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Editor
Tim Knaggs

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Group Advertisement Manager
Debbi Bonner

Advertisement Consultant
John Labdon

Advertisement Production Manager
Stephen Bell, PGDip

Marketing Manager
Adelaide Proctor

Publisher
Mark J Staunton-Lambert

Published by:
The Royal Institution of Naval Architects

Editorial & Advertisement Office:
10 Upper Belgrave Street
London SW1X 8BQ, UK

Telephone: +44 (0) 20 7235 4622
Telefax: +44 (0) 20 7245 6959
E-mail: editorial@rina.org.uk
advertising@rina.org.uk
Website: www.rina.org.uk/tna
Subscriptions: subscriptions@rina.org.uk

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THE NAVAL ARCHITECT

Seen here shortly before her launch at the Madenci Shipyard on Turkey's Black Sea coast is the 3300m³ LPG carrier *Merope Star*. She is the lead ship of a new series for the Italian owner G&H Shipping. The design has been made by the Trieste-based consultancy Marine Engineering Services. An article on these interesting vessels starts on page 41.

PRINCIPAL ARTICLES

SPECIAL FEATURES

REGULAR FEATURES

The Royal Institution of Naval Architects

RINA Historic Ships Conference

4-5 October 2006

First Notice & Call for Papers

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Courtesy F Walker

There are a huge number of historic ships that are in need of restoration/preservation. Several organisations exist, who aim to preserve these ships for the benefit of future generations.

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- Techniques for conservation and restoration.
- Recording and deconstruction
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Winds of change blowing through LNG carriers

THE unfortunate tank containment problems on LNG carriers at Alstom Marine and Samsung could be construed as indicators of an apparent wind of change blowing through the international LNG shipping industry. *Gaz de France* Energy is now a year behind her original delivery date - the ship and all marine systems are perfect, it is just that secondary barrier leaks have called for extensive rebuilding work. It is true that this 75,000m³ design was the guinea pig for GTT's newest CS1 technique, and therefore minor problems might have perhaps been expected, but at Samsung, the BG ship *Methane Kari-Elin* is fitted with the very well established Mk 3 system, also from GTT.

These difficulties themselves are probably not the cause of current diversions into some interesting and uncharted fields - clever minds were at work before - but they will certainly ensure that decision-makers examine new alternatives very closely for new ships. We have already witnessed one giant swing towards diesel-based machinery (medium-speed diesel-electric or slow-speed diesel-mechanical) and further contenders wait in the wings, particularly the gas turbine. Now a second wind is blowing, ushering in a new raft of tank concepts.

One of the prime catalysts for such R&D, particularly where yards are building large numbers of LNG carriers and where most of the practical expertise has been built up, might be attempts to overcome patent fees payable to licensors in foreign countries (in the case of Far East shipyards). In the case of the Korean Gas Corp's (Kogas) membrane proposal on show at the 2005 Gastech exhibition in Bilbao, Spain, and reported in this journal's May 2005 edition, it might also be possible, by using an innovative shape of the corrugations, to speed up welding on the stainless steel membrane.

Kawasaki Shipbuilding's second ship to feature the pressure-build-up concept, *North Pioneer*, was completed recently. Although only small at 2513m³, she marks a further waypoint towards new thinking in LNG carrier technology.

Others are pursuing more radical prospects. We have already reported on ExxonMobil's proposal for a pressurised natural gas carrier (June 2005, page 20), although this is probably more suitable for remote or stranded fields - but with a very large capacity up to 200,000m³. In this issue we examine the ConocoPhillips prism tank shape, already approved in principle by class society ABS. This is especially aimed at limiting one of the troublesome aspects of membrane designs - the free-surface effect and resulting sloshing loads in partially filled tanks. The prism concept team also believes that the idea will be very suitable to mega-size LNG carriers.

As has been noted on several occasions, Moss-type spherical tanks do not suffer so much from this problem, and *The Naval Architect* believes that this type of tank may yet see a re-emergence into playing a leading role again, notwithstanding the loss of space and restricted forward visibility from the wheelhouse. Meanwhile, in the USA, work is believed to be still proceeding on another interesting alternative: a cylindrical tank developed by a company known as Ocean LNG. This is based on the IMO Type B independent tank principle but conceived to minimise filling restrictions due to sloshing effects. A 25% increase in cargo carrying capacity for a given hull form is claimed over spherical tanks.

A further Type B system, the prismatic SPB, from Japanese shipbuilder IHI Marine United, still awaits general acceptance by the industry, with only two LNG ships completed. Many consider that despite several interesting attractions, it is too expensive, although it has good sloshing characteristics and thus could be useful in offshore processing roles. Two ships have already been built by IHI for LPG: an FSO and an FPSO.

A different IMO technique, the Type C tank, is making positive waves in Japan, following completion in 2003 of a mini gas carrier, the 2500m³ *Shinju Maru No 1* and that ship's highly successful operation distributing LNG to utility companies. A report on this ship appeared in our June 2005 edition (page 29), and very recently a second vessel, *North Pioneer*, has entered service. *Shinju Maru No 1* pioneered Kawasaki Shipbuilding's pressure-build-up technique, in which all boil-off is contained within the aluminium cylindrical tanks - the Hanshin main engine burns only oil. Kawasaki says the system can be used on ships up to around 10,000m³ or 15,000m³ capacity before the tanks start to become uneconomically heavy.

Type C principles are also being used in the newest and perhaps most interesting LNG proposal of all: Tractebel's bi-lobe system. This German specialist has used its extensive experience in LPG and ethylene carriers to extrapolate an LNG design suitable for ships up to 40,000m³ and aimed at overcoming the expense of conventional containment systems.

The biggest challenge which has been overcome by Tractebel has been design of a support system able to handle the -163°C temperature of LNG cargoes - much lower than that at which LPG is normally carried. A patent is pending on this, and the design has been approved by an unspecified class society. Even more fascinating is that the designer considers the technique as an upgraded ethylene system; therefore, ships fitted with these tanks plus an appropriate reliquefaction plant could load not only LNG but also LPG and ethylene.

To add to this heady mixture of new ideas, Norwegian class society Det Norske Veritas confirmed last month that it is undertaking a joint industry project to develop an unspecified new LNG containment system. A confidentiality clause precludes any more news at present.

At the same time, we commented in this column last month that Aker Finnyards used to have a production line at Turku for manufacturing Moss-type tanks. It is now confirmed that this no longer exists; nevertheless, it is intriguing to note that today gas tanker production has been assigned to the Aker yards in Germany at Warnemünde and Wismar, Germany, but 'it is not yet decided where and for which types of tanks' a new line might be created.

A third new entrant into the ring is, surprisingly, the medium-sized Polish shiprepairer Remontowa, in Gdansk. This adventurous yard, which has recently been making useful inroads into the newbuilding field with several technically-notable one-off ships, has announced that it is very keen on constructing LNG carriers and is actually involved in a possible project right now.

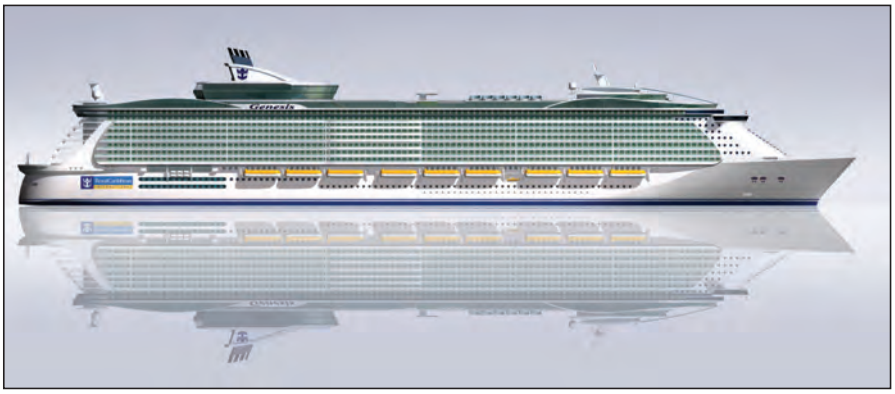
Certainly, the LNG sector around the world in 2006 appears to navigating up some most interesting new channels. Maybe more revelations will be made soon, possibly before September when The Royal Institution of Naval Architects holds its second gas carrier conference in Pusan, Korea, or at the Gastech 2005 exhibition and conference to be held during November in Dubai.

Largest passenger-capacity cruise ship ordered

ROYAL Caribbean International has booked a new-generation cruise ship from Finnish **Aker Yards**, able to carry 5400 passengers - news which arrived just too late for inclusion in our February Finland report. With a contract price of approximately €900 million, this is believed to be the most expensive ship ever ordered in the history of commercial shipbuilding.

This 220,000gt prototype, developed under the name Project Genesis, will be delivered from Aker Yards, in autumn 2009. The contract includes an option for a similar vessel.

Taking a huge leap of 43% in size from the new record-breaking *Freedom of the Seas* (to be delivered to Royal Caribbean from Aker Yards' Turku complex in April), the new giant of the cruise market will be 360m long, 47m wide, and will have a 65m height above the waterline. No further details are currently available.



This huge new cruise ship, ordered by Royal Caribbean International, will be 360m long, and will be able to accommodate 5400 passengers.

NEW NATURAL GAS RESEARCH VESSEL TO BE BUILT IN CHINA - A diesel-electric natural gas hydrate integrated research vessel will be built by Wuchang Shipyard, Wuhan, China. Owner and operator, the Guangzhou Marine Geological Survey, will take delivery of the vessel some time next year. It has been designed by the MARIC Design Institute, Shanghai, and is optimised for comprehensive marine survey and natural gas research operations.

With a length overall of 106m, a length bp of 96m, a breadth of 17.4m, a depth of 8.3m, and a design draught of 5.5m, the vessel will be equipped with three MAN B&W Alpha diesel engines, type 6L27/38, each with an output of 1980kW and driving alternators. Speeds of 17knots will be possible, with a 15,000nm endurance, and the twin-screw propulsion plant will be based on a low-voltage Siemens package powering a pair of Schottel thruster propellers.

NIGEL GEE TO COOPERATE WITH FINCANTIERI - An agreement has been signed between Italy's Fincantieri Shipyards and BMT Nigel Gee & Associates Ltd, to develop and market advanced high-speed ships based on BMT's patented Pentamaran designs and advanced catamaran hull forms. This agreement, for an initial three-year period, will focus on large, fast, efficient multi-hulls for modal-shift fast-freight applications. BMT Nigel Gee & Associates previously had a similar agreement with the Spanish IZAR group, now effectively dismantled and partly re-branded as Navantia. The Pentamaran hull form comprises mature designs with classification society approval for ro-pax, ro-ro, lo-lo, and sealift variants, all capable of speeds of 40knots and above. Fincantieri and BMT are already in discussion with a number of interested owners and hope to move towards the first Pentamaran shipbuilding contract soon.

BMT Nigel Gee has also entered into a licence agreement with shipbuilder FBMA Marine Inc, allowing the latter to market and construct smaller vessels designed by BMT NGA.

ANOTHER PRICE HIKE FOR COATINGS - Unprecedented raw material costs have forced International Paint to initiate a new round of price increases. Over the past few years, the costs of all of the company's key raw materials have risen significantly in price; in particular, the international metals market is booming, and the new pricing level looks set to stay, 'creating a new cost base for marine coatings', the company believes. Metals are an important component of marine paints.

Paint solvent prices are closely linked to the oil price, which last year rose nearly 50%, and consequently 2005 saw significant price rises of over 20% for key solvent groups used in the production of International Paint's marine products. Concerns remain over solvent refining capacity, and therefore supply is likely to remain constrained in 2006.

Furthermore, steel and tinplate packaging manufacturers worldwide are about to be hit by further price increases from their suppliers.

IMPORT OF CHINESE STEEL PLATES EXPANDED - Hyundai Heavy Industries (HHI) is expanding the import of steel plates from China for its shipbuilding activities. This leading Korean yard recently signed a memorandum of understanding to buy 180,000tonnes of steel plates annually from Baoshan Iron & Steel.

HHI will consume three million tonnes of steel plates in 2006, 17% (or 500,000tonnes) of which will be imported from China. Imports of steel plates from China have more than doubled compared to last year's number of 200,000tonnes. The quality of Chinese steel plates has improved, while the industry there has managed to keep prices lower than its Japanese counterparts, according to HHI.

HHI procures 55% of its total consumption of steel plates from domestic companies, including POSCO and Dongkuk Steel, and imports the rest from Japan (30%) and China (15%). Baoshan is China's largest steel company with an annual capacity of 23 million tonnes of blister steel and 1.4 million tonnes of plates for shipbuilding.

NEW SHIPS FOR AIRBUS PROJECT - Singapore Technologies Marine Ltd (ST Marine), the marine arm of Singapore Technologies Engineering Ltd (ST Engineering), has secured two contracts from Seaplane Two SAS and Seaplane Three SAS, totalling around Sing$120 million, to construct two ro-ro vessels. Construction is expected to commence in the second half of this year.

The first vessel is expected to be delivered in the first half of 2008 and the second in the second half of the same year. The previous deepsea Airbus ro-ro ship, *Ville de Bordeaux*, was built in China by Jinling Shipyard and was covered in *Significant Ships of 2004*.

Seaplane Two SAS and Seaplane Three SAS are joint venture companies of two shipping groups, Louis Dreyfus Armateurs SAS, France, and Leif Hoegh & Co AS, Norway. The vessels will be chartered to Airbus SAS for the transportation of large aircraft components, including sections for the new A380 aircraft. When not employed by Airbus, the 3500dwt vessels, 127m long and 21m wide, will be chartered for the transportation of cars, trailers, reefer containers on trailers, and heavy ro-ro equipment. They are specially designed to transport aircraft sections efficiently and are equipped with highly automated ship control systems. To meet the special requirements for loading of aircraft sections, unique features will be included, such as a stern mooring system, cargo hold environment control, and special lashing arrangements. Cargo deck space will total around 9300m^2 with ro-ro lanes totalling approximately 3100m.

SPANISH SHIPBUILDING REGAINS MOMENTUM WITH RUSSIAN CONTRACTS - Last month, President Putin confirmed trade initiatives between Russia and Spain with the reported announcement of orders for new ships in Spain. Three ice-class high-specification shuttle tankers will be built by Factorias Vulcano for Rosneft. These vessels, for trade in the Russian and Baltic areas, are set for delivery in 2007 and 2008, and will have their hulls constructed by Navantia (formerly the IZAR Group).

In addition, Pymar, an association of privately-owned small- and medium-sized vessel builders, will build four container ships, three multi-purpose cargo designs, and six bulk carriers for Northern Shipping, Murmansk Shipping, and FESCO respectively. This order is reportedly worth US$375 million.

Ask us about …
LNG

DNV has been an active contributor to LNG shipping since the early 1960s. We have been involved in the development of all current containment systems, including CNG (Compressed Natural Gas). Class notations for operating in cold climates, such as the "Design Ambient Temperature", DEICE and the newly introduced Winterized and Winterized Arctic notations have been developed by DNV. The world's largest LNG newbuilding (February 2006) – a 217,000 m3 ship – will be built to DNV class.

LNG carriers are valuable ships, representing significant investments by their owners. Many of these vessels are intended to have an operational life of 40 years, and charterers are generally putting forward high expectations in terms of operational and technical safety. Advanced fatigue and coating specifications are typical examples.

DNV also has a long history in the offshore industry, with solid experience related to pipelines, process plants and floating installations. These are key elements in relation to LNG terminals and facilities.

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MANAGING RISK

New solutions for waste and ballast-water issues

THE Bremen-based company RWO Marine Water Technology has been working in the water and wastewater treatment solutions for ships and offshore application for 30 years, and more than 9000 water treatment systems have been sold worldwide to yards and owners. RWO is a member of the Veolia Water Solutions and Technology group.

The new IMO-Resolution MEPC.107 (49) requires a stringent test procedure. Previously, type-approval regulations specified the testing of bilge water separators with oil-water mixtures only but the new resolution requires an additional performance test with a chemical/oil/water emulsion.

To meet the new requirement, RWO upgraded its SKIT/S oily-water separating system, which had already been approved in accordance with IMO resolution MEPC.60 (33), with a second-stage process unit having a very compact oil and hydrocarbon absorber to remove emulsified oil with a claimed very high efficiency. This new bilge-water separator, known as the SKIT/S-DEB, is certified in accordance with MEPC.107 (49).

The coalescing-type design is claimed to guarantee an overall high performance. Periodical back-flushing keeps the coalescer surface clean and should ensure long-lasting operation without constant attendance and maintenance. The unit also provides less than 1ppm oil content in the effluent water under IMO test conditions. All special rules of restricted areas have also been fully met, such as those of the US Coast Guard, Alaska, Great Lakes, and St Lawrence Seaway.

The system comes as a space-saving package, skid-mounted, complete with all necessary accessories and controls. The IMO-approved 15ppm oil content alarm and monitoring device records date, time, and performance status, and the recording device stores data for at least 18 months. The protocol can be displayed in accordance with IMO regulations.

SKIT/S-DEB units are currently being delivered for *Gold Star*, claimed as the world's largest megayacht, building in Dubai, as well as for an offshore jack-up rig and a drilling rig at Keppel FELS, in Singapore.

RWO's new SKIT/S-DEB bilge-water separator is certified in accordance with MEPC.107 regulations.

New treatment solution for water ballast

For a number of years, marine biologists together with IMO have been warning owners about the settlement and enrichment of harmful organisms in foreign waters caused by the global transport of ballast water. Finally, after 18 years of negotiation, the International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted at a Diplomatic Conference of the IMO in February 2004.

This convention will enter into force 12 months after ratification by 30 states, representing 35% of world merchant shipping tonnage. By December 2005, six states had signed, but a lot more have announced future ratification. Additionally, single approaches for national regulations such as in the USA will force the implementation of ballast water treatment systems.

After ratification, ballast water treatment systems have to be in use from 2009 to 2016, depending on keel laying and the total ballast water capacity of each ship. The earliest effective date will be 1 Jan, 2009 for small-, and medium-sized ships with total ballast water capacities below 5000m³.

New-generation systems ready by 2007

Guidelines for type approval were agreed at the last session of the IMO Marine Environment Protection Committee (MEPC53), in July 2005. This approval procedure consists of a land-based type approval over at least 70 days, followed by a shipboard type-approval over six months. The latter is required for a water treatment system being designed for the first time for marine use, while the former is a supplementary, basic approval of the active substance used in disinfection, which has to be accepted by IMO.

Both approval procedures together will last approximately a year and a half, so type-approved ballast water treatment systems will not be available on the market before 2007. However, equipment is already being requested by shipyards, as current systems have to be adjusted to ballast pump capacities and piping, and therefore integrated in a ship design before construction starts.

The future performance standard D2 requires that ships discharge:

- <10 viable organisms per cubic metre =50µm in minimum length
- <10 viable organisms per millilitre <50µm and =10µm in minimum length
- certain numbers of indicator microbes (Vibrio cholera, E. coli, and Enterococcus).

It is important to note that IMO requires a certain number of organisms in the discharged ballast water, because recently some suppliers claimed a killing rate around 99.9%, which will not be in compliance with this regulation. In order to meet this discharge standard, RWO's ballast water treatment solution is a modular design for various ship types and capacities and consists of:

- advanced mechanical separation to remove suspended solids, sediments, and a large number of organisms during ballasting
- disinfection to reduce the number of viable organisms during ballasting
- second disinfection to reduce the number of viable organisms, according to the future performance standard D2 at ballast water discharge.

