with the flow, avoiding local disturbances to the propeller inflow. Those shaft struts in Plate 5 should in fact be re-aligned to better cavitation performance.
- **Blade Loading:** Reduce propeller loading per unit area by means of appropriately large propeller diameter and blade area ratio (BAR, the area that is covered by the developed blades as compared with the area swept by the prop during one revolution). Increasing BAR will spread

the hydrodynamic load carried by the prop over a larger area, thereby helping to alleviate the overall pressure levels on the propeller blades. Note that maximum BAR will of course be limited if CPPs are to be fitted as it must be possible to reverse pitch. Increasing blade area will also reduce the propeller’s propulsive efficiency.

- **Skew** (e.g. *tangential sweep of blades*): As the propeller rotates, each consecutive blade excites the hull through its displacement action as it travels past the top dead centre. This excitation will occur more gradually, if the blade tip pressure field is spread out circumferentially and therefore the gradient of excitation force vs. time is smaller. This is achieved through the application of skew.
- **Tip Rake:** Cupping propeller tips to the high pressure side will reduce propeller tip vortices, as well as it slightly increasing propeller efficiency through reduced tip losses.
- **Blade Sections:** Employing a blade section featuring an evenly distributed lifting line along the chord of the blade as well as carefully rounding the leading edge will avoid local pressure drops which might cause cavitation.
- **Radial Load distribution:** Unloading the blade tips helps to avoid tip cavitation (see helix, Figure 4). This will however, increase the load on the central radii and

therefore needs careful balancing against possible cavitation inception there.

The naval architect should be aware, that if a propulsion test has been performed at a ship model basin, the results should be treated very conservatively since the design propellers may as a result of the above considerations be less efficient than the stock propellers (such as those of the Wageningen Series), used for the propulsion experiment. Further more, when evaluating high performance craft in the tank, the results of the propulsion test will usually be without consideration to possible cavitation related thrust reduction.

Design evaluation

At the time of writing, model tests are still considered the most reliable source for hard numeric results in a commercial environment. As a pre-requisite for the cavitation experiment, resistance and propulsion experiments will have to be done. Further, an open water experiment needs to be carried out, to determine the characteristics of the designed propeller. These experiments serve to generate the input into the cavitation experiment: Thrust, RPM and stern wave height as a function of velocity.

The result of the cavitation test will be the pressure pulses, frequency spectrum (see Figure 5), a check for erosive effects and possibly loss of thrust owing to cavitation as well as the margin against tip vortex cavitation. Pressures are recorded at several locations at about the propeller’s top dead center. The described experiment is generally gifted with good reliability if an experienced model basin has been chosen.

The ultimate evaluation will of course be that at sea. The hydro-acoustic performance will frequently be done indirectly through noise and vibration measurements in the accommodation areas. However, further insight into the cavitation performance may be gained by means of pressure pulse measurements and boroscope high speed optic and acoustic recording technology that allows to observations and records of in-service cavitation patterns. **NA**

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Raytheon launches NautoSteer AS

German-based Raytheon Anschutz has introduced its latest steering control systems on to the market that it says will improve handling and allow installation at the shipyard more easily.

A ship's steering control is one of the most critical systems onboard a vessel. The latest advancement of the NautoSteer AS was developed with regards to fail-to-safe principles. The development of this steering system is the latest product that will combine with its integrated navigation system (INS) Synopsis Bridge Control.

The system has integrated steering failure and wire-break monitoring, the steering control system permanently monitors actual rudder with the set rudder and wire breaks to prevent any unwanted rudder actions such as hard rudders which may cause damages to ship, loading or passengers. In addition integrated data integrity monitoring ensures the inconsistencies within the steering system do not necessarily degrade the performance of the system.

"The development of NautoSteer AS has come from customer demand. We also included additional safety features in to the product. The installation and fitting of the system is easy as it is done with a PC. Looking further down the line, when it comes to maintenance of the system this is also easier," commented Martin Richter, marketing, Raytheon Anschutz.

NautoSteer AS is based on CAN-bus technology, whereas all important components such as follow-up amplifiers, autopilots, interface units and alarm monitoring units are connected via redundant CAN-bus systems. Should a failure happen, the steering control system automatically switches over to a redundant CAN-bus, providing most secure data communication and built-in reliability of the whole system.