Three years ago, within the scope of a R&D project, RWO started to test different mechanical separators and disinfection processes in parallel,

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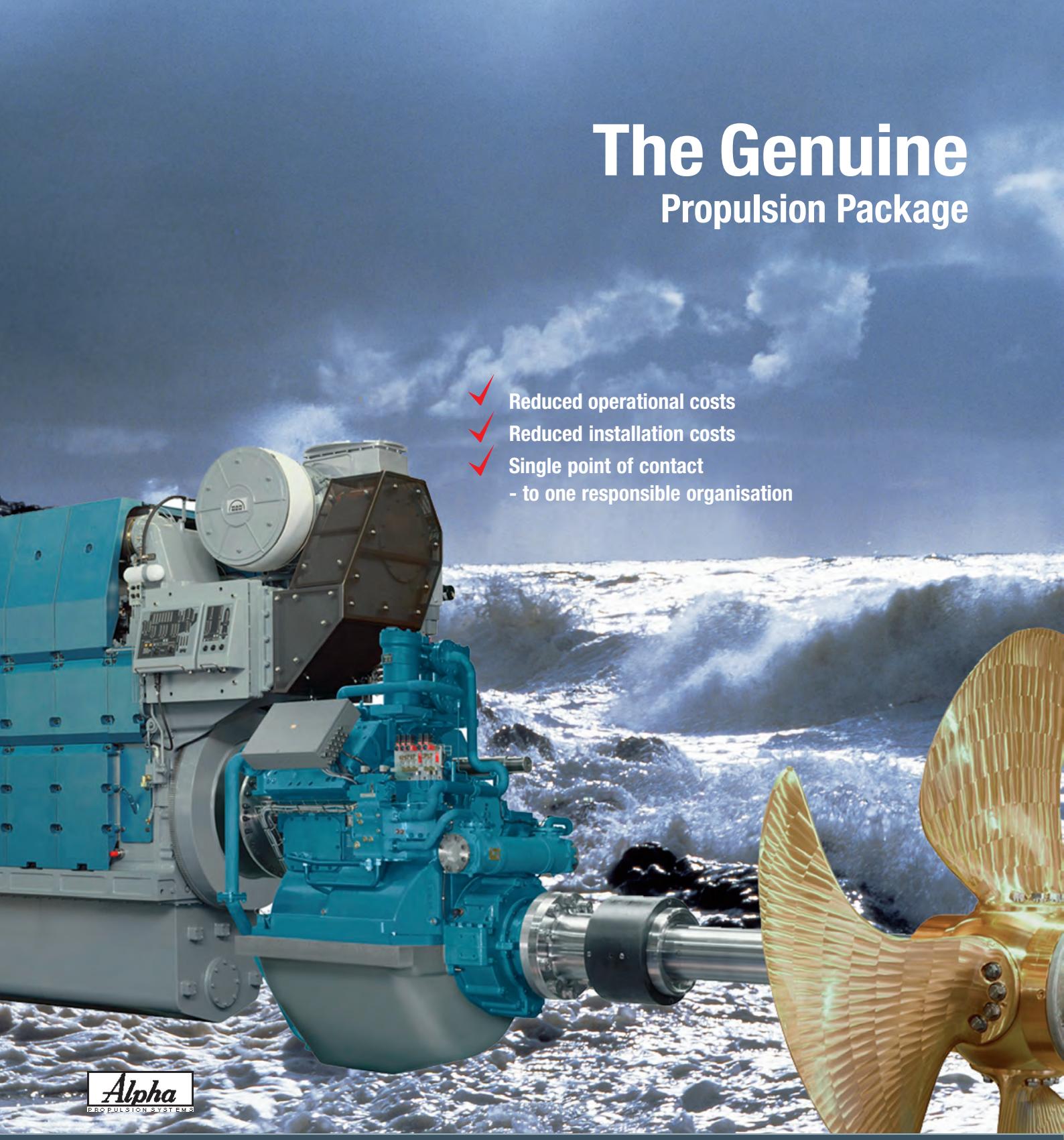

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The test site for RWO's ballast water treatment system is situated in an ideal realistic position - on a container pier - where operators are likely to take on or discharge ballast.

to access the best technology for efficient particle removal, high ballast water production and killing rate of organisms, as well as for onboard requirements.

For example, hydrocyclones as mechanical separators have the disadvantage here, claims RWO, that they can only remove particles heavier than water and not lighter particles such as algae; up to 30% of the inlet water is continuously discharged, with the underflow resulting in low ballast water production; this has to be equalised by longer ballasting operations or a significant resizing of existing ballast water pumps and piping. Hydrocyclones also create a high pressure loss, which make ballast water pumps with higher pressure heads necessary.

In the optimised RWO ballast water treatment solution, an advanced filtration with filter fineness <50µm gives release to the disinfection step, resulting in lower footprint and added values, because the sediments are mostly removed before they can accumulate in the ballast water tanks. The small fraction of remaining very fine particles will be swept out of the tank during the next discharge. Today, sediment accumulation in ballast water tanks effects costs, due to lost weight for cargo and time spent on tank cleaning.

RWO's modular solution has undergone land-based testing with over 10,000 hours at four different locations in river-, brackish- and sea-water. The land-based plant is actually operated on a container pier under very realistic conditions with above 800mg/litre total suspended solids. The system is specially-designed to handle and remove high sediment loads in harbours and estuaries, where most shipboard ballasting operations take place. This guarantees a fast ballast water production in a short time.

The systems are laid out to meet performance standards at all global water qualities, to achieve fast ballast water production at high sediment load and strong algae blooms, to be adaptable to each type of vessel given by modular design and low footprint, and to guarantee a high level of automation and operator convenience. An RWO package should also make the required recording of ballast water management onboard easier, be efficient and cost-effective in shipboard use, and be environmentally friendly (with no use of biocides for disinfection).

RWO is preparing to run through the type-approval procedures this year, and its ballast water treatment solution will be commercially available in 2007. The guidelines for prototype testing have not been adopted by the IMO yet, but will probably give a 'grandfathering' of five years until prototypes have to meet the performance standard onboard vessels. RWO intends to install prototypes onboard of seagoing ships this year.

Faster ship production through better information handling

THE Finnish company Kronodoc Oy, established in 1997 as a spin-off from a CERN engineering project and which provides information logistic solutions, has developed an information management, collaboration, process and follow-up software system, which has gained much popularity within the industry. The company claims over 20,000 industrial daily users of the Kronodoc solutions, each with an average of some 30 customers. Among Kronodoc's clients are Wärtsilä, ABB, Aker Finnyards, the Finnish Navy, and Finnlines (the last-mentioned company has employed the Kronodoc system especially for managing its three-plus-two ro-pax ferries ordered from Fincantieri). The company employs some 30 professionals but expects to have grown to 80 in three years from now.

Kronodoc claims that 20% to 30% of a ship's design time is committed to searching, circulating and following-up of information flows by those participating, and promises to cut that time by half with its system. Faster and more efficient information logistics for the entire shipbuilding process drives material logistics, production and payments, which in turn increases competitiveness.

By organising efficient information handling, Kronodoc claims faster ship deliveries also improved accuracy and increased productivity.

The software is built on a fully web-based information logistic platform. In a shipbuilding project, there are typically some 5000 documents and 10,000 photoprints of engineering documentation, drawings, correspondence, agendas, memos, and reports. Kronodoc aims to speed up real-time collaboration, access of information, and search functions of the up to 100,000 files needed, thus saving working hours.

In cooperation with Aker Finnyards, Deltamarin, Finnlines, and Wärtsilä, Kronodoc has just finalised its marine project within the Finnish MERIKE technology program. The objective was to further develop the software product, making it better suited to the marine industry. Advances made were based on the requirements of marine customers, to enable further improved working processes across organisational boundaries and to reduce significantly time spent on managing documents and information exchange in ship delivery projects.

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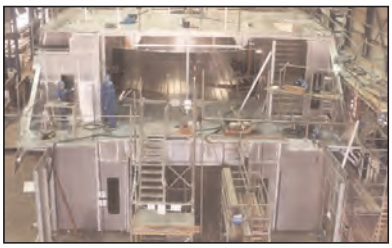

In a world of rapid changing technology, the education, training and professional development of a modern engineer will start at further or higher educational establishments but must continue throughout the engineer's professional career.

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Implications of common structural rules

David Tinsley examines some of the latest technical moves and newest tonnage on the bulk carrier scene. He starts with a report on the much-vaunted, common structural rules (CSR) for bulk carriers of at least 90m in length (also tankers of 150m length). They have now been adopted by the International Association of Classification Societies (IACS) and will be brought to bear on newbuildings contracted on or after April 1 this year.

THROUGH the formulation of a common ruleset to replace the individual requirements of IACS member societies, the fundamental objectives of the initiative have been to achieve more robust, safer ships and to obviate competition between all IACS societies on scantlings. Both single-side-skin and double-side-skin bulkers are covered by the CSR, which had been drawn-up by the Joint Bulker Project consortium of seven societies: Bureau Veritas, China Classification Society, Germanischer Lloyd, Korean Register, Class NK, Registro Italiano Navale, and the Russian Maritime Register of Shipping.

A key element of the new bulker rules has been the adoption of a net scantling approach, with corrosion additions expressed as an absolute number rather than as a percentage. Meanwhile, a common ruleset applicable to double-hull tankers of 150m and greater has been prepared in parallel by the three other IACS members (American Bureau of Shipping, Det Norske Veritas, and Lloyd's Register) and is also set to enter force at the beginning of April. Each society is incorporating both bulker and tanker CSRs into its rule book, and significant progress has reportedly been made towards the goal of full harmonisation of the two sets of rules within the next few years.

CSRs draw on the experience of all the IACS societies, and have been developed with an eye to IMO's Goal-Based Standards (GBS) philosophy, aimed at creating an overarching framework for future standards. For example, the incorporation of the 25-year North Atlantic fatigue-life criteria is based upon the indication from IMO that this standard will be adopted for the GBS. It is anticipated that the IACS common rules will dovetail with IMO's GBS targets, providing the detail necessary to bring those standards to fruition.

Expanding on the rationale behind the CSR project, and the IACS decision to change a very long established system, ABS observed that 'With the emergence of advanced structural and hydrodynamic computational methods, designers have been able to meet classification rule requirements while optimising scantlings based on accepted, alternative direct calculation methods.

'Many shipowners expressed concern that this optimisation process, based on these alternative methods, was leading to ships that, while fully conforming to class rules, were less robust in the past', added ABS. 'The new IACS common structural rules have used these same computational methods to establish new criteria, applied in a consistent manner, that not only will result in more robust, safer ships, but also eliminate the possibility of shipbuilders using scantlings and steel weight as a competitive element when selecting a class society to approve a new design'.

Although the new rules are aimed at stamping out scantlings-based competition, each society retains the right to develop its own common rule software or to forge alliances with other societies to share software. The commonality of results will be validated by a rigorous and comprehensive series of software comparisons and testing carried out by each society, according to ABS.

In addition to the change in the fundamental boundary condition that establishes a 25-year North Atlantic fatigue life, another particularly notable element of the common rules is the adoption of a direct calculation method and criterion for hull girder ultimate strength. The process entails examination of the hull girder strength for yielding, buckling, and progressive collapse modes, and effectively considers what it would take for the hull to fracture catastrophically. The consideration of dynamic loads at the initial design stage represents a change from the traditional, prescriptive rule-making approach of a number of societies.

Setting corrosion margins

Huge feedback from the industry in response to the first draft of the new rules has been taken on board to shape the final document. One difficult task was to set corrosion margins acceptable to both owners and yards. In the event, the corrosion addition was increased by 0.5mm/0.9mm. In combination with statistical analysis by the Joint Bulker Project team on the way different ship sections have corroded, the figure can be used to derive absolute thickness values at different locations, taking into account a two-and-a-half-year reserve to cover the period between intermediate and full surveys.

'Traditional rule making relied on prescriptively setting the gross scantlings of a vessel and then, on the basis of empirical experience, establishing an allowable percentage wastage distribution. This percentage approach was not able to differentiate between the differing corrosion rates experienced by different sections of the structure', explains ABS.

The net scantlings approach is based on the application of sound engineering principles to establish the criteria for the basic structure that satisfies the necessary strength requirements. Adding a corrosion margin in millimetres to the net scantlings produces the gross scantlings to which the ship must be built. The corrosion margin is derived from known data collected through many years of experience and analysis for such failure modes as fatigue and buckling.

'Importantly, the corrosion margins specified in the new rules reflect the different rates at which different areas of the ship corrode in service, since local areas corrode at rates that can vary widely from the average corrosion rate of the whole vessel', points out ABS. Although concerns have been raised in the industry regarding the wastage allowances so derived, the society suggests that the net scantlings approach is the more logical, scientifically based method of allocating steel to the areas where it is most needed.

Steel weight increases

Industry sources estimate that the change has meant that the steel weight for a standard bulk carrier has increased from 2.5% above that of IACS UR (unified rule) S25-compliant ships in the first draft, to 4% more in the final draft. Introduced following industry concerns about the robustness of bulkers, the S25 unified requirement typically increased the steelweight of a design by approximately 3%, and became mandatory for bulk carriers of at least 150m in length contracted on or after July 1, 2003. The steelweight effect of the new rules, therefore, could be as much as around 7%, by comparison with pre-S25 tonnage.

Sanoyas Hishino Meisho has recently completed *Kavo Alkyon*, the 33rd example of its 75,500dwt bulk carrier. This ship, seen here, is owned by Falcon Ventures, and classed with ABS. She has seven holds with a total cargo capacity (grain) of 89,250m³. Following soon will be the first examples of Sanoyas' new generation of environment-friendly super-Panamax designs with single skins. These were discussed in our June 2005 issue, page 34.

First of Trader series almost complete at Indian yard

Developed by GTR Campbell (GTRC), the renowned designer of standard dry cargo vessel types, the Trader class of Handysize, double-hull bulk carriers is currently contributing to the re-invigoration of Indian shipbuilding.

THE imminent delivery of the 30,000dwt *Bossclip Trader*, the first of six such vessels contracted by Denmark's Clipper Group from Cochin Shipyard, signals a new milestone for the industry in India. A further four Traders are in hand at the Visakhapatnam premises of Hindustan Shipyard, to the account of the Indian trading company Good Earth Maritime. The lead ship in that quartet is expected to be commissioned in June.

The Trader programme denotes India's market emergence as a serial producer of one of the most populous categories of mercantile tonnage, in a field dominated by players representing the eastern Asian shipbuilding powerhouses of Japan, South Korea, and China. A recent agreement by the UK-based Graig Group with Hindustan over the construction of Diamond Handymax bulkers has raised the Indian profile still further.

The Nassau-registered *Bossclip Trader* is destined for operation with Bossclip, a specialist in 'parcel' bulk services from Brazil to the US Gulf, and a partnership between Clipper and Rio de Janeiro-based BOSS. The subsequent vessels from Cochin are scheduled to be commissioned at five-month intervals.

Ships from the GTRC stable have a fine pedigree, and earlier examples have included the Handysize Clipper class (presented as *Clipper Fantasy* in *Significant Ships of 1996*) and the later Fortune Mk 2 and Valiant types (*Cinnamon* and *IVS Viscount* respectively, both in *Significant Ships of 2003*). *Bossclip Trader* is a true maid-of-all-work, conceived for efficient shipyard production and as a competitive, long-term trading unit. She offers a below-decks cargo capacity of some 40,000m³, complemented by a self-sustaining capability through an outfit of four 30tonne cranes. The type ensures a high degree of port and terminal accessibility by way of a length overall of 178.70m, beam of 28.00m, and fully-laden draught of 9.50m.

***Bossclip Trader*, first of the new series of six Trader-class bulk carriers, is seen here at Cochin's outfitting quay. A further four ships are on order at Hindustan Shipyard.**

***Bossclip Trader* is seen here in the building dock at Cochin Shipyard.**

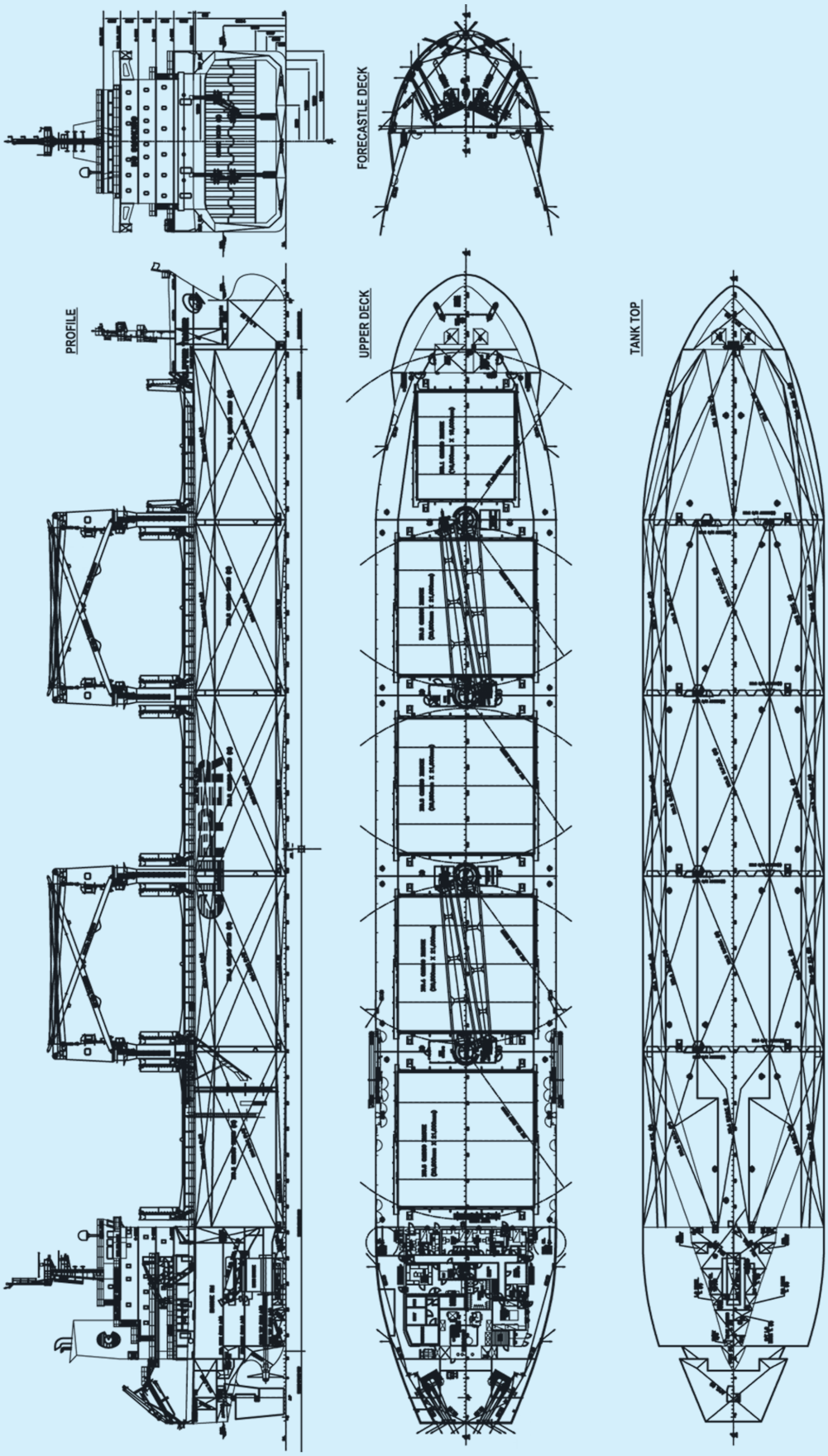
TECHNICAL PARTICULARS
BOSSCLIP TRADER

Length, oa	178.70m
Length, bp	170.00m
Breadth, moulded	28.00m
Depth, moulded	14.00m
Draught, design	9.50m
Deadweight, design draught	29,300dwt
Draught, scantling	9.70m
Deadweight, scantling draught	30,000dwt
Cargo hold volume	40,000m³
Deck cranes	4 x 30tonnes
Gross	approx 20,000gt
Main engine	MAN B&W 6S42MC
Output	6480kW
Speed, service speed	14.30knots
Endurance	15,500nm
Class	ABS +A1 (E) Bulk Carrier, AMS, ACCU, SH (SafeHull), SHCM (SafeHull Construction Monitoring) with description ESP and Strengthened for Carriage of Heavy Cargoes - No 2 & 4 holds may be empty

The Cochin deal includes options on seventh and eighth vessels, raising the prospect of a total of 12 newbuilds from India in total. Prior to the contracts at Cochin and Visakhapatnam, four Traders were entrusted by the Clipper Group to Shanhaiguan Shipyard in the China Shipbuilding Industry Corp (CSIC) group. A new wave of ordering by Clipper has seen firm contracts covering six Traders, plus four options, placed with Jiangsu Hantong Shipbuilding, the recently established Sino-Korean venture in China's Jiangsu province. At the time of writing, the design had thereby commanded 20 concrete orders and six options.

continued

General arrangement plans of the new 30,000dwt Trader class bulk carriers, the first of which, *Bossclip Trader*, is due for imminent delivery from the Cochin yard in India.



Developed by GTRC in conjunction with its associated, concept design firm Algoship Designers, of the Bahamas, the Trader is the outcome of a highly circumspect, commercially-attuned technical approach. It has been shaped not only by GTRC's longstanding experience in standard ship design and newbuild supervision, but also by extensive discussions with Clipper's chartering and operations departments and with Clipper's technical management contractor, Dockendale Shipping, which is also associated with GTRC. Dockendale and Clipper have become close business partners. Clipper handles the commercial management of Dockendale ships, and Dockendale oversees the technical husbandry of Clipper vessels, while GTRC provides design, technical consultation, and supervision for Clipper newbuild projects.

High-specification machinery and equipment incorporating safe margins have been nominated for the Trader class, including a six-cylinder MAN B&W S42MC Mk7 two-stroke main engine of 6480kW output, giving a service speed of 14.3knots. The 1300mm-wide double hull is said to give ample access for surveys and inspections, while the tar-free, light-coloured coating used for the ballast spaces assists with visual condition monitoring. The tin-free antifouling nominated for the design promises 60 months' coating life.

Occupying some 75% of the beam, the characteristic Algoship wide hatches and minimum underhang, along with large hold tanktop footprints, small side hoppers and square bulkhead stools, facilitate the cargo-handling process. The four sets of 30tonne cranes, incorporating radio-controlled grabs, enables the ship to work cargoes without requiring secondary cargo handling equipment such as forklifts and loaders in the holds. The arrangements favour reduced damage as well as faster handling and lower overall costs.

Practical advice for owners in new bulker guide

RECENT years' upsurge in market demand for bulk carrier tonnage and the attendant bonanza in ordering has meant that this sector has drawn in a number of shipyards and shipowners with limited experience in bulker construction. In addition, the emergence of new design concepts and features poses added technical challenges.

Against this backcloth, BIMCO's Marine Committee and the Piraeus-based Marine Technical Managers' Association (Martecma) have together developed a manual to assist users with reading and understanding a newbuilding specification, and aimed mainly at owners entering the sector or those who have hitherto tended to rely on secondhand purchases.

The outcome, the *Bulk Carrier Newbuilding Specification Guide**, is experience-rich, highly detailed, and replete with practical advice; it has been inspired by Intertanko's *Tanker Specification Awareness Guide*, published in 2003. Advice is offered on commercial considerations and the choices that have to be made between a vessel of more robust construction, designed for a longer life, or a more basic type of bulker, which could incur more expense and problems with age. Recommendations are included on the different forms of newbuilding contract, modifications and guarantees, and on the detailed matter of the specification.

The volume encompasses hull steel, material protection, cargo handling arrangements, hull outfit, ballast system, hull piping, accommodation, machinery, automation and instrumentation, electrical system, navigation equipment, communication equipment and alarm systems, and a makers' list.

Solid advice on contract wording and on the way of approaching issues relating to subsequent changes to the technical specification are intended to obviate unforeseen problems and costs. The guide's compilers note that the guarantee period for a bulk carrier is normally limited to one calendar year, but suggest that the guarantee term for the main components, such as the hull structure, should be extended to the first special survey at the fifth anniversary. Furthermore, it is felt that the ballast tank coating and cargo hold coating should be guaranteed for 15 years' life, in accordance with the IMO guidelines presently under consideration. 'This would be necessary to commit the shipbuilder to ensure that the standard and workmanship of the bulk carrier would be adequate and long-lasting', observe the authors.

The pragmatic nature of the content points to firsthand experience on the part of those who prepared the guide. For instance, owners are advised to be circumspect in the important matter of a makers' list, which often reflects a shipyard's cost-orientated preferences. 'Although all items of equipment arrive with class certificates, that does not necessarily warranty quality', reports the guide. It is essential to establish what tests and inspections support the certificates.

The guide continues: 'Anchors have been delivered to the shipyard with serious casting defects. Steering gear cylinder castings have been delivered with casting sand in the pores, contaminating the hydraulic oil and affecting the steering gear's operation, despite valid certificates'. In its examination of main machinery, the BIMCO-Martecma report team underlines the pressing need for owners to investigate the track record of the proposed engine model or type, in the interests of reliability, operating efficiency, and after-sales issues.

There is also the suggestion that 'A relatively new engine model but with a proven track record is preferable. A newly-developed model without service experience may hide design imperfections, which may need a long time to appear, and become costly to repair'.

* *Bulk Carrier Newbuilding Specification Guide*, published by BIMCO and Martecma, available from BIMCO, Bagsvaerdvej 161, DK-2880 Bagsvaerd, Denmark. Tel: +45 44 36 68 00. Fax: +45 44 36 68 68. E-mail: mailbox@bimco.org

Credo: new Baltic tonnage for ESL

ENSURING dependable and efficient bulk commodity transportation on a year-round basis in the tough environs of the Baltic Sea demands particular qualities as regards both ship design and ship operator. Finnish specialist ESL Shipping, which carried some 14 million tonnes of bulk materials for Baltic industry in 2005, has embarked on a fleet modernisation and development programme using an existing Japanese-built vessel of 19,625dwt as a particular point of reference. A prerequisite for the given area of trade is the highest Finnish-Swedish ice class, 1A Super.

Delivered in 2001 from Tsuneishi Shipbuilding's Tadotsu yard, ESL's *Eira* is said by the operator's parent group, Aspo, to have proved her worth in size and technology under 'very trying' winter conditions. The recently commissioned *Credo*, a geared vessel of 21,353dwt constructed in China by Shanghai Edward, together with two 18,800dwt bulkers newly contracted from India's internationally-ascendant ABG Shipyard, will enlarge what Aspo describes as the *Eira* class fleet to four. In practice, it is the synergies between the four vessels of similar size which makes for a 'class', since the various designs involved are distinct.

The latest order will help Aspo and ESL secure long-term competitiveness of the fleet, as regards both technology and unit costs. Set against the backcloth of a bullish shipbuilding market, the Indian tender was attractive as regards not only price but also delivery terms, with respective completions expected in May 2008 and February 2009.

Credo, the new entrant to the fleet, embodies the robustness, cargo handling versatility, compactness and manoeuvrability characteristic of the modern generation of Baltic trader, and is distinguished by the nature of her engineering arrangements including electronically-controlled, virtually smoke-free, two-stroke main machinery. She has been purpose-designed to suit the year-round needs of Baltic cargo generators, not least the Finnish steel sector, and is testament to the Chinese shipbuilding industry's growing capability to deliver non-standard, higher value-added tonnage to demanding overseas clients.

ESL/Donsötank's new 21,353dwt bulk carrier *Credo*, sailing from the Shanghai Edward yard in China. She has a most interesting technical specification to ensure efficient operation in the Baltic arena.

TECHNICAL PARTICULARS
CREDO

Length, oa	159.26m
Length, bp	151.90m
Breadth	24.60m
Depth, to upper deck	13.50m
Draught	9.40m
Deadweight	21,353dwt
No of holds	2
Cargo capacity	25,667m³
Deck cranes, on hook	3 x 37.5tonnes at 28m
Deck cranes, grab	3 x 30tonnes at 28m
Main engine	Diesel United-Sulzer 6RT-flex50
Output	9720kW

The newbuild project had been implemented in the immediate aftermath of the signing of a joint venture between Donsötank of Sweden and ESL Shipping. For the Finnish bulker exponent, the earlier sealing of a long-term transport partnership arrangement with steelmaker Rautaruukki had spurred the acquisition of additional, bespoke capacity. Following handover by Shanghai Edward in February 2006, *Credo* went into service on charter to ESL and under Donsötank management.

She is arranged with two holds, of 25,667m³ total capacity, accessed through very wide hatch openings and served by three deck cranes, fitted on high stools along the ship's port side. The MacGregor Hägglund cranes are rated for 37.5tonnes on the hook at an outreach of 28m, and each have a 30tonne lift capacity with a 12.5m³ grab at the same span.

This compact bulker provides a new, ice-going vessel reference for Wärtsilä RT-flex low-speed diesel engine technology. Paving the way to Chinese production of the RT-flex series (already under way at Dalian, as reported last month), the ship's six-cylinder Sulzer RT-flex50 prime mover was built by Japanese licensee Diesel United at Aioi, and shipped to the Shanghai yard for installation in *Credo*. The engine has a maximum continuous rating of 9720kW at 124rev/min.

The RT-flex plant was favoured on account of the raft of operational and environmental benefits the technology offers. Smoke-free performance, even at the lowest engine loads, was deemed particularly important for a ship intended to serve the Baltic market, while the flexibility conferred with regard to engine settings promised long-term economic advantages. Donsötank has a long relationship with Wärtsilä, and the Swedish company's previous newbuilding, the tanker *Evinco*, is powered by Wärtsilä main machinery incorporating common-rail technology.

In addition to the RT-flex50 prime mover, Wärtsilä has supplied three 20-series, 750kW Auxpac auxiliary engines in four-cylinder configuration, a Lips 5.5m-diameter CP propeller, Lipstronic decentralised pitch control system, and Flender PTO tunnel gear with an A Van Kaick shaft alternator. The 2000kW shaft generator does not incorporate a frequency converter, such that it will only be employed during normal operating conditions to cover the vessel's entire electrical power load while under way, or in special mode to feed the bow and stern thrusters.

The arrangements are relatively unusual, not least in the coupling of a low-speed engine with a CP, rather than FP propeller, and in a 1A Super ice class application using a shaft alternator in different operating modes.

The thruster outfit is from the Norwegian specialist Brunvoll, and comprises an 850kW retractable unit in the bow, and 670kW stern tunnel thruster, conferring the requisite side force for manoeuvring at terminals and in confined fairways.

The 18,800dwt sisters ordered at ABG in India will be slightly shorter, but beamier than *Credo*, by virtue of a length of 155.40m and breadth of 25.20m, and will draw slightly less, at 9.00m, when 'full and down'. As with *Eira*, these bulkers will have an ice bow instead of a bulb.

Umiak-1: a new Canadian Arctic bulk carrier

CANADIAN operator Fednav is re-investing in its capacity to lift cargoes from difficult northern climes, with an April 2006 handover anticipated for a 31,500dwt icebreaking newbuilding under construction at Universal Shipbuilding's Maizuru yard in Japan. *Umiak-1* will be managed and operated by Canship Ugland, of St John's, Newfoundland.

This project is intended to serve a long-term contract covering the bulk transportation of nickel concentrates from northern Labrador to the St Lawrence River. The concentrates, deriving from Inco's new Can$3 billion Voisey's Bay Nickel Co mine, will be loaded out of Edward's Cove, for the 1100nm passage to Quebec City, from where trans-shipment will be made to rail for deliveries to smelters in Ontario and Manitoba.

Classed by Det Norske Veritas, the vessel will have five holds encased by a double hull, providing a total enclosed volume of 30,218m^3. Cargo handling self-sufficiency will be conferred by an outfit of three deck cranes, two of which will lift 30tonnes at an outreach of 25m, while the third will be rated for 50tonnes at 25m. The ship has been designed not only to carry nickel concentrates, but also re-supply cargoes for the mine project, including fuel oil. All shipments of concentrates and related services will be made in accordance with the project-related agreements between Voisey's Bay Nickel and the government of Newfoundland and Labrador, also the Labrador Inuit Association and Innu Nation.

TECHNICAL PARTICULARS
UMIAK-1

Length, oa	188.80m
Breadth	26.60m
Depth	15.70m
Draught	11.50m
No of holds	5
Cargo capacity	30,218m^3
Deadweight, summer	31,500dwt
Gross	22,600gt
Net	9400nt
Deck cranes	2 x 30tonne; 1 x 50tonne
Main engine	Hitachi-MAN B&W 7S70ME-C
Output	21,770kW at 91rev/min
Open-water speed, laden	13.50knots
Class	Det Norske Veritas +1A1 Bulk Carrier, ESP-ES(D), BC-A, Nos 1 and 4 or No 3 Hold may be empty, ECO, dk(+), ha(+), ib(+), T-MON, INERT, Nauticus(Newbuild)
Ice strengthening	DNV ICE-15 DAT (-30°C)

Although Voisey's Bay is located just south of the 60degN parallel, outside the Arctic Circle, winter ice conditions are more demanding than those in many high Arctic areas. On her regular run down the Labrador coast, *Umiak-1* will have to contend with some of the world's most rugged ice conditions, including icebergs, from November to July of each year. The 50km channel to the Edward's Cove loading terminal passes through a maze of islands, and has a five-month 'open' season. In addition to the subsequent ice build-up seawards, ice originating further north is driven southwards by the Labrador current, creating particular challenges to navigation.

Umiak-1 will be larger and more powerful than Fednav's 1978-built, 28,400dwt *Arctic*, and will incorporate many design and operating features derived from experience with the existing ship's winter voyages to the Raglan mine in northern Quebec state. Besides an icebreaking bow, and bow wash system to help reduce friction in ice, the new bulk carrier will have a V-shaped stern and ice knife to protect the rudder. Canadian technical expertise will also be applied to the ship in the shape of a state-of-the-art navigation system developed by Fednav's associated company Enfotec.

This Canadian bulker provides a milestone reference for electronically-controlled, two-stroke diesel propulsion machinery in an ice navigation environment. She will be fitted with a seven-cylinder model of the MAN B&W-designed S70ME-C engine, delivering 21,770kW, running at just 91rev/min and driving a CP propeller surrounded by a duct. While the open-water speed in a laden condition will be 13.50knots, the new bulker will be capable of making 3knots in level first-year ice of 1.5m thickness.

The ME concept was adopted by Fednav out of consideration of the vessel's demanding and mixed operating profile, calling for a broad range of operating modes, including ice ramming, slow steaming and open-water service, entailing both high load and low load scenarios. The electronically-controlled engine promises the requisite degree of flexibility and performance, with attendant, overall operating economy. The engine thrust bearing structure - a new patent design - has been optimised to meet the criteria for DNV's Polar 15 class. As reported in our special supplement *Marine Power and Propulsion: Solutions for Naval Architects* (October 2005), *Umiak-1* will also be the first ship to feature a new MAN B&W integrated exhaust gas bypass system for the turbocharger, designed for extremely cold Arctic conditions. This avoids too high scavenge air pressures as a result of too high air density.

It is understood that Inco's long-term plan is to process Voisey's Bay concentrates at Argentia, near St John's, where a new refining plant is foreseen. This points to a switch of unloading port for *Umiak-1* by 2013 at the latest, entailing voyages via the east coast of Newfoundland to Argentia rather than through the Strait of Belle Isle and up the St Lawrence river. Fednav's new asset, though, has been designed with the flexibility to offer competitive use in general international bulk trade, notwithstanding her special ice-going capabilities.

The company's present, and pioneering, icebreaking bulker *Arctic* was built on home ground, at the Port Weller yard in Ontario, and has hauled lead, zinc, and nickel concentrates from Canada's northernmost mines for many years. Compared with the 22.90m beam of Arctic, *Umiak-1* has a breadth of 26.60m, which precludes transits of the St Lawrence Seaway system.

Special ice navigation software

All ships working from the base metal mines north of 60degN in Canada utilise Enfotec Technical Services' IceNav system, which has been selected for *Umiak-1*. Using IceNav, for which Fednav's *Arctic* had provided a developmental platform, mariners can reliably receive clear, accurate, and up-to-date ice chart and satellite imagery to assist in navigation.

The main constituents of the system are the IceNav Navigation Module and the Marine Radar Module, operating on a single PC with displays on separate screens. The two modules are completely integrated with all route plans created on one module and displayed on the other. An additional, more recently developed component of the Marine Radar Module is the IceNav Hazard Detection Module, specifically designed for ships that routinely navigate in high concentrations of first-year ice where old ice and embedded icebergs and 'bergy-bits' are a hazard.

LETTER TO THE EDITOR

Deadweight or displacement?

Sir - In the January 2006 issue of *The Naval Architect* (page 11), Douglas Brown made comment about my use of deadweight tonnage instead of displacement. This referred to an article that I had written earlier for this journal on interaction effects between two vessels passing in a river.

I agree with him. When dealing with the physics of interaction, it is indeed better to use the actual displacements recorded at the time and day of the passing manoeuvre. However, I used the summer deadweight tonnage for both ships, each one merely as a size indicator for the vessels under consideration.

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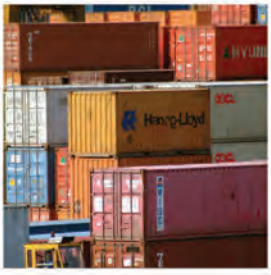

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Integrated propeller, bulb, and rudder from Rolls-Royce

IN November 1998, we reported on a novel propulsion-improvement concept, the Propac rudder, launched by the Wärtsilä group, which featured a faired bulb behind the propeller which continued into the rudder. Now competitor Rolls-Royce has designed a somewhat similar system following several years of R&D study into interactions between hull, propeller, and rudder. This interesting new arrangement is initially being promoted for single-screw vessels operating at speeds up to 17knots.

The technology comprises a combination of bulb, hubcap, and twisted rudder to smooth the flow of water from the propeller as it passes over the rudder, thus improving propulsive efficiency and reducing fuel consumption. A tapered cap is fitted to the hub of the propeller, and this leads the water flow on to a bulb which forms part of the spade rudder. Bulbs on rudders have been used occasionally for many years, the most well-known design being the Costa bulb, while the twisted rudder has been successfully exploited by the German manufacturer Becker Marine Systems.

Energy in propeller slipstream swirl is often lost in conventional propulsion systems, but by twisting the leading edge of the rudder, the rudder forms a cambered hydrofoil profile, enabling some of the swirl energy to be converted into additional forward thrust, which in turn helps to propel the vessel. The difference from earlier concepts in the Rolls-Royce solution is claimed to be integration of propeller, bulb and rudder.

The design brief stipulated that the bulb, hubcap and twisted rudder system should work efficiently, not only with the rudder set straight ahead but also during normal course corrections, which involve typical rudder angles of between 1deg and 4deg, as well as when the rudder is put hard over during low-speed manoeuvring.

Manoeuvrability should be improved across the speed range, says Rolls-Royce, primarily because the twisted rudder delays flow separation for a given speed and helm angle, and creates a higher side force (approximately 15% increase) during low-speed manoeuvring.

With this new system, pressure pulses from the propeller can also be reduced. Because of the presence of the hubcap and bulb, the risk of hub vortex cavitation is removed. Consequently, the radial distribution of hydrodynamic loads on the propeller blades can be modified, increasing the loading in towards the hub and reducing tip loading, which helps to cut the intensity of blade pressure pulses.

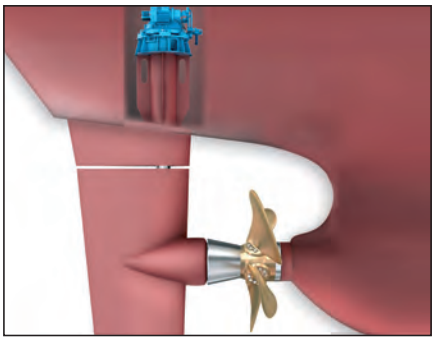
Design calculations have been verified in the Rolls-Royce Hydrodynamic Research Centre cavitation tank in Sweden. In particular, interactions between the hubcap and the curved leading edge of the bulb have been studied at different loading conditions and rudder angles.

In theory, the gap between the hubcap and the bulb's forward part should be as small as possible. In practice, there has to be a gap sufficient to allow for structural deflection under load of the propeller aperture and rudder; also, the steelwork has to cope with the tolerances that can be realistically achieved under shipbuilding conditions.

Savings in fuel consumption can be considerable, claims Rolls-Royce. Göran Pettersson, project leader, says that for a typical merchant ship hull operating at up to 17knots, improvements in efficiency of approximately between 3% and 6% should be possible, giving a payback time of one to two years.

In due course, the company hopes to offer the system for faster vessels, up to around 21knots. The percentage efficiency improvement for faster twin-screw vessels will be smaller, but still significant. These vessels typically burn much more fuel in the course of a year and a payback time of around two years is expected, depending on the hull design and operating profile.

An impression of the new Rolls-Royce integrated propeller and rudder system, which is expected to offer efficiency improvements of between 3% and 6% for a merchant ship sailing at speeds up to 17knots.



Shaft generator selection for two-stroke engines

At times such as the present, when fuel prices are very high, attention often turns to devices that save costs. An informative publication*, newly published by the Copenhagen division of MAN B&W Diesel, has arrived at the perfect time; it explains in detail the benefits and disadvantages of various types of alternator arrangement that can be driven by a two-stroke propulsion engine at the same time as the propeller.