Mr Richter added: "With the installation the power and the new CAN-bus system makes the installation of the system easier than before. The



The NautoSteer AS steering control system is available in customised configurations.

interface is now more flexible, allowing it to be integrated with bridge systems. The system allows you to take over steering from any position. The graphical operator unit also allows taking over controls from any position"

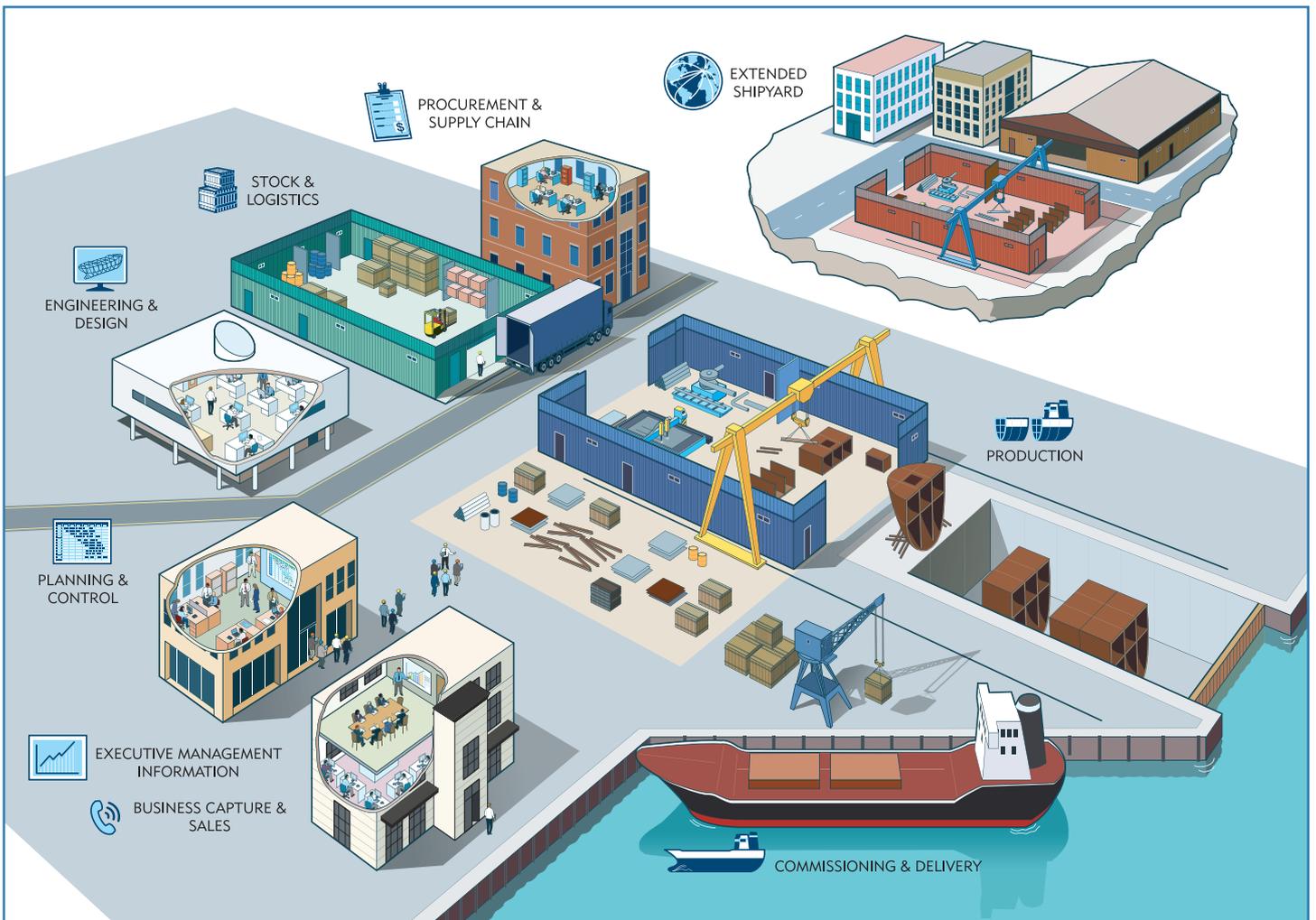
As another safety-relevant benefit a new and simplified steering mode selector switch separates an independent "main" non-follow-up steering position from a "secondary" steering position with CAN-bus based autopilot or follow-up and non-follow-up bustiller controls.

Olav Denker, product manager, Raytheon Anschutz said: "Compared to other steering control systems the new NautoSteer AS prevents from switching from a defective steering control to another defective steering control position. In case of an emergency, when time is crucial, this architecture supports the crew in their fast and safe decision making. NautoSteer AS will

significantly contribute to safe and comfortable steering."

NautoSteer also bring further improvements in handling with all steering controls following the same user-orientated and intuitive design. Central alarm reset and central and central dimming for the whole steering control system is also possible. The system also allows the user to define up to four different dimming groups in accordance with different conditions of lightning on the bridge, for example on the main bridge, port and starboard wings or aft bridge.