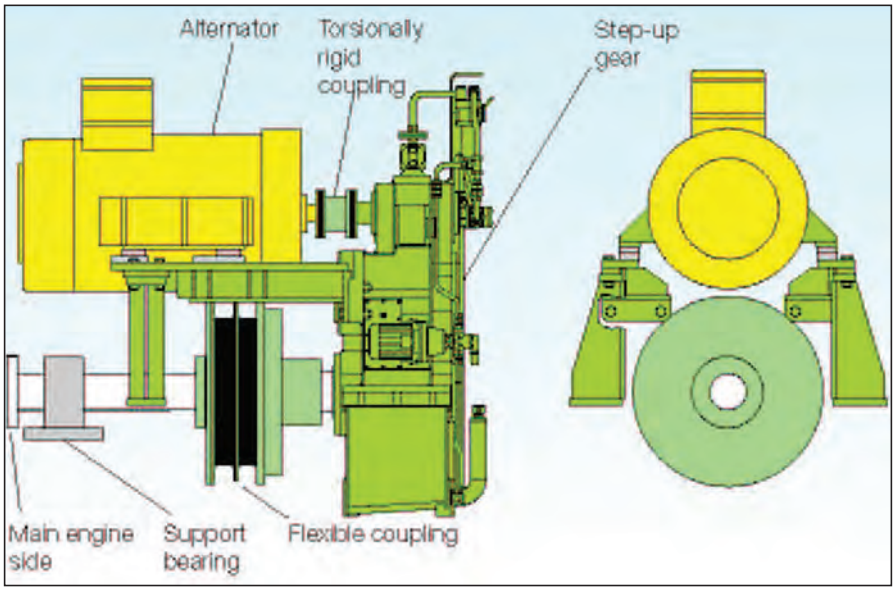
THE technique of main-engine-driven electrical alternators is, of course, not new, and a great many medium-speed four-stroke plants take advantage of a reduction gearbox to build-in a power-take-off shaft for alternator drive. On two-stroke engines, turning at slower and sometimes variable speeds, the concept is not so common but useful economies can be made. In many case, however, naval architects must pay careful attention to machinery space dimensions and layouts.

Depending on the version chosen, an alternator can be mounted directly on the engine or on the tanktop. Although there are one or two exclusive systems, such as the Renk RCF design, most leading gearbox manufacturers can normally provide the necessary gearing. Actually, it is possible to avoid a gearbox altogether by specifying an alternator mounted directly on the front end of the crankshaft, but this solution is rarely used owing to the number of accessories needed (mounting an alternator directly on the propeller shaft is another possibility used by some owners).

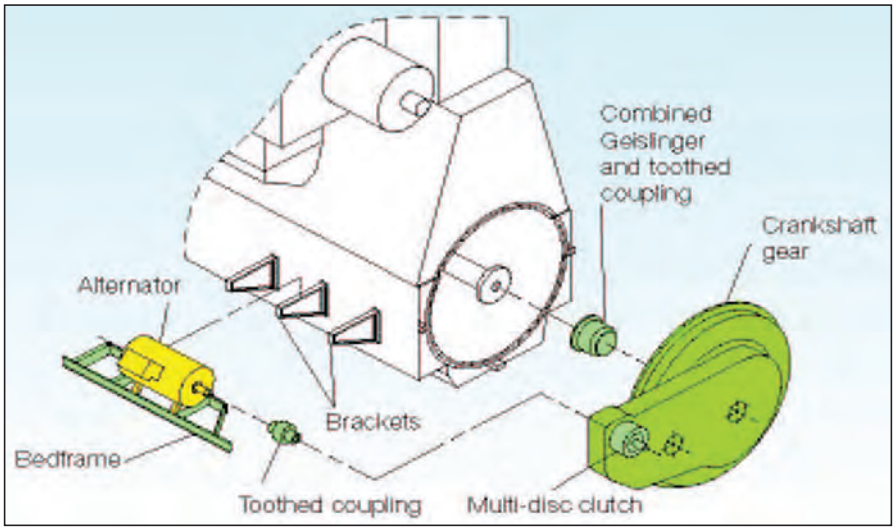
MAN B&W first started investigating main-engine-driven alternators in the early 1980s following the launch of its MC series, and several standard arrangements were designed, which subsequently became quite popular. The principal reason for this was because, at that time, most gensets were unable to burn heavy fuel (which was even higher-priced then), so significant cost savings could be achieved. Today, of course, most auxiliary diesel engines operate reliably on heavy fuel. Despite this, several owners of container ships, product tankers, and shuttle tankers consider a shaft generator to be a worthwhile investment.

Many layout options are possible but MAN B&W believes that there are three basic versions:

- power take-off with a constant-ratio gear, consisting of a flexible coupling, step-up gear, torsionally rigid coupling, and alternator
- power take-off with the Renk constant-frequency (RCF) gear consisting of a flexible coupling, step-up gear, torsionally rigid couplings, RCF gearbox, and alternator (Renk is a member of the MAN B&W group)
- power take-off, constant-frequency electrical arrangement, consisting of flexible coupling, step-up gear, torsionally rigid coupling, alternator, and electrical control equipment, alternatively a slow running alternator with electrical control equipment.



Layout of a space-optimised solution, with the alternator placed horizontally between the step-up gearbox (from A Friedrich Flender) and the front end of the two-stroke engine. This utilises the space that would have to taken up in any case by the flexible coupling.



An example of a side-mounted alternator, featuring a Geislinger coupling, Renk gearbox bolted directly to the engine front-end face, a multi-disc clutch, and toothed coupling. This arrangement is MAN B&W's preferred standard, since it is compact and allows easy shipyard installation.

Power take-off with constant-ratio gear

This is the simplest arrangement, since no speed or frequency control systems are incorporated; in most cases, electric power is generated at constant electrical frequency. However, since this frequency is proportional to engine speed, the engine must run at constant speed, which is normally only possible with a CP propeller. Total efficiency is around 92%.

Such a system is unable to run in parallel with auxiliary gensets for long periods, owing to the small engine speed variations that occur even in a constant-speed main engine. Consequently, gensets are normally shut down at sea when such a system is operating. However, during manoeuvring, when engine speed is reduced, the alternator can be used as a separate source to supply a bow thruster.

Investment costs are less than alternatives but the extra cost of a CP propeller must be taken into account. An engine running at constant speed also reduces propeller efficiency at reduced propulsion load when compared with a CP propeller running in combinator mode (reduced speed at reduced propulsion load) or an FP propeller.

Power take-off with a Renk constant-frequency (RCF) drive

This system, designed and built exclusively by Renk, includes a multi-disc clutch, a speed-

* *Shaft Generators for the MC and ME Engines*, published by MAN B&W Diesel, Copenhagen, Denmark. February 2006.

controlled planetary/epicyclic gearbox with a hydrostatic 'superposition' drive - a hydrostatic motor controlled by electronics and driven by a built-on pump. In a standard layout, the constant output speed range of the gearbox is set between 100% and 70% of the engine speed at specified MCR.

An electronic control system ensures that signals to the switchboard are identical to those of the gensets, and thus such a system can operate alone or in parallel with gensets throughout the complete constant-output speed range of the gearbox. Therefore, this solution can operate with a FP propeller. Total efficiency varies between 88% and 91%.

Power take-off with constant-frequency electrics

The most practical arrangement for this mode is with a slow-running alternator coupled directly to the free end of an engine or installed with the rotor integrated into an intermediate shaft. Slow-running alternators are much larger than high-speed versions but in return no flexible coupling or step-up gear is needed.

However, extra electrical equipment is required to provide thyristor control of frequency. This arrangement can operate in parallel with gensets at full rated electric power when the main engine speed is between 75% and 100% of specified MCR output. Total efficiency is lower than other alternatives, at between 84% and 88%.

Side mounting: the best?

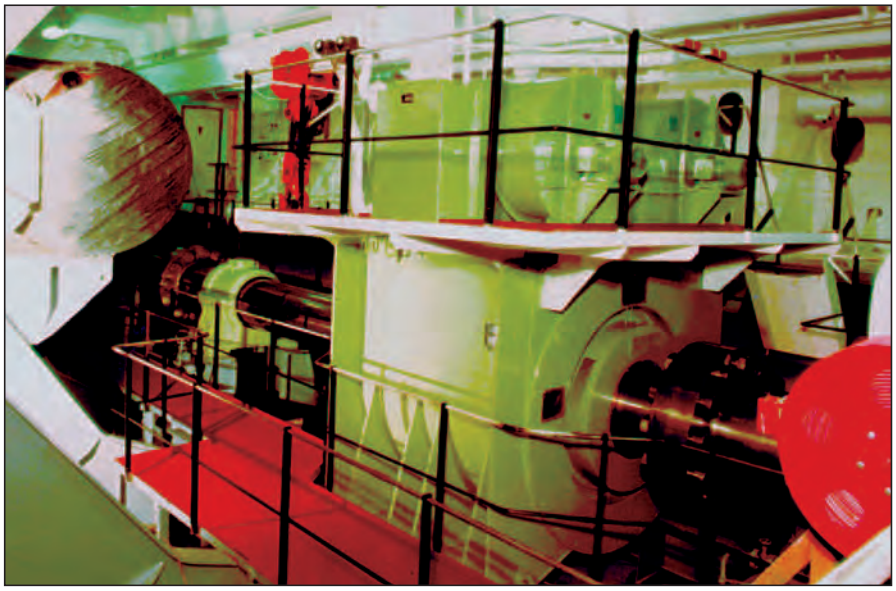
As mentioned, and depending on the system eventually chosen, an alternator can be mounted on the engine itself or on the tanktop. Apart from the front of the main engine, other positioning possibilities include side mounting or, by using a tunnel gear, on the propeller shaft. The investment cost of a side-mounted solution is, says MAN B&W, typically higher than alternatives but has been adopted by the company as its standard since it is compact, allowing a shorter engineroom and easy installation by a shipyard.

A standard gearbox design for side-mounting, from Renk only, is available for MAN B&W 42MC engines and larger models, including for ME electronic versions. Standard alternator outputs are 700kW, 1200kW, 1800kW, and 2600kW, but others are possible. The necessary step-up gear is bolted directly to the engine front-end face, and a Geislinger elastic damper coupling is included in the package. A multi-disc clutch can also be fitted so that the alternator can be disengaged.

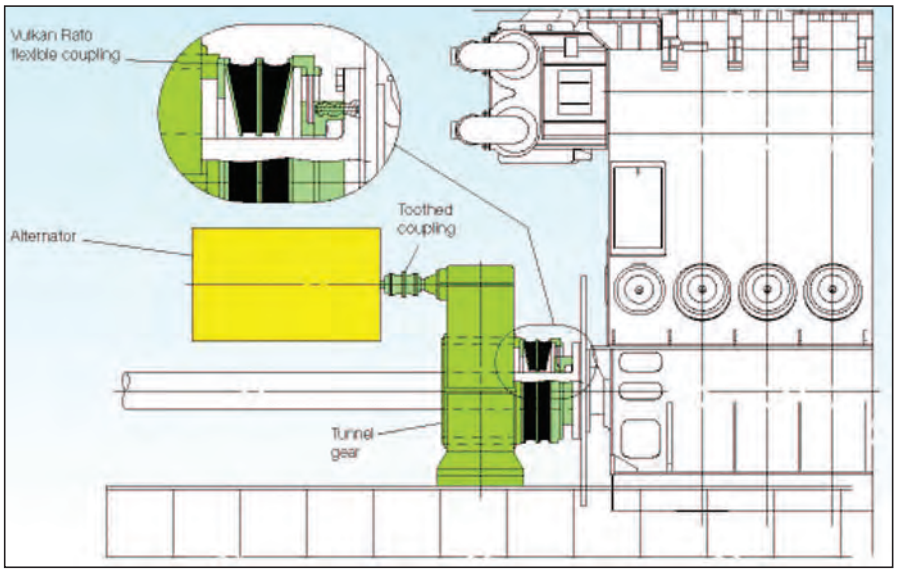
Tunnel-gear solution

A number of gearbox manufacturers can supply a tunnel gear, although if the RCF electric concept is being considered, this must come from Renk. Such a system can often be installed with

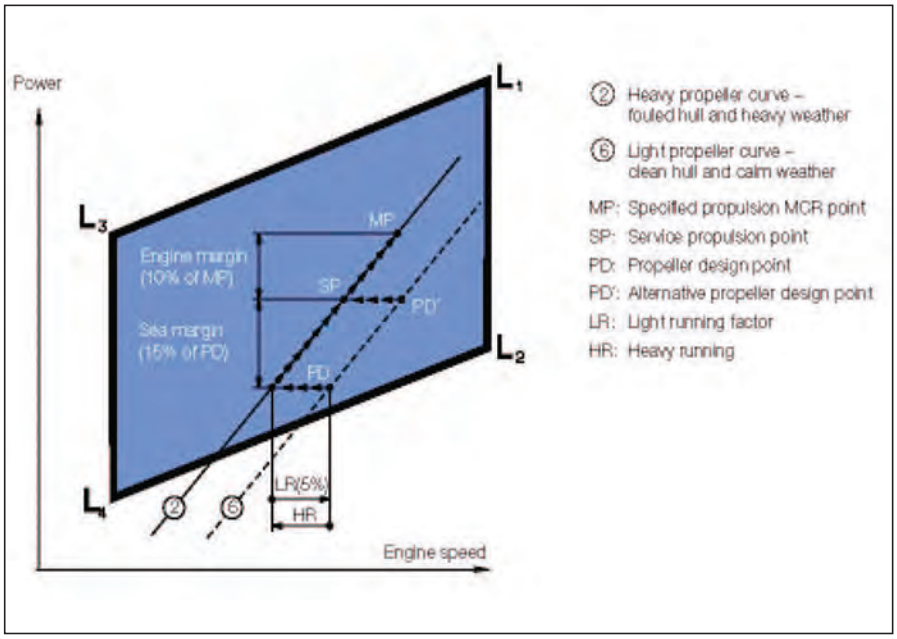
Naval architects and engineers need to make careful propulsion calculations if a shaft-driven alternator is being specified. In most cases, as shown here, the specified MCR (SMCR) output of an engine fitted with an alternator is found by adding the maximum power consumed by the shaft generator to the specified MCR point.



An installation with an AEG alternator integrated on the intermediate propeller shaft. The shipyard needs to provide a foundation for the stator housing.



A typical tunnel-gear installation on the propeller shaft for alternator drive, and featuring a Vulkan Rato flexible coupling.



already-available space around the shaftline, without increasing total length. No preparations on the engine itself are need for such a system but the intermediate propeller shaft flange must have additional bolt holes for the necessary flexible coupling. In a more complex arrangement, the alternator can be designed to additionally act as an auxiliary propulsion motor, a solution sometimes chosen by operators of chemical and gas tankers.

Another possibility is to mount the alternator with its rotor integrated into the propeller shaft itself. This has a lower price tag than a tunnel gear and is more straightforward. Additionally, manufacturers can offer PWM (pulse width modulated) technology to allow the inverter to produce both the active and reactive electrical power, thus eliminating the need for a synchronous condenser; this makes for a simpler installation overall.

Careful calculations necessary

Apart from taking care of the physical requirements of a main-engine-driven alternator installation, naval architects and engineers must be very careful to analyse the resulting effect on power and speed. Calculations may reveal that an extra engine cylinder is required to ensure that the specified MCR (SMCR) point is placed inside the top of the layout diagram. This will entail extra costs and more space but to avoid this, it is possible to restrict load on the shaft alternator when the engine is operated close to the SMCR point. Careful investigation must also be made into torsional vibrations, especially with alternators producing large outputs, such as on shuttle tankers.

Advantages and disadvantages

Benefits of a shaft-generator system on a two-stroke engine can be summarised as: small space requirement, lower investment cost, low installation cost, reliability, low manhour costs for maintenance, low spare parts costs, long lifespan, and low noise levels (considerably less than a genset, unless the latter is in an acoustic enclosure). On the other hand, disadvantages can include: no electrical power in harbour - unless a clutch is included to disengage the propeller (such as on Arco's Millennium class tankers discussed in *The Naval Architect* March 1999, page 17), higher main engine load and higher fuel consumption, reduced propeller and engine efficiency at low outputs for some versions, no longtime parallel running for some versions, and a more complex shaft arrangement.

On a reference basis, figures reveal that most MAN B&W two-stroke engines are at present, specified without a shaft generator, although approximately 317 references have been logged. This is, believes the company, because many owners and yards prefer a simple engineroom arrangement featuring a number of gensets, supported by low prices, heavy-fuel capability, and improved reliability. Nevertheless, where surplus capacity is available at the main engine, a shaft-driven alternator remains a viable alternative. In the light of a return to very high fuel prices, maybe owners will re-examine the benefits.

Low-CO_2/negligible-NOx engine planned in Japan

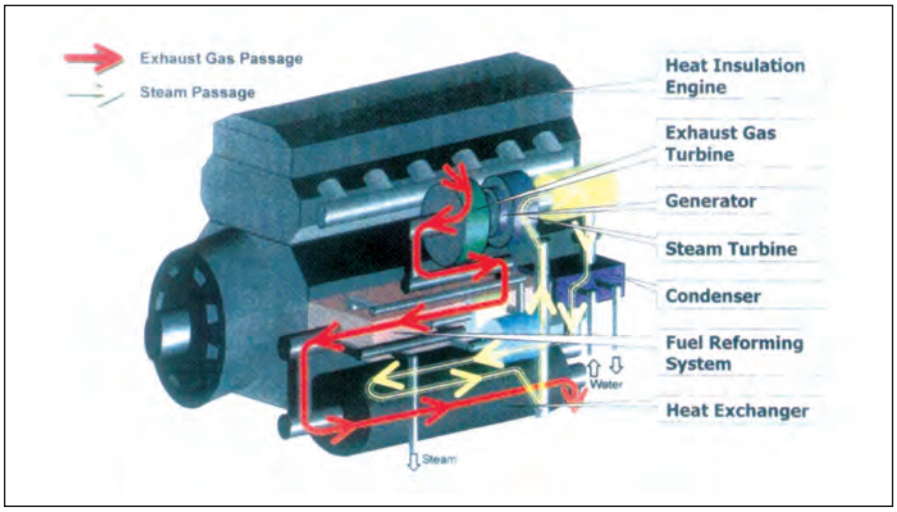
SINCE fiscal year 1998, Japan's Ship & Ocean Foundation (SOF) has been developing a so-called heat-insulation engine, which aims to reduce CO_2 emissions to one-third of present engine levels, while all but eliminating NOx and particulate emissions in the exhaust gas. In addition, the targeted thermal efficiency of the engine is 70% - well above current levels.

With strict emissions level controls already in place for land-based industrial and commercial installations of all types, it is clear that similar low-emissions levels will be demanded offshore Japan, in the future. Traffic in the Inland Sea areas around the Japanese archipelago is considerable, with a large number of coastal and short-sea vessels operating, and the need for low-emissions engines in replacement vessels is a pressing matter for engine designers and builders.

It is against this background that the SOF has been developing a natural-gas-burning engine using heat insulation and an exhaust-gas reformer to provide high thermal efficiency and low exhaust-gas emissions. Initial development work on the prototype engine itself is complete, with progress towards a new type of turbo-generator, which will be part of the engine system, now under way. Following that, and to complete the total package, will be design of the fuel-reforming components.

At the heart of the concept is a combustion chamber enclosed by heat-resistant Incolloy 903. This material is used as a cylinder head liner, and on the piston crown. It is also used for the control valve cage, which incorporates the fuel injector and a pre-combustion chamber. Reformed natural gas is used as the fuel.

With the high degree of heat insulation around the combustion chamber, high-temperature exhaust gas is available for steam generating purposes and for the fuel reformer. A degree of exhaust-gas recirculation (EGR) is also used to provide so-called homogeneous-charge compression-ignition (HCCI) combustion - and thus a reduction in NOx emissions.



Exterior of the planned engine, showing the two turbines driven by exhaust gas and steam, also the fuel-reforming unit.

A CO_2 separator absorbs that gas in the exhaust stream and then releases it to supply the fuel-reforming unit. Exhaust gas leaving the cylinder first passes through an exhaust-gas turbine, to drive an electrical generator, then into the fuel reformer, and finally to a heat exchanger for steam-generation purposes. This steam is led to a small turbine, also driving the electrical generator.

The combination of an exhaust-gas turbine and a steam turbine driving the electrical generator raises the thermal efficiency of the engine to around the planned 70%. The fuel-reforming device includes a catalytic agent and adds heat from the high-temperature exhaust gas, to the fuel, so effectively raising its calorific value.

A prototype single-cylinder engine has a cylinder bore of 132.9mm and a piston stroke of 145.0mm, while the speed is 1500rev/min. Alongside the design of this engine, a six-cylinder version is also under development. While the goals of this advanced engine are highly laudable, it is to be hoped that more practical commercial value will be realised from this project than from some other recent sponsored by Japanese government organisations.

Turbochargers - meeting the emissions challenge

New, innovative products developed by ABB Turbo Systems support engine builders' and end-users' efforts to comply with stricter ship emissions regulations.

Insertion of a compressor wheel in ABB's largest and most powerful turbocharger, the TPL91-B.

REGULATORY shifts in the diesel and gas engine market are a key factor in turbocharger development. One such shift with major implications for diesel engine manufacturers and their suppliers was the 2005 enactment by IMO of exhaust-emission regulations for the marine industry. These and other legislation in the pipeline puts the onus on engine builders and turbocharger manufacturers to develop technologies that will enable ship operators to meet new limits for the main exhaust compounds.

Rules for a 'greener' environment

Shipping's important role in the new global economy comes with an environmental responsibility that the marine industry is meeting with strict new international regulations, such as IMO's MARPOL Annex VI and, in the USA, EPA Tier 2, which sets even lower NOx and particulate matter (PM) limits.

EU standards for inland waterway vessel emissions due to be implemented in 2006 will be in line with EPA Tier 2. There are also plans by the EU to propose by the end of 2006 the tougher Tier 2 NOx limits for engines on ocean-going ships, should the Annex VI limits remain unchanged.

Voluntary programmes

Ship operators also have to take account of voluntary regimes. These, like the 'Blue Sky' limits in the USA, may go much further or apply earlier than IMO regulations. Media scrutiny of a shipping line's efforts to comply with these can be a strong inducement to operators to invest in environmentally friendlier equipment.

Other inducements driving emissions compliance can be differentiated port dues and tonnage taxes. Several countries and harbours around the world have introduced these in recent years.

Advanced engines introduce new technologies

All the major engine builders have introduced or are introducing environment-friendly products, such as electronically controlled engines, to the market. While technologies such as Miller valve timing already allow compliance with current IMO NOx limits, innovative solutions are required if plans to lower significantly the limit are to be realised sometime in the near future. The turbocharging system is a key factor here, since it has considerable potential in several areas important for NOx reduction.

Turbochargers' 'green' contribution

Higher turbocharger efficiencies are recognized as a factor in reducing engine CO_2 emissions, but the marine industry is wakening up to the fact that soot emissions can also be controlled by combining the turbocharger with a 'smart' system that ensures an optimised air-to-fuel ratio.

One way to reduce smoke emissions is to improve the cylinder filling at low loads, for example, through variable inlet-valve closing and variable turbine geometry (VTG) or, alternatively, by means of a bypass connection from the turbocharger compressor to the turbine. Both the VTG and the bypass solution involve switching to higher boost levels during low-load operation.

Change-over to gas engines is another of the marine industry's options for reducing emissions. Here, too, turbochargers with VTG play an important role by allowing precise control of the air-to-fuel ratio without any loss of efficiency.

The best NOx reduction results are achieved by the engine builder and turbocharger manufacturer working together to reduce the temperature in the cylinders, for example, by means of Miller timing. The bottom line, however, is that a very high boost pressure is needed. Controlled two-stage turbocharging is a possible solution here.

New-generation turbochargers

Based on analyses of the future diesel and gas engine market, ABB began, in the 1990s, to develop a new generation of more compact high-performance turbochargers as successors to its VTR, VTC, and RR series.

Over the following decade, new-generation ABB turbochargers were successively introduced to the market under two new product names: TPS and TPL. Ongoing evolution of these two families has meanwhile produced a range of turbochargers designed specifically for the new diesel and gas engines entering today's more environmentally conscious market.

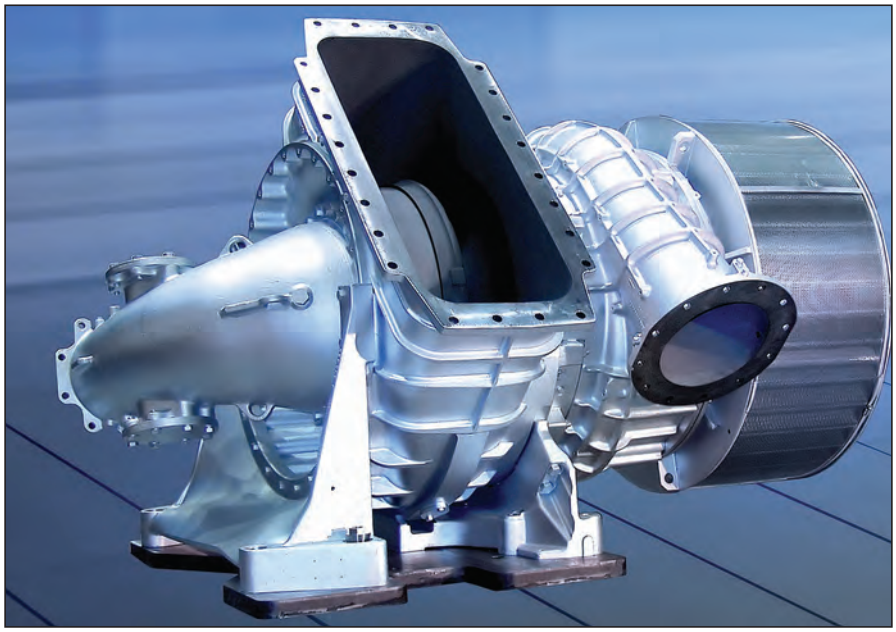
High-pressure turbocharging of four-stroke engines

For small medium-speed and large high-speed four-stroke diesel engines and gas engines in the 500kW to 3300kW power range, ABB has developed the TPS..-F series. The efficiencies also the full-load pressure ratios (up to 5.2 – ie, that the air leaving the turbocharger has 5.2 times the pressure that it had on entering) of these turbochargers allow engine builders to raise brake mean effective pressure (bmep) and to reduce fuel consumption, while also lowering emissions, eg, with the Miller cycle. A VTG version of the TPS..-F is also available, as is a version with bypass connection.

ABB also recently introduced its TPL..-C turbocharger for advanced medium-speed four-stroke diesel engines and gas engines in the 3MW-20MW power range. The compressors developed for this new series allow significant increases in efficiency, maximum pressure ratio, and specific swallowing capacity. Pressure ratios of 5.0 and 5.2, the latter being achieved with optional compressor cooling, support Miller timing on most new types of engine.

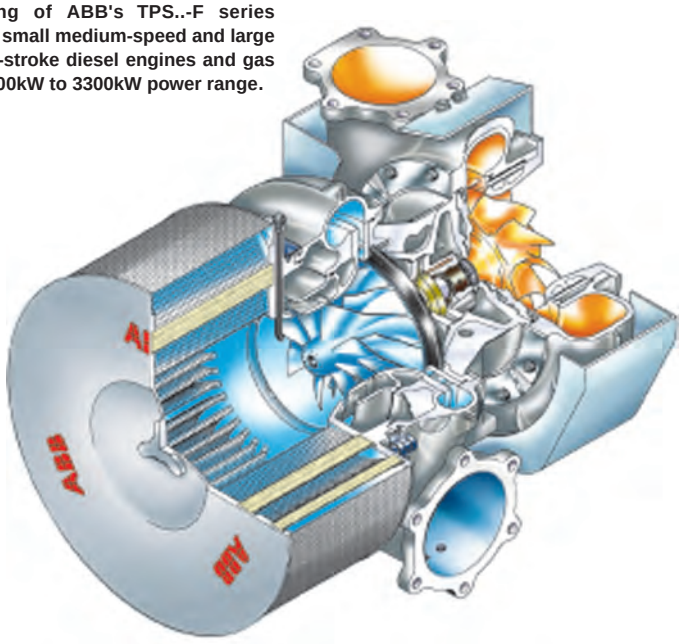
Two-stroke considerations

Based on the proven TPL platform, ABB's TPL..-B turbochargers for two-stroke diesel engines are also designed to meet the



An example of the TPL76-C turbocharger, developed by ABB for advanced medium-speed, four-stroke diesel engines and gas turbines.

Cutaway drawing of ABB's TPS..-F series turbocharger for small medium-speed and large high-speed, four-stroke diesel engines and gas turbines in the 500kW to 3300kW power range.



emissions compliance requirements of engine builders and end-users. Here, the traditional role of the turbocharger as a fuel-saver comes especially to the fore. Full-load compressor pressure ratios of up to 4.25 and high turbocharger efficiency are important factors in lowering greenhouse-gas and PM emissions.

ABB power turbine

Since SOx and PM emissions depend not only on sulphur and ash content of the marine engine fuel but also on consumption, every improvement in fuel economy benefits the environment. TPL..-B turbochargers are so efficient that 'surplus' exhaust gas from a ship's main diesel engine can be diverted to a so-called power turbine, which uses it to produce energy for different on-board applications. Designed to work with waste heat recovery systems for new ships, ABB power turbines, denoted PTL, cut total fuel consumption by as much as 10%, depending on the system configuration. This is believed to be the only technology commercially available today which, since there is no trade-off, reduces fuel consumption and cuts exhaust emissions at the same time.

The power turbine's energy can be utilised either directly to produce electrical power for a maximum fuel-saving of 4%, or in a steam cycle for fuel savings of up to 10%. The stand-alone, exhaust-gas configuration allows a more flexible supply of energy to generators or to the shaft motor, while the steam cycle arrangement has major revenue benefits for marine vessels with engines rated at 20MW and more.

'Green' development priorities

Today, engine development engineers have to give due consideration to environmental regulations that go well beyond those currently in force. Roadmaps for the next five years or so give absolute priority to emissions compliance, without any concessions to industry demand for higher efficiency and more power output. ABB Turbo Systems' development priorities are fully aligned with these goals.

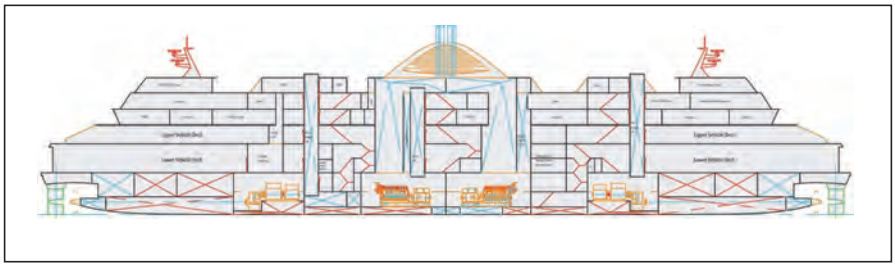
This article is an edited version of the article 'Meeting the emissions challenge', published in *Turbo Magazine*, 1/2006, published by ABB Turbo Systems Ltd, Baden, Switzerland.

MaK engines for BC Ferries' Super C-class double-enders

ONE of the most interesting marine projects currently proceeding in Europe is that at Flensburger Schiffbau-Gesellschaft, in Germany, to build a trio of large double-ended ferries for BC Ferries, from Vancouver, Canada. Flensburger took on a fixed-price contract, which includes delivery to the Canadian west coast, plus penalties if the ferries fall more than one-tenth of a knot below their 21knot service speed. The first ferry should be delivered in December 2007 and the last in June 2008.

The machinery specification for these Super C-class ships is equally interesting, being of the diesel-electric power-station concept, with engines, motors, and a propeller at each end of the hull; high standards as regards noise and vibration are demanded. Primary power will be generated by four diesel-alternators (two at each end of the ship); these will comprise 4000kW eight-cylinder M32C engines from the Caterpillar MaK stable, running at 600rev/min.

Each engine will drive an alternator supplying power to the motors at either end of the hull; each motor is split into two tandem units, and a service rating of 10,150kW will be available at the CP propeller (which is driven through a stepped gearbox), with 2400kW for the hotel load. Propulsion efficiency will be raised by the inclusion in the rudders of a Costa bulb. Even with only two generators running, a cruising speed of 18knots will be possible.



An elevation of BC Ferries' three new Super C-class double-ended designs, on order at Flensburger Schiffbau-Gesellschaft. Each will feature four Caterpillar MaK 8M32C engines driving alternators in a diesel-electric power-station plant.

The low emission figures attainable on the M32C design will be useful in an ecologically sensitive part of Canada, and an important option will be the possibility to retrofit Caterpillar's ACERT system, should lower emission figures be mandated in the future. This will involve the company's flexible cam technology (FCT) or Caterpillar common rail system (CCR); some of these options were discussed in *The Naval Architect* May 2002, page 6, with FCT able, claims Caterpillar MaK, to shrink NOx emissions to below 8g/kWh (the current limit is 17g/kWh) and to make soot invisible under part-load conditions. An update on Caterpillar MaK's emission-reduction strategies will be presented at the Green Ship Conference, to be held on March 29-30, in Hamburg, Germany.

BC Ferries has already had good experience of MaK machinery. As long ago as 1970, two ships were converted to this marque, and since then a large proportion of new ferries feature either Caterpillar or MaK designs. The latter make, in its M43 model, has also featured strongly in Flensburger's very successful ro-ro freight ships, many of which have been built for Turkish and UK owners (*UND Akdeniz*, *Significant Ships of 2000* and the modified version for the UK Ministry of Defence sealift charter, *Hurst Point*, *The Naval Architect* September 2002, page 70).

Saving fuel with the aid of an emissions monitor

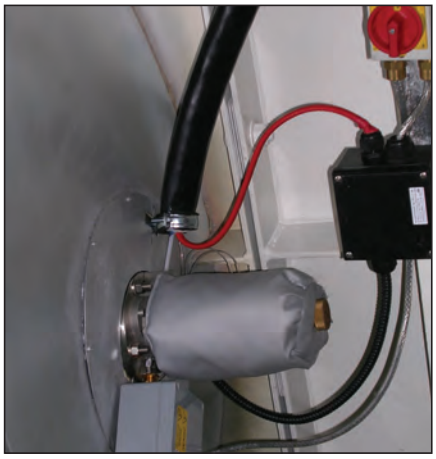
FOLLOWING successful three-month trials last year on the BP Aframax tanker *Loch Rannoch* to prove equipment compliance of the Marinox exhaust-gas monitor with MARPOL Annex VI regulations, the UK company Martek Marine has now completed further trials with another owner which reveal that an efficient NOx exhaust-gas analyser can additionally help to make important savings in fuel costs. At the same time, as a result of the *Loch Rannoch* trials, BP is planning to install similar Marinox equipment on all its ships.

Today, ensuring that a large two-stroke engine produces satisfactory exhaust emissions under various operating loads is a tricky task, and to meet the newest MARPOL limits (currently 17g/kWh for NOx), designers of such machinery have had to make various adjustments, including retarding fuel injection. This can reduce overall combustion efficiency and affect the generation of NOx gas. A Marinox monitor can help to optimise an engine.

Most ships operate under partial load conditions, says Martek Marine, therefore engine builders have also developed variable injection timing and fuel quality setting techniques to help compensate. In reality, claims the company, many engines struggle to produce peak optimisation at partial load conditions, even with these special features.

The fuel-saving trials were carried out in cooperation with leading German owner Peter Döhle and Chilean operator CSAV on the 5527TEU container liner *Copiapo*, built in 2004 by China Shipbuilding Corp, in Taiwan, and presented in *Significant Ships of 2004*. Work started in September last year when the Marinox equipment was installed at sea (in the Mediterranean) on the exhaust line of the ship's HSD-built (today Doosan) Sulzer 10RTA96C-B two-stroke engine, which has an output of 54,904kW at 100rev/min.

A good start was made when set-up measurements reported the same figures as should be achieved on a testbed. As soon as the engine reverted to optimised operating conditions (by adjusting fuel injection timing), a fuel reduction was measured, and confirmed over a period of two voyages and during different weather conditions, at an average engine speed of 96.5rev/min^{-1}. The fuel savings achieved varied between 0.6% and 2.1% - an average of 4.2tonnes. This is a significant figure in today's climate of high bunker costs; on *Copiapo*, where typical daily consumption of the main engine would be between 195tonnes to 215tonnes, these percentages amount to daily savings of approximately US$1200. Martek Marine believes that it will actually be possible to slim these figures even further in the future.



The heated sample probe is installed in the main exhaust uptake. An insulated cover allows for easy probe filter replacement.

Under such conditions as achieved on *Copiapo*, these figures would also equate a savings of 12tonnes of CO_2 gas, although there will probably be a small penalty in NOx emissions but certainly the engine will remain within MARPOL limits. If owners also want to measure SOx output, then Martek Marine says it can easily fit an additionally rack in the main cabinet.

The *Copiapo* trials confirm that large two-stroke engines can be optimised outside the allowable parameters in an engine's technical file while still remaining in compliance with the bounds of the NOx code.

To date, Marinox gear has been ordered for approximately 20 new-generation LNG carriers. These particularly include all those ships to be installed with heavy-fuel-burning slow-speed MAN B&W engines for Pronav and OSG, as well as ships for Teekay; these are on order in Korea at Samsung, DSME, and Hyundai Heavy Industries. An additional order has come from Leif Hoegh, for retrofitting to an existing car carrier, *Hoegh Tokyo*.

Martek Marine plans to set up a so-called Green Funnel Flag notation, in association with other providers of 'green' equipment for marine machinery. It is envisaged that ships would be issued with an individually-numbered plaque and certificate. In an associated noble move, Martek is additionally buying new trees for planting in the Brazilian rain forest. A total of 50 new trees are being purchased for every order secured.

The main Marinox cabinet is placed in the engine control room, with electrical and gaseous inputs led through the bulkhead using approved penetrations. Exhaust gas is vented back through the penetration into a local vent line.

Wärtsilä licensee in Brazil

Prospects for the return of commercial shipbuilding in Brazil have been given a significant boost by the decision of Wärtsilä to grant a licence for the construction of two-stroke diesel engines to Nuclebras Equipamentos Pesados, at Itaguai. The agreement will cover models of the electronically controlled common-rail type in bore sizes between 500mm and 680mm. Completion of the first engine is expected in early 2008, and the annual output is anticipated to be between six and 10 units annually. No marine engines have been built in Brazil since 1996 but the government is trying to revitalise the country's once most energetic shipbuilding industry, not only for domestic owners but for export.

Lower sulphur content for fuel

Concern over pollution is likely to mean that heavy fuel with a sulphur content below the current average of 2.7% will become commoner in the years ahead, as forthcoming legislation restricts emission limits of SOx, NOx, particulate matter, HC, and CO. The simplest method would be refineries to supply low-sulphur oil but this possibility is uncertain. As from May 19 this, the European Union sulphur limit in the Baltic Sea, English Channel, and North Sea will be 1.5%, and passenger vessels sailing between EU ports will also have to comply with this level from the same date (originally July 1, 2007). Inland ships and sea-going ships at berths are restricted to 0.2% sulphur, which will reduce to 0.1% by January 1, 2010, and for 16 unifuel ferries serving Greek islands, January 1, 2012. Further limits are likely to be imposed by IMO and the European Union.

Options are exhaust-gas scrubbing systems (generally considered only practical on larger vessels) and so-called emissions trading. Operators will have to take all these factors into consideration and take care with fuel compatibility on their engines. A useful technical brochure on this subject (for two-stroke engines) has been newly published by MAN B&W, Copenhagen.

Making better use of exhaust gas

A new concept to generate electrical energy from exhaust gas has been perfected by the industrial solutions and services group of German electrical giant Siemens. This is claimed to reduce fuel consumption, to cut CO_2 emissions by 12%, and to result in lower NOx and SOx levels. Three systems are already in operation. Outputs of up to 6MW are possible. Siemens can, in addition, supply one of its alternators that are mounted directly on the propeller shaft; with such a system, it is possible to provide an extra 2MW. In addition, such an alternator can be arranged to act as an auxiliary motor, if needed, with the whole arrangement controlled by energy management software so that the shaft alternator is adjusted automatically to current requirements; optimum use is therefore made of the energy available.

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Fossil-free propulsion for commercial ships - the tide is turning

Andrew Spyrou presents some further facts for digestion - and makes some astute claims - on the difficult question of nuclear power for merchant vessels.

RECENT developments in Europe and the USA have created an optimistic mood, and the indications are that the tide is turning for the civil nuclear industry. In the presentation titled 'Quest for fossil-free commercial ship propulsion', published in *The Naval Architect* May 2005 (page 41), the question of what is the future of civil nuclear power, was left unanswered, because the future looked bleak. Today, this is not the case. It is now accepted that a reliable, safe, and non-polluting source of energy provided by modern nuclear power plants could make a substantial contribution to the world's energy needs.