Raytheon Anschutz has said that the system has now been launched on to the market and expects to see deliveries of the system by the end of the year to both naval and super yacht projects. The system can fully integrate with any Raytheon Anschutz product and can also be integrated with other systems. **NA**



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Vizada looks to the stars

Satellite communications provider Vizada has launched its latest very small aperture terminal (VSAT) fixed satellite communications service, Pharostar, which will be able to cater for band widths of 1024kbps.

Pharostar will provide crew onboard ships with IP connectivity via satellite while at sea and meet the increasing demand for high performance broadband connectivity as sea, said Vizada.

Pharostar is based on direct technology, which optimises satellite broadband communications at sea and integrates band-switching, flexible bandwidth management, in one modem. With this technology Vizada can provide its customers with a standard IP data speed of 1024kbps for multiple applications such as internet and e-mail.

The connectivity is able to match that of corporate networks, said Vizada and with its 'always-on service' allows for unlimited data transfer. The service enables crew onboard merchant vessels, tankers and oil and gas platforms to use voice and data services simultaneously with near global coverage.

"Pharostar was integrated into Vizada's portfolio of products and solutions because there was a need for a standardised broadband service at sea with fast and reliable connections. Pharostar also enable Vizada to offer



Pharostar offers customers a better broadband service.

customers a combination of mobile and fixed satellite services on one vessel (many require both onboard for back up purposes), as well as to cater for the needs of larger vessels which require 'always-on' cost-effective communications," said Jeff Irwin, product director, Vizada.

Pharostar pricing is based on a fixed monthly basis allowing for unlimited use through its 'always-on system'. Mr Irwin pointed out that: "currently the market is driven by price rather than by actual need and solutions. Shipping companies' main concerns are cost control to monitor and minimize total cost of ownership, predictability of how the connection will be used, crew

welfare and entertainment in order to boost valuable crew members' moral and motivation, and compliance with local and international regulations."

"The price is very competitive compared to other VSAT service on the market today, and the fee is fixed on a monthly basis allowing for unlimited use through an 'always-on service'. Voice and data services can be used simultaneously – a crew member can check e-mail while the captain communicates via telephone with onshore administration," he added.

Vizada has said that through the Pharostar it is now able to offer its customers additional services such as an e-mailing messaging systems, maritime weather information, onboard antivirus technology and individual phone cards for crew members, all aimed at making the end-user communication experience quick and reliable.

Vizada has said that the response to its latest product has been very positive with orders and shipments underway as planned. Also, several major Vizada service providers are looking to sign up with the company to be able to distribute the Pharostar service this year. **NA**

Telmar and Vizada join forces with PIL

Vizada in partnership with Telmar has signed a contract with Singapore-based Pacific International lines (PIL) to provide broadband communications for their container vessel fleet.

The contract is for 88 vessels and 27 newbuilds, which will see the supply of broadband to the fleet for a term of three years that includes the supply of 124 Inmarsat FleetBroadband terminals and Thrane & Thrane Sailor 250 and 150 terminals. The supply of broadband will involve two Inmarsat terminals working in parallel that overall will give the service more flexibility and stability for the customer. In addition the system will have an IP networking system and LAN with 12 onboard connection points.

Telmar will provide a turnkey installation at the terminals in ports for PIL vessels as well as the LAN and installation onboard. PIL will also have a selection of Vizada products that it can choose from to accompany the broadband system installed onboard.

"We selected Telmar and Vizada because of their long-term expertise in customising maritime communications. Along with daily business communications, we are also interested in Telmar and Vizada's expertise for crew onboard," commented Captain Desawar, general manager of the fleet management for PIL. "By using the dedicated FleetBroadBand terminal in combination with solutions such as the prepaid feature of Sky Mail, crew members keep in touch with loved ones at home. The universal card gives them the freedom to use their dedicated communications budget as they wish whether for voice calls, e-mails or text messages which helps boost crew moral."

Crowning glory

Turkish ship owner, Densan Shipping, has ordered two of Sinopacific's Crown58 bulk carriers, the yard's first orders for 2011. The popular design among owners is known for its cost effectiveness and reliability.

Sixty five orders for Sinopacific's Crown58 supramax 58,000dwt bulk carrier design have been ordered and the latest contracts have come from Densan Shipping, the Turkish carrier which this year celebrates 43 years in the business.

On 24 January the chairman and CEO of Sinopacific Shipbuilding Group, Simon Liang and Hasan Akcal director of Densan Shipping, the Turkish carrier which this year celebrates 43 years in the business, penned a contract for the ships that will be built at the Yangzhou Dayang Shipyard and delivered in the latter part of 2012.