The British and US Government's change in attitude towards civil nuclear power for energy generation is bold and timely. It is best that it was made now, rather than wait until a crisis forces governments to act when there is an energy problem. This change of heart is confirmation that both countries' governments have accepted the fact that energy will be one of the defining issues of the 21st century, and every effort is being made to accelerate conservation efforts and to ensure protection of the environment.

Amongst steps taken is the decision by British Energy (BE), to extend the operation of its eight nuclear reactors by 10 years - the plants will continue operating until 2018. The extensions follow lifetime extensions in the USA, of civil nuclear reactors, where several have been granted extensions of up to 20 years.

Re-appearance of coal and hydrogen prospects

Both governments have realised that electrical generating companies, driven by rapidly increasing oil and gas prices, are reverting to the use of coal - coal deposits in the USA are the largest in the world. Rising oil and gas prices, plus environmental constraints on coal, have combined to put civil nuclear power back on the agenda for projected nuclear energy capacity in Europe and the USA. The authorities have also accepted the fact that, none of the so-called 'benign' energy sources - hydro, solar, wind, and ocean - can contribute significantly to global demand for energy.

As regards fuel for commercial ship propulsion, development of a significant hydrogen economy will reduce dependence on oil, thus reducing atmospheric pollution and greenhouse-gas emissions. Electricity from nuclear energy will separate water into hydrogen and oxygen by electrolysis, or utilise thermochemical water splitting - a process that achieves the same objective as electrolysis.

This process offers the potential for efficient, cost-effective, large-scale production of hydrogen by a series of thermally-driven chemical reactions. Hydrogen will be converted back to electricity at the site for use by fuel-cells onboard a ship, or to provide mechanical power, as now used by the automotive industry. In July of last year, a decision was taken by the USA, Japan, the European Union, Russia, China, and South Korea, for the International Thermo-Nuclear Experimental Reactor (ITER), to be established in France.

Commenting on efforts to convince the general public of the likelihood of catastrophic global warming by greenhouse-gas emissions, particularly CO_2, Dr Wilson Flood, in his recent presentation to the Institution of Engineers & Shipbuilders in Scotland (IESIS), in Glasgow, mentions 'the speed with which the idea of significant anthropogenic global warming due to CO_2, has become an unquestioned truth without more rigorous scrutiny, should be a matter of concern', and that, 'in the absolute literal sense, global warming is Alice in Wonderland science - the verdict has been delivered before we have even had the trial'.

Temperature trends show possible cooling

Dr Flood also notes, that close examination of temperature records kept by the UK Meteorological Office in central England, which started in 1659, has recorded the average annual temperature for each year to the present day. Figures show that there was a very cold period at the end of the 17th century, with widespread starvation in Scotland in the 1690s due to failing harvests. The climate starts warming dramatically after 1700 with no carbon dioxide to help it. The coldest year in the record is 1740. Up until 1986, there is nothing remarkable in the record. Then there was a sustained four-year rise in temperature to 1990, but since then temperatures have reached a plateau.

The long-term temperature trend in UK records shows that the climate is actually cooling. An example of that is Greenland, where 1000 years ago, the Vikings arrived and it was warm enough to allow them to farm for several hundred years, before the climate turned colder.

It is also pointed out that, during the 1920s, the Serbian civil engineer and amateur astronomer Milutin Milankovitch, became convinced that ice ages were under astronomical control (so-called Milankovitch cycles), caused by orientation of the earth as it moves around the sun. Even today, we know very little about how the atmosphere works, and Western societies, to ensure future generations do not freeze in darkness, have established the World Nuclear University.

This was established in September 2003, and its main function is to foster cooperation of participating institutions for their mutual benefits, while setting and enforcing high academic standards. The WNU is not a new campus. It is a network for coordinating and supporting institutions which are already established, and for boosting their endeavours and profiles. Its first summer institute was held last year, and the next one will be held during 2006 in Stockholm, Sweden.

51/60DF: a new multi-fuel engine from Augsburg

LAST November, in our special supplement, *Marine Power and Propulsion: Solutions for Naval Architects*, we reported on work at Augsburg by MAN B&W on the development of a large-bore dual-fuel four-stroke engine. This new model, known as the 51/60DF, is now ready for the market; it is designed to run not only on natural gas and marine diesel oil but also long-term on pure heavy fuel. The 51/60DF is based on the well-established 48/60B model, well proven in both marine and stationary applications, and it includes experience accumulated with a smaller dual-fuel engine, the lean-burn 32/40DF. Primary target of the new engine is, of course, LNG tankers.

The 51/60DF is believed to be the largest four-stroke gas engine on the market and will be offered in all cylinder configurations, ranging from six cylinders in-line to 18 cylinders in vee-form, with powers ranging from 6000kW to 18,000kW. Running speeds will be 500rev/min or 514rev/min.

A special common-rail pilot oil injection system is said to make the engine exceptionally environment-friendly. The first production engines are expected to roll out from Augsburg in mid-2007.

More than 50 Wärtsilä DF engines on order

Meanwhile, competitor Wärtsilä, which launched the first modern dual-fuel medium-speed engine some years ago, has now notched up contracts for a total of at least 52 units of its 50DF model (which can also burn natural gas, light oil, or heavy fuel) for installation in new LNG carriers. Other engines have also been booked for operation in FPSOs and on offshore supply vessels, and a proposal for a cruise-ferry powered by dual-fuel machinery has also been made.

The first orders for LNG carriers were for Gaz de France's three ships at Alstom Marine (the 75,000m³ *Gaz de France Energy*, which is still awaiting delivery due to cargo containment system problems, and two larger sisters, *Provalys* and *Gazelys*). Other DF engines have been secured for LNG ships at Samsung (at least 24) and at Hyundai (at least eight sets).

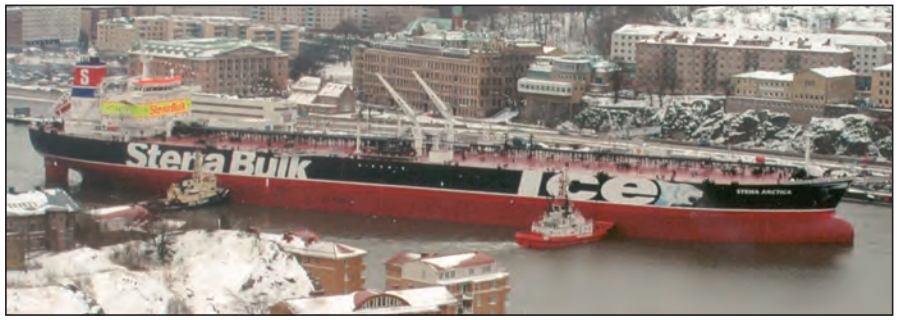
Stena Arctica: the largest ice-class tanker?

AT the end of January, the tanker *Stena Arctica* was named in the port of Göteborg. This notable vessel, of 117,100dwt, is not only the largest Swedish-flagged ship in that country's merchant fleet but is also believed to be the largest tanker with the highest ice-class in service.

Her hull is heavily reinforced and the propulsion plant is considerably more powerful compared with normal tankers of the Aframax size, thus enabling her to navigate safely in a Baltic winter. The wheelhouse is also designed for 360deg viewing. Two further near-sisters, of 114,000dwt but with a lower ice rating (1A), are expected to join the Stena fleet during 2006.

Stena Arctica, working together with additional ice-strengthened tankers and in cooperation with the Russian operator Sovcomflot, will mainly transport Russian crude oil from the Gulf of Finland to the European continent. Built at Hyundai Heavy Industries, in South Korea, the vessel has a length overall of 249.8m, a width of 44m, and a draught of 15.4m, and features five pairs of cargo tanks. The length and breadth are greater than most Aframax-class ships.

Stena Arctica has been built in accordance with Swedish-Finnish Ice Class 1A Super regulations, which means that she can sail under her own power through 1m thick ice. By 2008, Stena Bulk and its sister company Concordia Maritime will be operating a fleet of about around 12 large, ice-strengthened tankers. *Stena Arctica* has been equipped with a main MAN B&W engine and propeller built by Hyundai Heavy Industries.



This new 117,100dwt tanker, *Stena Arctica*, seen here in Göteborg, has been built to the highest ice class, Swedish-Finnish 1A Super, for use mainly in Russia and the Gulf of Finland.

Cooperation between the shipping companies Stena Bulk and Sovcomflot includes building up a pool of 10 to 15 ice-strengthened tankers, which was set to begin in February. The objective is to ship 20-25 million tonnes of Russian oil annually from the Baltic to the UK/continent. This is equivalent to about one third of the total shipped from the terminal in Primorsk in the Gulf of Finland.

Volumes of Russian oil transported through Swedish waters have rocketed since the new terminal in Primorsk was built in 2001. During the first year, 0.3 million tonnes were exported and in 2005, 57 million tonnes were transported from the Gulf of Finland.

Another ambition of Stena Bulk and Sovcomflot is to jointly develop a so-called B-MAX tanker, with B standing for Baltic. This vessel type will be extremely wide-bodied with a shallow draught - following the concept of Stena's V-MAX, C-MAX, and P-MAX classes - and will able to load as much as 250,000tonnes. All propulsion systems will be doubled, which will give even better manoeuvrability while also enhancing safety.

Finally, cooperation in the training of crews for shipping in cold climates has begun, and this includes sponsorship of a training programme and a training centre at the Makarov Institute, in St Petersburg.

Multiple passenger-ferry propulsion orders

Color Line, Viking Line, and Tallink have all recently specified Rolls-Royce CP propeller systems and tunnel thrusters for new vessels they have ordered to be built in Finland (*The Naval Architect*, February 2006). The value of the contract to Rolls-Royce is about €12 million.

Color Line (SuperSpeed project) has ordered two 1900-passenger ro-pax day vessels capable of almost 30knots for its services linking Kristiansand and Larvik in Norway with Hirtshals in Denmark. Each vessel will have two 5.25m diameter Kamewa Ulstein ice-class 1B CP propellers with 19.2MW on each shaft line. Three tunnel thrusters per ship have also been specified; two rated at 2400kW each at the bow and a single 1200kW unit at the stern. Both these 211m long ferries will be built at Aker Yards in Rauma and are scheduled for delivery in February and May 2008.

Viking Line has ordered a ro-ro passenger ferry for the route between Helsinki and Tallinn - this operator's first new ferry for some years. It will be 185m long, able to carry 2500 passengers and will be built at Aker Yards in Helsinki for delivery in February 2008. The vessel will have two 5.3m diameter four-bladed CP propellers cast in stainless steel and designed to ice class 1A Super. Four engines (20MW per shaft line) will give a maximum speed of 26.80knots. Three tunnel thrusters will be installed in each vessel: two 1500kW units will be located at the bow and one of the same power at the stern.

A 212m long passenger cruise ferry for the Baltic Sea, capable of carrying 2800 passengers, is to be built in Helsinki for Tallink. This vessel will have two 5.0m diameter four-bladed CP propellers, again of stainless steel and designed to ice class 1A Super. The four engines (16MW per shaft line) give a maximum speed of 24.80knots. Two 1800kW bow tunnel thrusters will also be installed.

In each case, the scope of supply includes shaft lines, shaft line bearings, tailshaft seals, shaft line calculations, bulkhead seals, hydraulics, CanMan control system, and extensive performance guarantees. High-speed shafts are additionally included in the Viking Line contract.

Contact: Rolls-Royce Marine PO Box 160, N-6065 Ulsteinvik, Norway.
Tel: +47 70 01 42 35. Fax: +47 70 01 40 05.
www.rolls-royce.com

Stainless-steel quality standards now available on CD-ROM

BSI Business Information has just published a collection of essential stainless-steel standards on one CD-ROM to include all three available parts of *BS EN 10088 Stainless Steels*. Those in industry can use the series to quality-check a stainless steel specified to ensure products meet the high quality standards demanded by customers.

With the three standards now available together in one convenient place, steel professionals will find it easier to access information by using its search facility. Part 1 of the CD lists the chemical compositions of stainless steels (including a table of European standards, in which these stainless steels are further specified). They are subdivided in accordance with their main properties, into corrosion-resisting steels, heat-resisting steels, and creep-resisting steels.

Part 2 specifies the technical delivery conditions for hot or cold rolled sheet/plate and strip of standard grades, and special grades of corrosion-resisting stainless steels for general purposes. It also includes the use of flat stainless steel products including cutlery and other products in contact with foodstuffs.

Part 3 describes technical delivery conditions for semi-finished products, hot or cold formed bars, rods, wire, sections and bright products of standard and special grades of corrosion-resisting stainless steels for general-purpose use. The guide costs £250 +VAT, or £125 +VAT for BSI subscribing members.

Contact: BSI Business Information, London, UK.
Tel: +44 20 8996 7641.
Fax: +44 20 8996 7553.
www.bsi-global.com/businessinformation

New TTS orders from German companies

Sweden's TTS Ships Equipment AB, in Gothenburg, part of Norway's TTS Marine ASA, Bergen, has won orders from new German customers. One contract is from the J J Sietas yard, in Hamburg, for cargo access equipment on two 9500dwt ro-ro vessels, ordered by Godby Shipping, in Finland (hull numbers 1281/82). These vessels are intended for shortsea trades between Finland and the European continent, and are due for delivery during the second half of 2007.

Another German contract was signed in November with Flensburger Schiffbau GmbH, for delivery of cargo access equipment for a series of four (plus six options) 13,080dwt hulls of the new ConRo 200 type for an unspecified European owner (yard numbers 738-741). These ro-ro vessels will have a length of 180.89m, a draught of 7.40m, a service speed of 19knots, and a trailer lane capability of 2604m. This ConRo 200 design follows the yard's earlier ConRo types with five ro-ro decks. The four new vessels are all due for delivery by 2009.

The above new orders will increase TTS Ships Equipment AB's contracts for deliveries to more than 25 ro-ro ships during 2006-2009, in addition to the more than 40 contracts for delivery of ro-ro equipment to car carriers.

The Sietas contract will include cargo access equipment consisting of a stern ramp, a ramp cover, also bulkhead and bunker doors. The stern ramp will have a length of approximately 15m, a driveway width of around 15m, and a total load capacity of 200tonnes. It has been designed for accepting rolling vehicles such as Mafi trailers, road trailers, forklift trucks, and translifters with a maximum axle load of 32tonnes.

Access to the lower hold is arranged by a fixed ramp covered by a TTS hydraulically-operated watertight ramp cover in three sections, with a total length of about 46m and clear driveway width of around 4m. The entrance to upper deck is sealed watertight by a top-hinged door with clear dimensions, with a width of 13.2m, and height of 4.6m. Additionally, TTS will also deliver two hydraulically operated combined pilot and bunker doors of vertical sliding type.

The contract with Flensburger Schiffbau will include ro-ro equipment consisting of a stern ramp and door, a ramp cover, positioned on the main deck, pilot/bunker doors for both port and starboard sides, and accompanying hydraulic and electric systems. The stern ramp is 18m in length (including flaps), and the driveway width between kerbs is 15.6m. The entrance to the ship has a clear height of 7.35m. The pilot doors of vertical sliding type are hydraulically operated and cleated. As an option, hoistable car deck and ramps will also be arranged between main and upper decks.

The stern ramp has been designed to accept loads including Mafi trailers, road trailers, tugmasters, and translifters with axle loads of 34tonnes and boggie loads of 68tonnes. The ramp cover can also accept special SECU boxes with a load of more than 90tonnes. The fixed ramp to the tanktop is secured by a watertight cover divided in three sections and hydraulically operated.

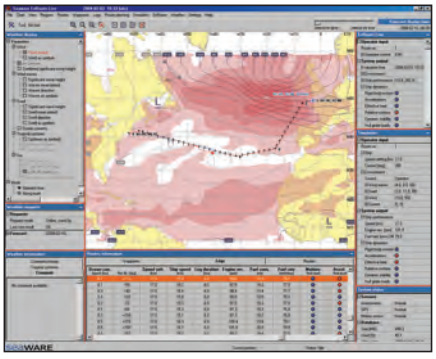
Contact: Nils O Ericsson, sales director, TTS Ships Equipment AB, Gothenburg, Sweden.
Tel: +46 31 725 7902.

Three PCTCs installed with Seaware EnRoute Live

Wallenius Marine is currently installing EnRoute Live, an onboard seakeeping guidance system that helps bridge personnel navigate safely around and through bad weather, on three PCTC carriers. This technology is supplied by Seaware, a Swedish ship technology software company which pioneered the concept around 10 years ago.

EnRoute Live is a multi-feature system, focusing primarily on seakeeping. Its main purpose is to increase the safety level for the crew, and to prevent and reduce damage to both ship and cargo that may arise from bad weather. Unlike other similar systems, EnRoute Live combines three tools in one fully

A screenshot of Seaware's EnRoute Live, the onboard seakeeping guidance system, that is being installed on Wallenius Marine car/truck carriers.



integrated piece of software, namely, advanced route planning, at-sea seakeeping guidance and decision support, and post-voyage analysis.

At sea, the system gives active seakeeping guidance by backing-up the route planning results with continuous evaluation of the surrounding sea state and the actual wave-induced effects on the ship. By comparing these figures with the ship's seakeeping abilities, it gives early warnings when a vessel's performance limits are likely to be exceeded. The system also features an advanced seakeeping advice facility to support operational decision-making. Wave-condition monitoring is achieved by means of an onboard motion sensor, which effectively turns the ship, says the company, 'into a giant wave buoy'.

Contact: Anders Olander, Seaware AB, PO Box 1244, SE-131 28 Nacka Strand, Sweden.
Tel: +46 8 601 91 90.
Fax: +46 8 601 91 91.
E-mail: info@seaware.se www.seaware.se

Automated material handling offers onboard advantages

German company Becker Marine Systems has increased its product range with the introduction of the automated material handling system (AMH). This method, it is claimed, ensures efficient, safe, and compact handling of provisions and materials on all types of ships.

AMH, which is particularly aimed at cruise vessels, ro-pax ferries, megayachts, and navy vessels, consists of well-proven and tested components which are adapted for efficient shipboard use. With such automation, the number of crew can be reduced, demurrages are shortened, and operational safety increased.

The control of stored goods is improved, says the company, through better monitoring of expiry dates of perishable items. The system is tailored to individual ship designs in order to achieve optimal space utilisation. Saved space can be used on cruise liners, for example, for additional passenger cabins.

Becker also offers a solution for storage and luggage transportation on cruise ships. With this system, passengers will receive a time schedule for receiving and check-out of their luggage. This is claimed to save manpower, reduce storage space, and avoid overcrowded corridors and lifts.

Contact: Becker Marine Systems, Neuländer Kamp 3, D-21079 Hamburg, Germany.
Tel. +49 40 24199-0,
Fax +49 40 2801899.
E-mail: info@becker-marine-systems.com

First phase of waste-heat recovery systems delivered

UK-based engineering company Peter Brotherhood Ltd, which specialises in the design and manufacture of steam turbines, has delivered six 6MW turbo-compound systems to Odense Steel Shipyard, in Denmark. It completes the first phase of several systems ordered by that yard.

Each turbo-compound system will be installed onboard a large container ship for Maersk Sealand. They will be used to convert energy in the exhaust gas from each main slow-speed diesel engine into electrical power. Each system consists of a 5.25MW Brotherhood steam turbine, a 2.25MW Mitsubishi power turbine, two gearboxes, and a 6MW Siemens generator - all on a combined baseframe. An electronic governor and PLC-based control system has also been supplied to regulate start-up, shut-down and running modes over the full range of main engine duties.

This first phase of delivery was completed between December 2004 and December 2005, following placement of the order in September 2003. Work has already started on the manufacture of the second batch of machines, which will be delivered during 2006 and 2007.

In most cases, according to Peter Brotherhood, this system can generate significant fuel savings, depending on a ship's operating regime. A similar saving is therefore made on the emissions in terms of NOx, SOx, and CO_2 from a main engine exhaust.

Contact: Colin Lake, Peter Brotherhood Ltd, Peterborough, UK. Tel: +44 1733 292330.
E-mail: calake@peterbrotherhood.co.uk
www.peterbrotherhood.co.uk

Noise and vibration: comfort standards evolving in the wrong direction?

Francesco de Lorenzo, from Italian shipbuilder Fincantieri (head, noise and vibration department), and Marco Biot, from the department of naval architecture (associate professor of ship construction) at the University of Trieste, examine passenger sensitivity to noise and vibration, and consider that new ISO rules for noise and vibration limits are inferior to those of 1984.