The ships represent the first orders for Sinopacific in 2011 and the company believes that the strength of their products, including the Crown63 and Crown118, 63,000dwt and 118,000dwt respectively, will see more orders for these vessel types in the coming months.

"This successful signing is another example illustrating Sinopacific Shipbuilding Group's product strategy... 'Perfection in simple products.' With the

deep and comprehensive understanding of the market and customer needs as well as leaner production management," said the company.

The Crown series of bulk carriers are designed by Sinopacific which has delivered 38 ships of this design already. And the company believes that this is because customers are getting a vessel that has a good safety record, has a higher dead weight and greater efficiency than comparable vessels on the market which in turn makes the design more environmentally friendly.

The Crown58 ships have an overall length of 190m, a beam of 32.2m and a depth of 18m with a scantling draft of 12.95m and a service speed of 14.3knots.

Densan currently operates a fleet of nine bulk carriers, three ships of 53,000dwt, two ships of 57,000dwt and four vessels of 58,000dwt. All the vessels in the current fleet are less than 10 years old and they have been built at yards in Vietnam and China. **NA**

A 3D representation of the Crown58 Supramax Bulk Carrier.



TECHNICAL PARTICULARS

58,000DWT Bulk Carrier

Length oa: 189.99m
 Length bp: 185.00m
 Breadth: 32.26m
 Depth: 18.00m
 Designed draft: 11.30m
 Scantling draft: 12.95m
 Deadweight at scantling draft: 58,000tonnes
 Speed at design draft: 14.30knots

Capacities:

Cargo holds (grain): 71,549m³
 Heavy fuel oil tanks: 2138m³
 Diesel oil tanks: 112m³
 Lower sulfur diesel oil tanks: 126m³
 Fresh water tanks: 398m³
 Water ballast tanks: 16,925m³

Cargo handling system:

Cranes: 4 sets x35tonnes, electric-hydraulic type
 Hatch covers: Folding type, hydraulic operated with following opening size for hatches
 Cargo holds: with CO₂ fire fighting system

Deck machinery:

Windlass combined with mooring winches: 2 sets, electric-hydraulic, high pressure type
 Mooring wiches: 2 sets x 15tonnes /15m/min, electric-hydraulic, high pressure type
 Lifesaving appliances: Compliant for 25 persons

Machinery:

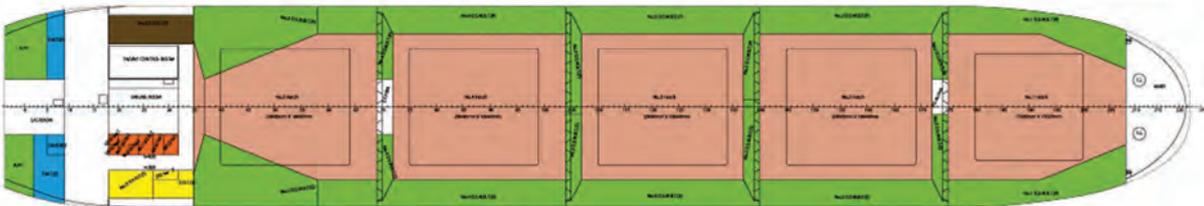
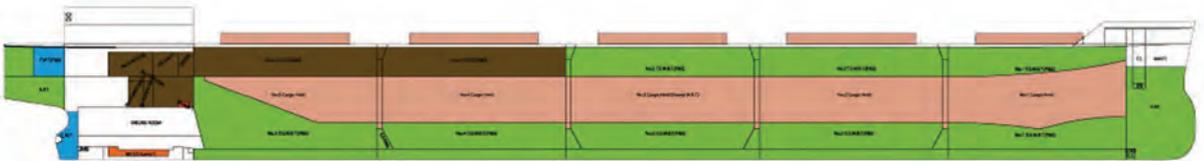
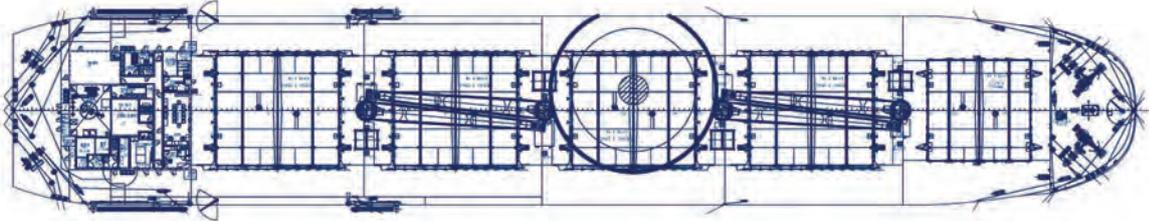
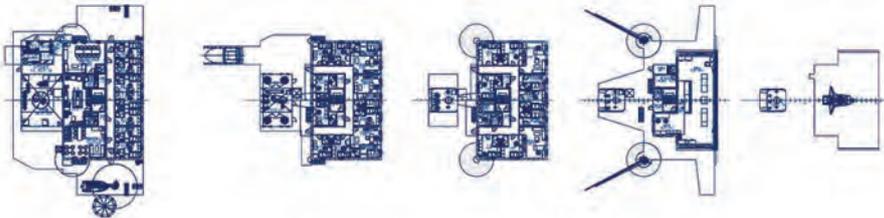
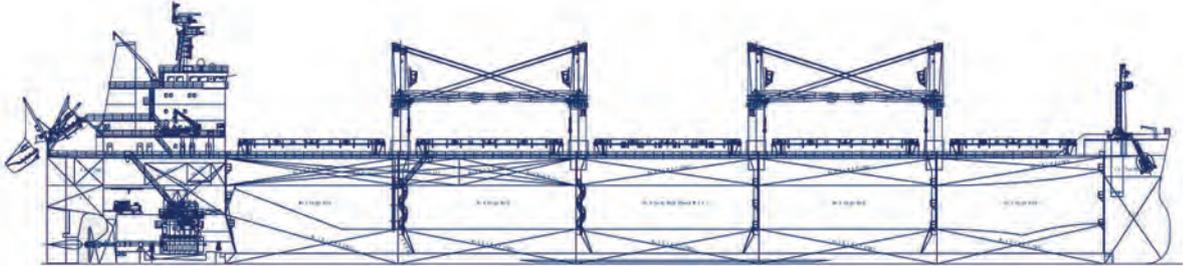
Main engine: MAN B&W 5S60MC-C7 T1 x 1 set
 SMCR: 8700kW at 120rpm
 CSR: 7395kW at 113.7rpm
 Main diesel generators: 3 sets x 645kWe (450V, 60Hz, 900r/min, 3 phase, 3 wire)
 Emergency diesel generator: 1 set x abt. 99kWe (450V, 60Hz, 1800rpm, 3 phase, 3 wire)
 Propeller: 1 set, fixed pitch, keynotes, aerofoil section, 4-blade solid type