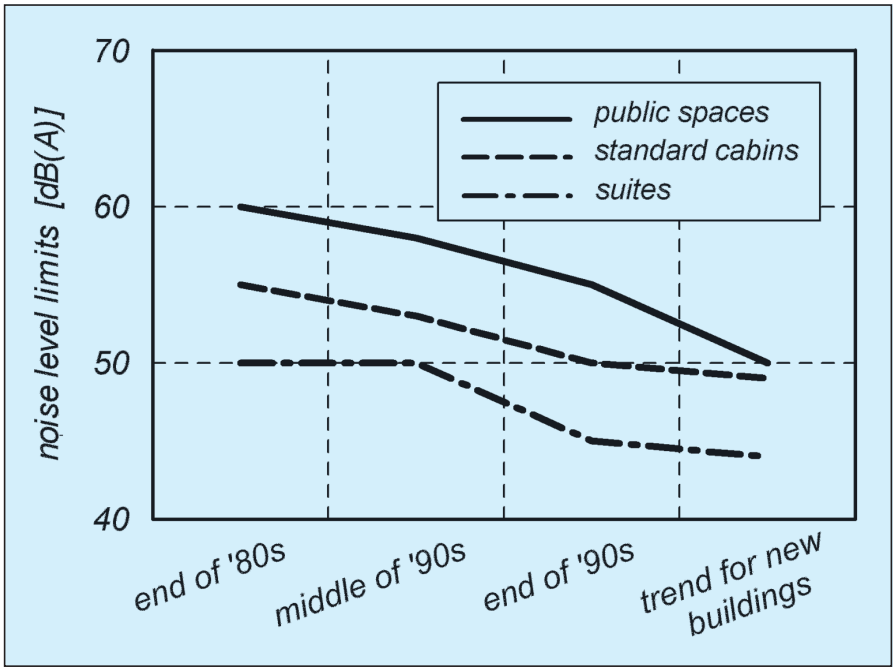


Fig 1. Trends in noise limits for passenger accommodation areas on cruise liners.

COMFORT on a ship as perceived by passengers is not related to formulae, numbers, and limits, according to the authors. Those conditions that determine the levels of comfort are, in fact, rather complex since they are the product of both a subjective and an objective component.

To better explain these obscure aspects of comfort, in the case of a cabin that, under equal cruising conditions, has been the subject of a claim by a passenger that it was not comfortable for one voyage can be considered. Probably, the cabin's habitability was actually satisfactory but the claim was presented by a passenger with higher subjective demands of comfort or which were simply different from average requirements. On the other hand, repeated claims concerning the same cabin, under the same cruise conditions, during different voyages, may be considered proof of a low comfort level.

This means that it is not possible to guarantee a sensation of comfort equally valid for everyone and, for this reason, the designer must aim at securing a 'suitable' comfort level: in the first case (the occasional claim) the design solutions adopted against noise and vibrations remain valid, while in the latter case the designer will be urged by the owner into investigating the causes of the problem in order to devise appropriate solutions.

Concerning noise, there is no close correlation between decreasing levels of sound pressure - dB(A) - in cabins and relevant comfort. In fact, it may happen that disturbances are caused, even if the noise background levels are low, by intermittent fortuitous noise or by a background noise with a spectrum characterised by a tonal component prevailing on the others. In confirmation, it has been noticed that those cabins more prone to claims are usually those where the background noise is lower.

Complaints about vibration

The matter is different concerning an acceptable threshold for vibration levels in accommodation areas, where they can be measured and compared with compliance limit values. In fact, it is a common experience - acquired in the cruise liner field - that compliance with vibration limits refer, in a certain frequency band, to the single harmonic components of the spectrum, and does not entail any problem of habitability for those onboard if the spectrum peaks all remain under a suitable threshold. Furthermore, comfort grows when the intensity of the spectrum single-peak values decrease.

Brief history

In recent years, world demand for cruising has registered a constant increase, and in this market European shipyards have played - and are still playing - a fundamental role. In view of intense yard competition, triggered by owners' increasing demand for quality, the ability to offer a ship featuring a high level of comfort represents a decisive factor for the success of a design.

In relation to accommodation noise and vibration, shipyard know-how has constantly improved, allowing yards to meet owners' most daring requests. In this framework, classification societies have provided guidelines for the evaluation of comfort onboard, setting vibration and noise limits. In particular, different comfort-class levels have been set, referring to different ship types.

The international noise level reference standard issued by IMO establishes an acceptable level of comfort to the crew only. Such standards have never been revised over the years and today are generally considered obsolete since sometimes the noise levels required by owners are lower.

On the other hand, the rules of the International Organisation for Standardisation (ISO) have always been a reference standard for both yards and owners concerning vibration limits. Limit values set by the rules (ie, ISO 6954) are a benchmark in the procedure for determination of shipboard vibration levels.

In the meantime, shipyards have been gaining their own wide technical experience on this matter; this is resulting in improvements of both quality of forecast calculations and the efficiency of acoustic and vibration solutions. Furthermore, the availability of a complete data bank has made possible solutions and improvements ever more effective.

Results of a consolidated balance

In the outlined framework, both owners and yards have been able to build up a confidence relationship, while also cooperating in R&D. Fig 1 shows that the trend is to keep improving the habitability standard in respect of noise. Specifically, the graph shows that, onboard newer cruise ships, owners are requesting stricter noise levels not only in passenger but also in crew areas.

As regards vibration limits, the value of 4mm/sec (as defined in the old version of the ISO rules) has represented the starting point for determination of an ever increasing level of comfort for accommodation spaces for both passengers and crew. This is clearly shown in

The Royal Institution of Naval Architects

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Second Notice

There is considerable optimism about the future of the natural gas market. A significant growth in the number of gas carrying vessels is expected, resulting from both an increase in demand and the current programme of scrapping older vessels.

While some companies are looking at the possible economies of scale of larger vessels (in the range of 175,000- 250,000 cu.m.) others are looking to develop options for developing small vessels to exploit shortsea and coastal trades in natural gas.

New alternatives to LNG including compressed/pressurised natural gas (CNG/PNG), where the gas is stored under pressure at ambient or semi-refrigeration temperatures, are also being developed. There is also a growing interest in floating production, storage and offloading systems for offshore oil & gas developments and re-gasification tankers and plants designed to avoid the need to construct huge land-based processing and distribution centres.

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Fig 2, where progress of peak limit values of specifications relevant to cruise ships is represented.

Comfort class: towards improved determination of comfort

Classification societies have also been interested in issuing guidelines concerning comfort on board. The first was Det Norske Veritas, which in the mid-1990s drew up a real class notation concerning the comfort - both noise and vibration. Other societies have now followed.

Noise and vibration factors vary between society. In particular, vibration limits pertaining to each class correspond to a standard that can be determined referring to the old ISO rule (at present adopted by DNV and Registro Italiano Navale, although DNV is expected to update its standard soon) or the new ISO rule (already adopted by Bureau Veritas, Lloyd's Register, and Germanischer Lloyd). Concerning noise, the comfort of a cabin is measured both referring to the maximum noise level that it is to be secured for assignment of the class, and on the basis of noise produced by human activity in the spaces contiguous to the cabin itself.

To quantify habitability of a cabin in connection with non-stationary noise (and hence the effectiveness of acoustic insulation between the different spaces), two types of sound disturbances are taken into consideration. These are correlated to the following indices: the sound insulation index, connected with noise transmitted from adjacent spaces, and the impact sound insulation index, characterising disturbance caused by impact noise on deck.

A further element of disturbance, which only lately has been taken into consideration, concerns intermittent noise. This is normally caused by machinery in operation for short periods with very long intervals between start-up (eg, swimming pool pumps, transverse thrusters, or sanitary discharge pumps). It has been proved that such noise causes worse disturbance than a continuous noise and, what is more, it often occurs in areas considered quiet.

In comfort-class guidelines, tables giving the limit values of levels of stationary noise and vibrations, also of the indices characterising non-stationary noise, are under continuous evolution, with the purpose of allowing the quantification of comfort quality onboard.

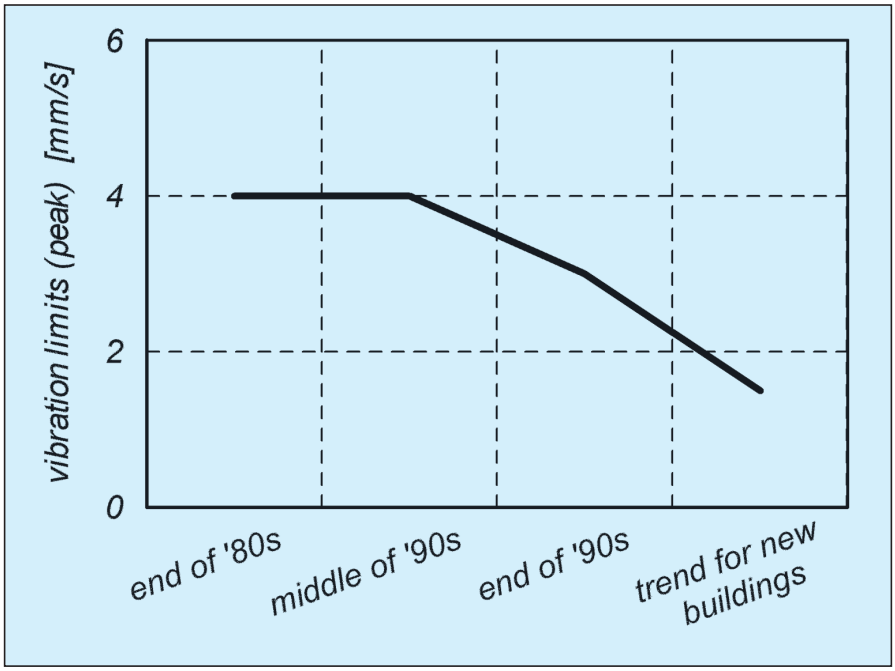


Fig 2. Trends in vibration limits for passenger accommodation areas on cruise liners.

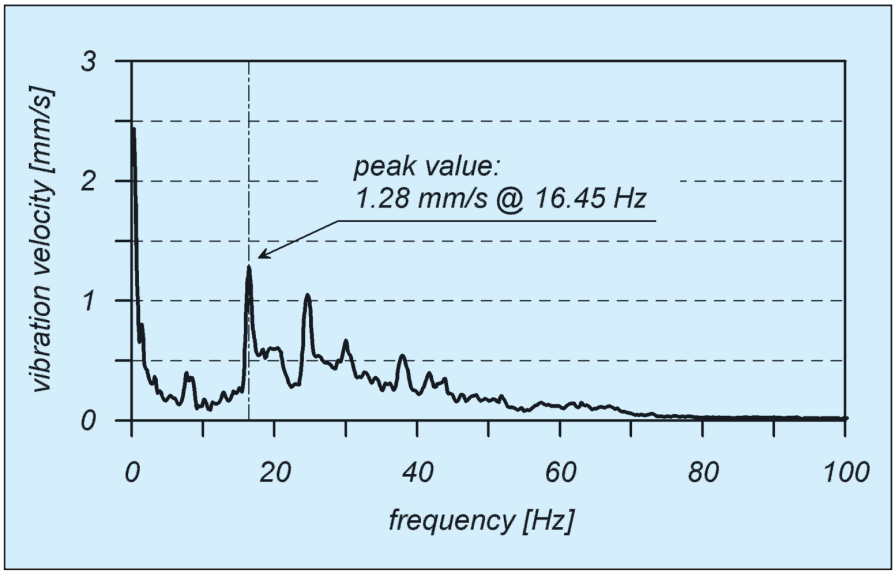


Fig 3. Spectrum of vertical vibrations measured in the accommodation area of a new cruise ship.

Breaking the balance

The balance attained between owners, yards, and classification societies has, however, been shaken by the introduction of new rules that, in respect of existing ones, are based on different concepts regarding the evaluation of acceptability of vibration levels. As already mentioned above, in the shipbuilding field noise and vibrations issues have been regulated over the years by two single rules:

- IMO A468 (XII) 1981 rule concerning air noise in the various types of spaces on board, including working areas (for instance, in machinery spaces)
- ISO 6954 rule concerning hull vibrations, meant to be applied to crew accommodation only, but at present applied mainly for passenger and crew accommodation areas, also if the curve limits are different.

While the first rule has remained substantially unaltered, the second one - concerning vibrations and issued in 1984 - was fully revised in 2000, with substantial modifications both on the theoretical approach and on its practical application.

More specifically, in the 1984 International Standard, the defined method for measuring and reporting shipboard vibration (ISO 4867 and ISO 4868 rules) and the ISO 6954 rule offered guidance for the overall evaluation of vibration in merchant ships. These standards, where the admissible vibration levels were

expressed as maximum peak value, being based on field observations and experience, did not reflect methods for predicting human response to complex vibrations. Finally, in 2000, ISO 6954 was revised in order to be able to reflect human perception of vibration.

Revision of the ISO 6954 Rule in 2000 does not refer to compliance with the limits of the single spectrum component but concerns instead an overall value characterising the spectrum, expressed in mm/sec RMS. Such a value is obtained summing up, in the field between 1Hz and 80Hz, the components in the third-octave band, after having suitably weighted them with some sensitivity curves.

New ISO rule: a critical analysis

When the version of ISO 6954 issued in 2000 on vibration became effective, it caused doubts and perplexities. The ISO rule in force is based on the philosophy of the control of vibration caused by machinery, to which the human body is subject during workshop activities. In particular, it covers the consequences that such an activity has on the parts directly exposed to the vibrations source, that is to say the arm-hand system.

Essentially, the foregoing rule has not been originated by experimental measures aiming at ascertaining the discomfort sensations connected with vibration phenomena. A regulation of this kind however does not attain its purpose if it attends to the comfort for all the persons onboard and mainly for passengers who, on one side expect a high level of comfort and on the other have a certain problem to familiarise themselves with the ship environment owing to their short stay on board.

With regards to the onboard situation, it is to be noted that vibration measured at frequencies close to 1Hz is not necessary, since in that field spectrum components do not exist which are generated by machinery and moreover could even be the source of errors. The measurement of vibrations according to these procedures means that it is necessary to introduce oscillating components connected with ship motions caused by waves (which do affect human wellbeing but in a different manner, such as seasickness).

Moreover, the system of comfort measurement proposed by the new version of the ISO rule is based, as already said, on analysis of the whole spectrum field and not only of the peaks connected with the first harmonics of the exciting source. Therefore, while with the old system it was possible to foresee with acceptable approximation, through numerical finite-element analyses, the hull response to the first propeller harmonic (this being the source of higher disturbance), at present there is no method applicable.

Obviously, this means that it is not possible for a designer to adjust the design to the limit value of the rule (thus spelling trouble for a shipyard trying to adopt such a rule in a ship specification). It is also to be pointed out that an important negative factor in application of the new ISO rule is the lack of sensitiveness of the designer toward the new philosophy.

As an endorsement of these observations, the spectrum (Fig 3) concerning vertical vibrations measured in the accommodation area of a new cruise ship can be considered. The narrow band measurement clearly shows the peaks generated by exciting sources (the harmonics due to the propeller are visible): they have values largely below the limit imposed by the ISO 6954 (1984) rule and indicate a high level of comfort: in fact, the measurement gives a maximum value equal to 32% of the limit value (equal to 4mm/sec).

A different conclusion can be reached if such a measurement is elaborated in accordance with ISO 6954 (2000): in fact, it results in the overall frequency weighted RMS value calculated in the range 1 ÷ 80Hz is 138mm/sec^2 and therefore goes much beyond the lower limit value of 71.5mm/sec^2, to be precise equal to no less that 193% of the latter. This result is clearly due to the low frequency vibration peak that can be connected with ship motion caused by the sea. In fact, the spectrum shows, in the field of frequencies from 5Hz upwards, a low energy content and extremely low peak values.

The foregoing comparative analysis confirms, according to the authors, that the new ISO rule, supplying indications that diverge from those of the old rule (considered fully satisfactory since it is extremely effective in emphasising critical areas) does not offer the same requirements of reliability. In other words, the new regulation may risk interpretations as critical vibration levels absolutely not noticeable by a passenger onboard.

Furthermore, analysis of the narrow band also allows direct correlation of the peak value to the source, which makes it possible to evaluate the most appropriate remedies. This is absolutely not practicable if the method of the weighted values on octave thirds is applied. As a consequence, it is impossible to state unequivocally the vibratory behaviour of a ship.

In short, regarding the ISO 6954 (2000) rule, evaluation of the extent of the vibration phenomenon in the thirds-of-octave band makes it impossible to determine unequivocally the exciting source and does not give a technical meaning to the final overall weighted RMS value, that is only a reference number.

Conclusions

Concerning the issues relevant to comfort, the future trend is, as widely illustrated, to make ever more complicated those rules concerning vibrations and noise onboard. Anyhow, while standards for the control of noise are ever more accurate, those rules concerning limit vibration levels appear to be inefficient in guaranteeing real comfort onboard.

The foregoing is substantiated by a series of doubts about the effectiveness of the new rule for the attainment of better standards of real comfort. On the other hand, the experience of shipyards suggests that the old ISO rule can be very effective: in fact, the observation that, cabins where low peaks levels are registered generally reveal no passenger claims, is generally valid. This means that methodology based on the ascertainment of a single peak frequency, when the limit value is well set, can provide an indication consistent with passenger sensitivity

All the unpleasant technical and economical consequences resulting in the application of the new ISO rule only contribute to discourage and advise both designers and shipowners against applying it. Therefore, the methodology provided for the old ISO 6954 rule is not only considered valid and of proven effectiveness, but it also allows calculations to be forecast and exploiting the knowledge acquired by shipyards to full advantage in determining real comfort.

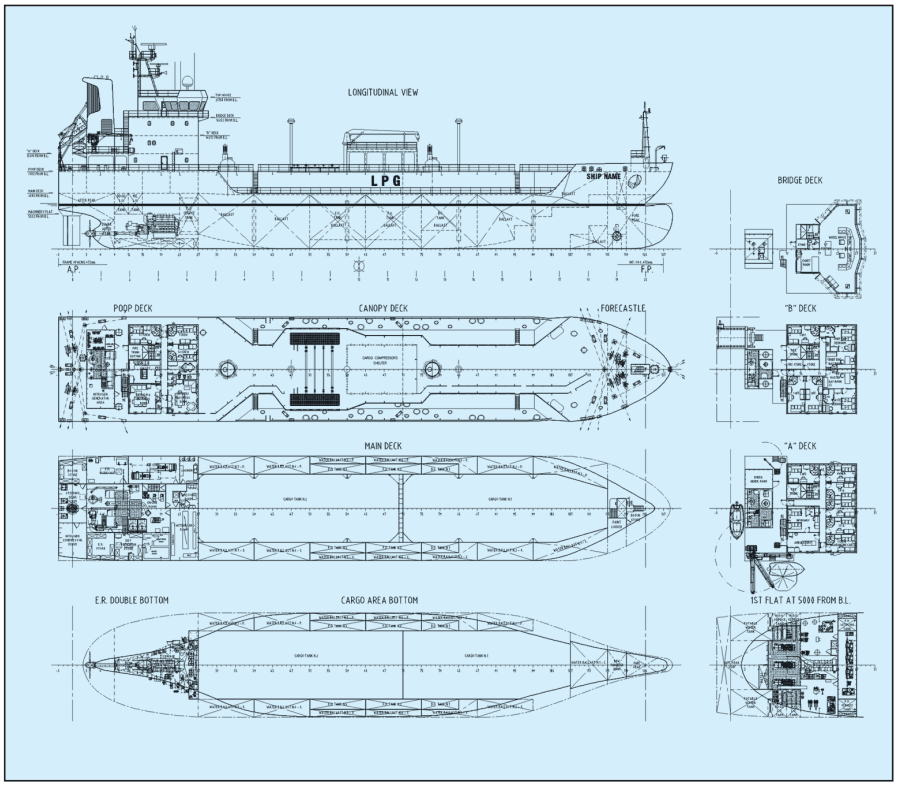
Italian-designed LPG tankers from Turkish shipyard

AN interesting project currently under way at the Madenci Shipyard, on Turkey's Black Sea coast, is that to build four 3300m³ LPG tankers - believed to be the first semi-pressurised, fully-refrigerated designs in that country - for G&H Shipping. These vessels have been designed by the Italian consultancy, Marine Engineering Services (MES), based in Trieste, a company with more than 20 years' experience in the chemical and gas sector.