Classification: BV * HULL * MACH, Bulk carrier, CSR, BC-A (holds 2 & 4 may be empty), ESP, GRAB(201, unrestricted navigation, CPS(WBT) * VeriSTAR-HULL, * AUT-UMS, MON-SHAFT INWATERSURVEY

Painting:

Water ballsat tanks: 2x200 mic pure epoxy
 Cargo holds: 125x100 mic mod epoxy

Crown58 Bulk Carrier.





Just a flush in the pan

The thunderous roar associated with the flushing of a vacuum toilet system is the starting point in the processing of black water or sewage.

Marine Bioreactors or MBRs are advanced wastewater treatment systems found on many cruise ships. They process the grey water from passengers and crew, while ensuring the common parameters used to determine the effectiveness of the treatment are met. These systems are designed to cope with the uneven loads in demand throughout a day, coping with the peaks occurring when entering and leaving port that coincide with tours and port visits, as well as at meal times.

The first stage of the MBR is to remove paper and other foreign objects using a screen press or filters. The mesh sizes vary according to the manufacturer. Dedicated personnel from the technical department ensure these bagged dry solids are taken for incineration onboard, usually at a frequency of four hours. The wastewater then enters a two-stage bioreactor, where micro-organisms which require dissolved oxygen to exist, reduce influent waste material by digesting the organic matter in it, turning it into carbon dioxide, water and new bacteria cells or biomass. Oxygen needed for the survival of the biomass is obtained using air diffusers. To ensure optimum conditions the system is automated. Any anomalies sound alarms alerting the officer of the watch in the engine control room.

Fine filtration then follows. In the case of Hamworthy's system, this is by using tubular membranes of 8mm bore mounted into a 200mm diameter fibre reinforced casing. The polymeric membranes varying in quantity depending on the size of the installation, act as a physical barrier to remove particulate matter and biological mass, which are returned to the bioreactors. The ultra filtration process uses high capacity pumps

to create a small differential trans-membrane pressure to force the permeate through the tube walls to the overboard. Treating this discharge with ultra violet light in order to further reduce any remaining pathogens has become the norm for many ships using the MBR system.

Foaming and membrane fouling are problems that can affect MBR system performance and require diligence on the part of engineering staff. Chemical foaming is usually caused by over dose of cleaning chemicals or detergents used onboard. Biological foaming on the other hand is attributed to the destabilisation of the treatment system, which can be caused by an over load of wastewater and in turn the supply of too much food for the biomass. Using antifoaming agents such as Gamazyme and the regular de-sludging of excess biomass outside the 12nm from shore limit at speeds greater than 6knots helps to keep the system running at its optimum.

Membrane fouling results from interaction between the membrane material and the components of the activated sludge liquor, which include biological flocs formed by a large range of living or dead micro-organisms along with soluble compounds. Keeping membranes clean by flushing, cleaning and disinfectants are critical in order to sustain the MBR's capacity to treat the most important parameters in the effluents, namely; Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) Faecal coliform, Total ammonia, pH and Free and Total chlorine.

COD's and BOD's are indicators of how much oxygen a pollutant is going to rob from water. If pollutants consume too

much oxygen, there is not enough left to support aquatic life. While TSS is a measure of the amount of solid material that is suspended in water, solid materials can keep light from penetrating into the water which is necessary for aquatic plant life. It can also settle on the bottom smothering fish eggs.

Faecal coliform is a class of bacteria that is found in the intestines of warm-blooded animals. While some forms are not harmful, their presence indicates that bacteria or viruses may also be present. If ingested by humans, they can create symptoms from mild nausea and diarrhoea to death. Equally, they can be harmful to marine life.

PH denotes the degree of acidity or alkalinity of the discharge. Water with extreme pH values can have a negative effect on metal piping (acid) and equipment and is also harmful to marine life. Finally, free/total chlorine measures chlorine which is an oxidising element that is used effectively in sterilising wastewater effluents and purifying potable water supplies. High chlorine levels can be toxic to aquatic life.

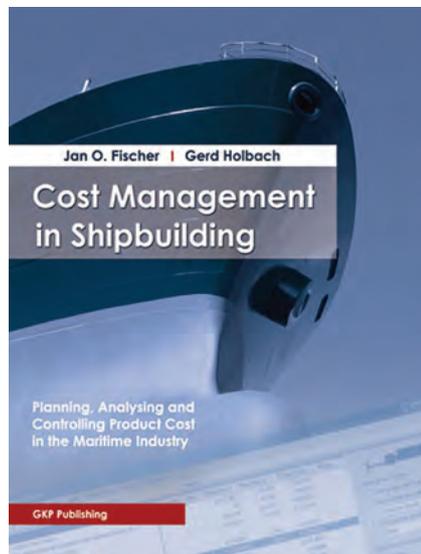
The effectiveness of MBRs can be measured by the increase in their orders for newbuilds and retrofits especially, on cruise vessels that might have to comply with the stringent regulations being adopted by individual states and countries to protect fragile eco systems. In Alaska for example, vessels approved for continuous wastewater discharge do so next to salmon spawning areas. These ships are randomly sampled by the Alaska Department of Environmental Conservation to ensure regulatory compliance in order to preserve the pristine environment. **NA**

Cost Management in Shipbuilding

By Eric Tupper

Cost Management in Shipbuilding

Written by J. O. Fischer and G. Holbach, published by GKP Publishing, Cologne, Germany, as a softback, 2011, 196 pp. ISBN 978-3-00-033225-8, 54.95 Euros (printed edition) 44.95 Euros (e-book).



Of the authors, Dr. Fischer has headed the Society for Cost-Effective Product Development (GKP from its German title) since he founded it in 2001 and has led the development of several software solutions supporting cost management in design and engineering. Professor Holbach has been the head of the Design and Operation of Maritime Systems Department of the Technische Universität, Berlin, for five years.

The book is based on the authors' more than 10 years experience in industrial cost management at the Flensburger Schiffbau Shipyard.

It is important to reduce and control costs as much as possible in the increasingly competitive world of shipbuilding and operation. Approximately 90% of the total costs for a ship are determined by decisions made during the initial design and design engineering phases although these two phases themselves only make up a small portion of the total cost. This means there is a need for accurate cost data very early on but, unfortunately, information is usually incomplete and imprecise at that stage. The authors emphasise the importance of through life costs and point out that some decisions to reduce overall costs will mean greater production costs in order to achieve savings during service. A dialogue is needed with the operator to ensure this is understood, otherwise an order may be lost to a builder who has concentrated on low production costs. The book contains a lot of detail and it is only possible to give a

flavour of its approach and contents.

Many readers of this review will have read the Editorial in the Jan/Feb 2011 issue of *Ship & Boat International*. This made the point that shipyards which can control their information flow throughout a project will improve their competitiveness. One difficulty they cite in achieving this is the "localised and disconnected information assets" within firms. That is, the considerable amounts of data held by individuals or departments which cannot be readily accessed by others. The present book makes just these points in relation to cost data and cost management.

Having discussed the importance of cost management in competitive shipbuilding the book reviews first the current situation in terms of organisation, processes and methods. It refers to NATO Allied Naval Engineering Publications (pointing out some inconsistencies in them). It then deals with theoretical methods including regression analysis for using statistical data, the error compensation effect, identifying cost drivers, calculating the life cycle costs and handling uncertainty.

The main part of the text (some 90 pages) presents the costfact software system. The system supports cost planning, analysis and management in shipbuilding. It is claimed that costfact

substantially reduces the effort and expenditure involved in cost planning whilst significantly improving its accuracy and transparency. It supports cost management through all project phases and the building group system to present cost data in a tree system suiting the product structure. Cost drivers are identified in the system by highlighting components whose summed costs exceed a chosen limit. Function costs are one output of the system, obtained by assigning building groups to a ship function. These costs provide the basis for discussions with the buyer as to whether a given function is really needed and, if so, whether a cheaper technical solution can provide an adequate level of function. It illustrates this in the naval context by taking the function of being able to overtake a chosen vessel. One solution was to give the ship a high speed but an alternative might be to provide it with a helicopter. In estimating life cycle costs, the book discusses how to deal with expenditures (and income) that occur over long periods of time. The system can carry out a sensitivity analysis to show how the value of a project is influenced by variations in assumed input values. In comparing two projects such analyses can highlight the critical value of an input parameter that can change the relative attraction of the two projects.

Appendices include a Glossary of Terms and details of the ESWBS Building Group System. The e-book contains the complete book with colour illustrations. In the printed book illustrations are in black and white. Updates are available on a web site. Whilst this is clearly a somewhat specialised work, the book would make useful background reading for those who are working on engineering design. It provides an understanding of the issues, methods (e.g. for dealing with overhead costs), uncertainties and potential benefit of good cost management. **NA**

E. C. Tupper



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Second Announcement



Following a highly successful conference in 2009, RINA is pleased to return to Genoa for the second edition of the super and mega yachts conference.

The luxury yacht sector has not been unaffected by the global financial situation, but it has survived in good form and is growing again. New regulations are being developed to deal with the increasing size of vessels and these are both helping and challenging designers and builders of the latest generation of yachts. This growth in size and complexity coupled with the new technologies becoming available bring new challenges requiring innovative solutions.



Today's owners are demanding ever greater levels of comfort and luxury, not only in terms of the vessel fittings and styling but also in the vessels behaviour whilst underway and at anchor. They are also increasingly aware of the impact of their vessels on the environment. Many vessels are now used for charter and this has implications for the way in which the vessel is designed and classed.

RINA invites papers on all aspects of large sail and motor yacht design, construction, and operation, from designers, researchers, manufacturers, operators, and regulators. Suggested topics include the following:



- All Aspects of Design - Hull, General Arrangement, Interior, Features etc.
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HUMAN FACTORS FOR NAVAL MARINE VEHICLE DESIGN & OPERATION

By Jonathan M Ross MRINA Ref: HFNM

There is a driving need for naval professionals to focus on human factor issues. The number of maritime accidents is increasing and the chief cause is human error, both by the designer and the operator. Decreasing crew size, lack of experienced operators, operations in higher sea states and fatigue worsens the situation. Automation can be a partial solution, but flawed automated systems actually can contribute to accidents at sea. This book integrates knowledge from numerous resources as well as the advice of a panel of eight recognised experts in the fields of related research, development and operation.

Member price UK £50 EUR £55 OVS £57.50

Non- Member price UK £55 EUR £60 OVS £62.50



SAFETY MANAGEMENT AND ITS MARITIME APPLICATION

By Professor Chengi Kuo FRINA Ref: SMMA

The author introduces this book by asking a seemingly obvious question "What is safety?". To show there is no straightforward answer he illustrates from his experience in conducting a number of safety workshops worldwide. In the foreword to this book Mr E E Mitropoulos Secretary General of the IMO writes: "As Professor Kuo points out early in his book, safety is not an absolute concept and the levels chosen are based on shared values. It is for this reason that this book is so useful because it introduces safety concepts, explains safety terms, and demonstrates how the different techniques can be applied in practice.

Member price UK £28.75 EUR £31 OVS £33.50

Non- Member price UK £31.75 EUR £34 OVS £36.50



INTERIOR DESIGN METHODS FOR YACHT DESIGN AND THE BOAT BUILDING INDUSTRY

By Lisa C. Hix Ref: IDMYD

In a first-time release to industry and the general public, the Westlawn Institute of Marine Technology announced in April 2009 this textbook was now available for purchase. Specifically prepared as a textbook for Westlawn's intensive Yacht & Boat Design Program, and also used as the text for Westlawn's continuing education course in boat interior design this book provides detailed technical information not available from any other source. Heavily illustrated, with numerous line drawings and photos on nearly every page, this textbook will answer almost any question a designer, builder, surveyor, crewmember, or serious boater may have about the accommodations and arrangements required for safe, comfortable, and efficient crew and passenger spaces. Though focused on boats (vessels under 200 feet or 60 meters), the information is equally valuable for commercial vessels of all sizes.

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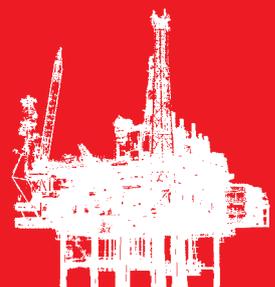
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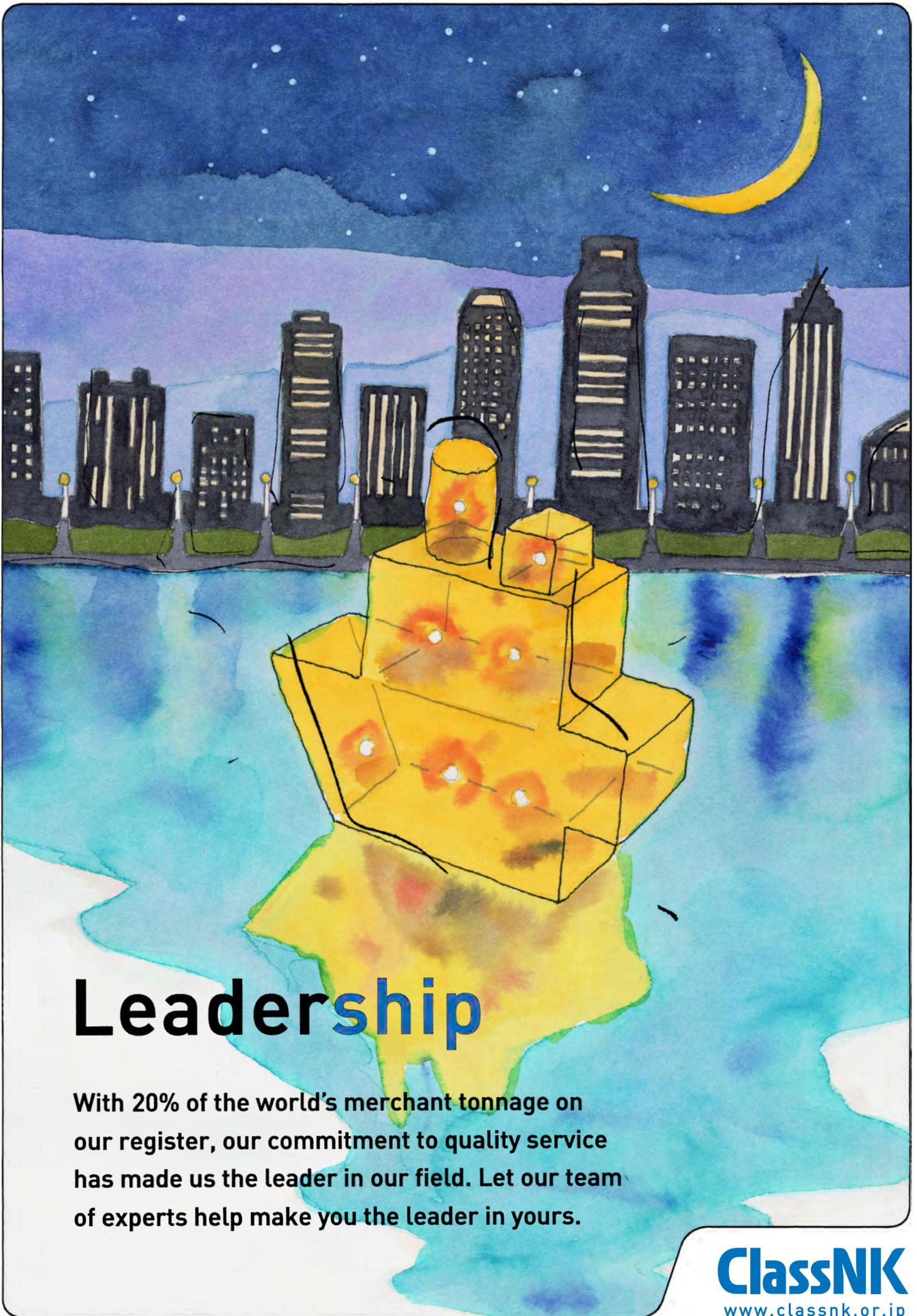


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