MES designed the 5884dwt chemical tanker *Cosmo*, built at the Celik Tekne yard (*Significant Ships of 2003*), also the 25,000dwt chemical tanker *Ottomana*, again from Celik Tekne, which is presented in the newly published *Significant Ships of 2005*; another current gas tanker project involves six 4000m³ LPG designs under construction at the Pesaro shipyard, in Italy. A further project is a twin-screw 18,000dwt ice-class 1A chemical tanker, again at the Celik Tekne yard, and again for Mediterranea di Navigazione, owner of *Ottomana*.

In the past, most MES work was concentrated in its home country, but following problems at many smaller Italian shipbuilders, ventures were sought overseas, and particularly in Turkey, which is currently enjoying prosperous times with smaller merchant ships, and particularly tankers. The first Turkish project - and believed to be the first ever placed by an Italian owner in that country - was that concerning *Cosmo*, for Mediterranea di Navigazione.

The 3300m³ LPG tanker *Merope Star*, seen here following her launch at Madenci Shipyard, in Turkey. Three sisters are to follow.



General arrangement plans of the 3300m³ LPG tanker *Merope Star*, designed by Marine Engineering Services and ordered from Madenci Shipyard by G&H Shipping.

TECHNICAL PARTICULARS
MEROPE STAR

Length, oa	88.40m
Length, bp	82.50m
Breadth, moulded	15.00m
Depth, moulded	7.80m
Draught, design	5.50m
Draught, scantling	6.50m
Gross	3395gt
Deadweight, design	2300dwt
Deadweight, scantling	3600dwt
Cargo capacity	3300m³
Heavy fuel	350m³
Diesel oil	90m³
Lubricating oil	30m³
Potable water	80m³
Water ballast	1300m³
Main engine	MAN B&W Alpha 6L27/38
Output	2040kW
Speed, service, 90% MCR, 15% sea margin	14.00knots
Complement	16
Joint classification	Registro Italiano Navale + Liquefied Gas Carrier, AUT-UMS, AUT-PORT, AUT-CCS, AUT-IMS, AVM-APS-NS, Cargo Control, Greenstar, Inwater Survey, MANOVR, MON-SHAFT, PMS, STAR-HULL-NB, SYS-IBS, Unrestricted Navigation, *also* ABS +A1, +ACCU, +AMS(E), Liquefied Gas Carrier, ES, NIBS, POT, R1

The lead ship of the new LPG tankers at Madenci, *Merope Star*, was launched in February. Cargo is carried in two independent IMO Type C tanks at -48°C and at a maximum operating pressure of 9.97bar g; the tanks were prefabricated in Italy by an associated company of MES, Gas & Heat (also an associate company of the owner), and are installed in a hull designed for minimum resistance.

Particular care was taken to optimise all hull aspects, including speed at the design draught,

A computerised impression of the gas-handling and compressor plant, with one of the cargo tank domes with its pump-drive motor (right).

The prefabricated canopy deck with cargo piping for the first of the three ships is seen being loaded in Livorno for shipment to Madenci Shipyard.

in ballast conditions, and at maximum deadweight, especially with a full cargo of vinyl chloride monomer (VCM). Extensive damage stability calculations and analyses were made, and the hull was fully tested at the Vienna Model Basin. The service speed at the design draught is expected to be 14.00knots at 90% MCR and 15% sea margin, or a maximum speed of 14.70knots.

The two cargo tanks have a total capacity of 3300m^3, and the gas-handling plant, supplied by Gas & Heat, comprises one redundant reliquefaction plant with two compressors and two condensers, designed for handling simultaneously two different products, one of them being refrigerated. Special venting controls are included, together with two separate main control systems: one using programme logic controls (PLC) for process operations and the other hardwired for critical sequences and emergency shutdown.

Systems and piping are able to deal with the following products: acetaldehyde, anhydrous ammonia, butadiene, butanes (both iso and normal types), butylenes, butane/propane mixtures, commercial propane, propylene, and VCM. A ship can be loaded from refrigerated shore tanks in five hours, assuming a vapour return line is available, while a complete cargo can be discharged in approximately eight hours, using two Hamworthy Svanehøj electric deepwell pumps simultaneously.

If two different cargoes are being handled, loading and discharge are performed using two crossovers and two separate lines for liquids and vapours. When required, a booster pump and cargo heater can allow a cargo to be discharged against counter-pressure and at a high temperature.

The propulsion plant was supplied as a package by MAN B&W Alpha and comprises a 6L27/38 engine running at 800rev/min and driving a VBS980 CP propeller of 4m diameter with four high-skew blades. The reduction gearbox is of the 56VO28EV type, fitted with a power take-off shaft for driving a 650kW Leroy Somer alternator. An Alphatronic 2000 propulsion management system, with stations in the engine control room, bridge, and bridge wings, is included. Three Yanmar-driven auxiliary alternators, each of 360kW, provide further electrical power. *Merope Star* and her sisters are being constructed to the joint requirements of Registro Italiano Navale and ABS.

The pre-insulated and self-supporting IMO Type C cargo tanks being loaded onto a Biglift heavy-lift ship, for the voyage to Turkey. They were fabricated by Gas & Heat, an associated company of Marine Engineering Services, based in Livorno.

New concept for small LNG carriers

A tank design that is claimed as competitive for smaller classes of LNG carrier up to 40,000m³ has been launched by German specialist Tractebel Gas Engineering. The technique could also be used to create ships capable of transporting ethylene and LPG as well as LNG.

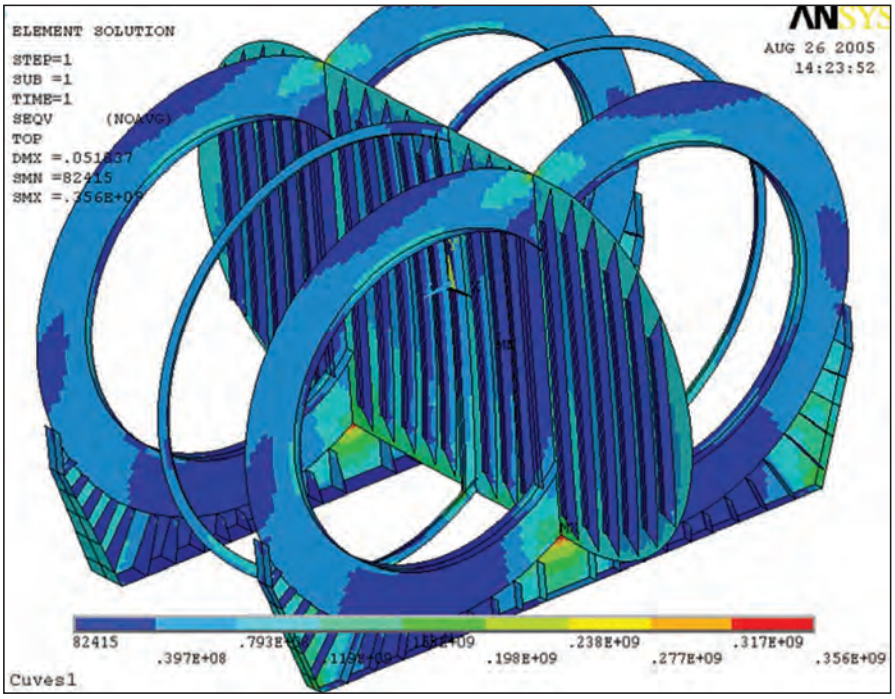
FUTURE trends in the LNG logistical chain suggest new market opportunities for smaller reception terminals and ships with cargo capacities between 5000m³ and 40,000m³. The main reason is probably that gas prices are considerably above the long-term average of the last 30 years and that liquefaction costs have been significantly reduced due to technology improvements. For example, in 2005 Tractebel, together with German engineering firm Linde, put into operation in Urumqi, China, a liquefaction plant with storage tank and distribution system, of 450,000tonnes annual capacity.

Further projects with similar capacities are under development, which require more cost-efficient transportation means. This market segment has not yet developed more rapidly, says Tractebel, because of high LNG carrier prices - mainly due to very expensive conventional containment systems (membrane type or spherical tanks). So far, more economical containment techniques, such as those using IMO Type C tanks, have only been installed on three very small LNG carriers below 2500m³ capacity. These are the Kawasaki-designed *Shinju Maru No 1* (presented in *Significant Ships of 2003*), which has very recently been joined by her virtual-sister *North Pioneer*, and *Pioneer Knutsen*, built in 2004 in The Netherlands by Bijlsma Shipyard, for Knutsen OAS.

Tractebel has extensive experience in the design of gas-handling systems for ethylene carriers. In particular, the company engineered and delivered the gas-handling systems and four Type C bi-lobe cargo tanks for each of five 22,000m³ semi/fully refrigerated ethylene/LPG ships built in 1999 and 2000 at the Jiangnan Shipyard, in China, for Navigator Holdings. Now the company has drawn-up a design still featuring bi-lobe cylindrical cargo tanks, but which can be applied to LNG carriers of up to 40,000m³ capacity with individual tank sizes up to 10,000m³. Such tanks can be fabricated by experienced manufacturers and easily be installed into a ship's hull.

The design parameters of the Chinese-built vessels were taken as a basis for the new LNG tank system. According to pressure vessel codes, the new concept will allow cargo transport at above ambient pressure, which offers advantages for LNG handling in smaller parcels. The major challenge with these tanks is, however, proper design of the supports.

State-of-the-art support designs used by ethylene carriers are not suitable for LNG cargoes because of higher shrinkage of the tanks due to lower cargo temperature. Therefore TGE has developed a new support design for bi-lobe tanks and other cylindrical tanks, which complies with the specific requirements of LNG transport. This newly created containment system, for which a patent is pending, has already been approved in principle by an unspecified classification society for a 30,000m³ vessel.



Because LNG is carried at much lower temperatures than ethylene, Tractebel had to design a new system of support for its bi-lobe LNG tanks. A finite-element model of the supports is shown here.

This new tank concept for small LNG carriers furthermore suggests, the company believes, a very economic design for gas carriers is possible, capable of carrying not only LNG but also ethylene and LPG cargoes. This would be achieved by additionally installing a reliquefaction plant for ethylene.

Emerging new markets for small-scale LNG transportation may not employ dedicated ships continuously for a long period. Hence, the economy of investments in such tri-cargo ships will be much more promising, if the flexibility of the ships can be improved by the capability to also carry other cryogenic gases. Accordingly, small LNG carriers based on Tractebel's new design may also be considered for an ethylene carrier being upgraded for LNG transportation. The company suggests that the additional cost for this upgrade from ethylene may increase the ship price by only 5% to 10%, depending on hull size and requested features of the gas-handling system. Consultation with interested shipyards has already revealed a promising future for this enterprising technique.

Renk gears and clutches for new-generation LNG carriers

THE appearance of a new breed of LNG carriers with diesel-electric or low-speed mechanical propulsion has called for the corresponding design of new-generation gearboxes and transmission components. For German gear manufacturer Renk this has been good news, and already a number of combining gearboxes are being built for diesel-electric carriers on order in Korea; the single propeller is driven by twin electric motors (for example, two x 15,000kW) which are linked to the propeller shaft by a twin-input/single-output gear with centre distances of 4m.

For the alternative twin low-speed diesel plant, as specified for 216,000m³ LNG carriers ordered at Samsung and Hyundai, Renk's Rheine factory is supplying a new type of propeller shaft clutch. This will enable either of the 8647kW MAN B&W 6S70ME-C engines on these twin-screw vessels to be disengaged for economy cruising under certain conditions. Renk is optimistic for further orders from LNG carrier operators featuring both diesel-electric and low-speed diesel transmission equipment.

Prism shape: a novel LNG tank containment proposal

In recent months, a number of attractive alternative proposals to the popular methods of cargo containment on LNG carriers have been put forward. Here, a group of authors discuss an unusual concept designed for ConocoPhillips* and planned to reduce free surface and sloshing loads.

WITH the current drive for ever-larger LNG projects, many are seeking ways to improve transportation performance.

ConocoPhillips has been working on a number of areas of technology relating to large LNG ships, and one of the first projects to achieve results is the Prism tank concept, which has recently received approval in principle from the American Bureau of Shipping (ABS).

The key feature of this tank's unique shape is its ability to reduce free-surface area, thus reducing high-impact sloshing loads and transverse resonance periods in the tank. This should lead to larger ships with fewer tanks and reduced cost.

The free-surface reduction resulting from the design is important because impact pressures due to sloshing motion from the cryogenic liquid cargo inside tanks are one of the most critical loads when designing LNG containment systems.

The magnitude, effective area, and duration of the impact load are all important when considering structural response of the containment system. It is also important to understand the spatial and temporal pattern of the impact load in concert with structural response of the containment system.

After preliminary in-house engineering design work, ConocoPhillips arranged for model tests on the Prism tank design to be conducted at Marintek, in Norway. Critical ship motion responses and sloshing impact conditions were calculated for North Atlantic environment conditions. In conjunction with the model tests, it was arranged for ABS Technology to apply its proprietary numerical simulation tools to predict the dynamic sloshing pressures acting on the membrane tanks in a seaway.

Motion response calculations and tank sloshing tests were performed for a four-tank version of an LNG vessel of approximately 228,000m³ capacity. Designs for ships of this size historically have required five or six tanks. Irregular wave conditions were simulated with three filling levels for the tanks and various ship headings. The results of the tests showed that the design was acceptable and the loads on the Prism tank were equal to or less than those experienced on a traditionally designed 138,000m³ ship.

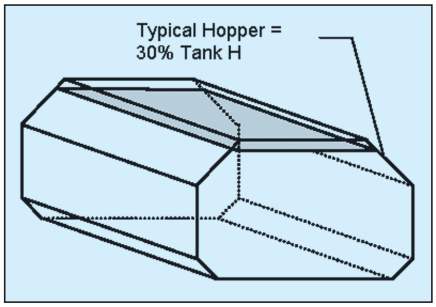


Fig 1. A conventional LNG tank configuration.

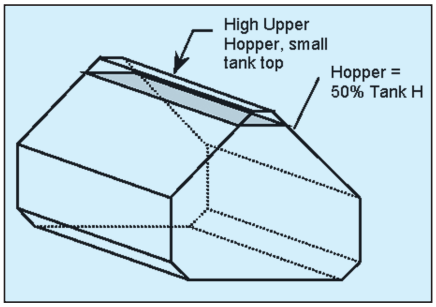


Fig 2. Configuration of the Prism tank concept.

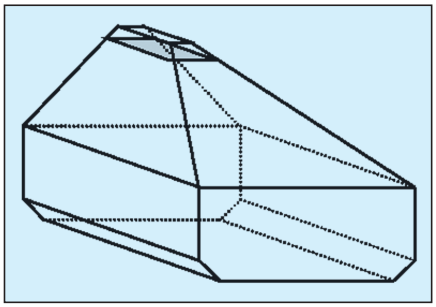


Fig 3. A development of the Prism concept: the Pyramid tank.

Concept description

The Prism tanks are similar to conventional membrane tanks except that they are configured with much higher upper hoppers than more conventional tanks that have been built to date, resulting in a long but narrow tank top. In a conventional tank (Fig 1) the upper hopper height is approximately 30% of the total tank height.

Fig 2 presents an isometric view of the Prism tank for comparison. This can have upper hoppers that are 50% of the tank height or higher (ie, resembling a prism). For the present design described in this article, only prismatic tanks were studied, ie, the cross-section does not vary along the tank length, although this is not a limitation of the concept. Fig 2 illustrates the high-peaked tank top and its long narrow liquid free surface.

An extreme development of this is the Pyramid tank, so-called because either or both of the fore or aft bulkheads are chamfered, resulting in a peaked or pyramid shaped top, with a very small free surface (Fig 3).

Conventional hulls can accommodate either of these designs, although the Prism tank ship would feature a conventional trunk deck that is increased in height and reduced in width over present-day membrane ships. The hull structure of a Prism tank ship may be designed and analysed similarly to other membrane ships, with the trunk deck offering good hull girder stiffness.

Parametric studies show that the ratio of membrane area to the enclosed volume of LNG can be minimised with careful selection of dimensions. This optimisation produces economies for overall ship costs and minimises boil-off rate.

Concept ship design

In the study described, the design of a 228,000m³ capacity ship utilising the Prism tank concept was carried through to the concept level to determine its feasibility and economic viability. Comparison was made with a concept ship design developed by

* Extracts from a paper presented recently at the Society of Naval Architects and Marine Engineers (SNAME) by Peter G Noble and Lars Ronning (both from ConocoPhillips Marine), John Paulling (from Herbert Engineering Corp), Rong Zhao (from Marintek), and Ho-Seong Lee (from American Bureau of Shipping).

Table 1. Comparative principal particulars for a conventional LNG tanker compared with a Prism type.

TECHNICAL PARTICULARS		
	Conventional	Prism
Length, oa	335.00m	327.00m
Length, bp	322.00m	314.00m
Beam	51.00m	51.00m
Depth	27.00m	27.00m
Draught, design	12.00m	12.00m
Displacement, design draught	158,109tonne	158,105tonnes
Air draught, at ballast draught	approx 49.50m	57.30m
Cargo capacity, 100%	228,000m³	228,000m³
Cargo capacity, 98.5%	225,000m³	225,000m³
Number of tanks	Five	Four
Speed, service	19.50knots	19.50knots

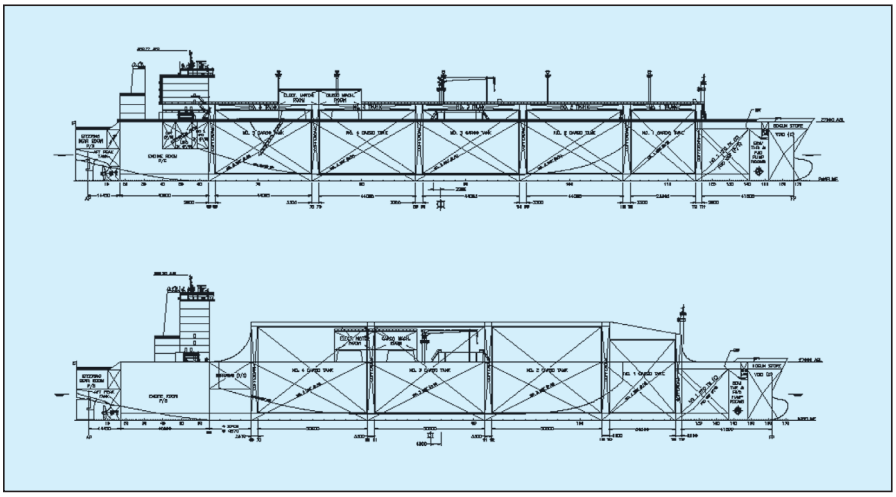


Fig 4. Profile of a conventional 228,000m³ membrane-type LNG carrier (top) and a similar capacity Prism ship (bottom), showing the shorter length of the latter. This results from the shorter cargo block and high block coefficient.

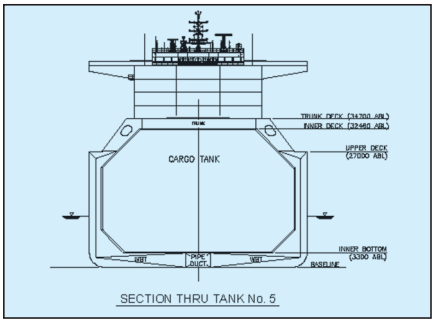


Fig 5. Cross-section through a conventional membrane LNG carrier.

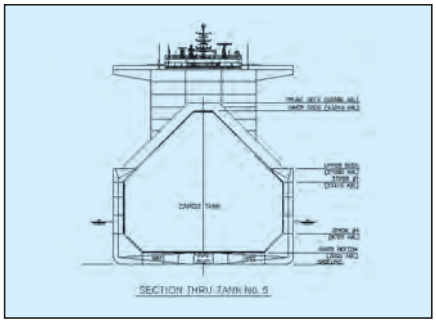


Fig 6. Cross-section through a Prism LNG carrier.

Samsung Heavy Industries for 228,000m³ capacity, dubbed the Superflex design. This design has five tanks utilising conventionally proportioned cargo tanks.

The ships described have two notable constraints. First, the draught is limited to 12m to accommodate both loading and discharge port channel depths. Second, they are both sized to accommodate one of the shipbuilder's two assembly docks on Koje Island that restricts the maximum beam to 51m. A secondary constraint is that the ships will transit the Suez Canal, so Suez tonnage measurement must be considered as well as maximum air draught.

The perceived advantages of the Prism ship are reduced LNG sloshing and higher LNG cargo volume to membrane surface area. This is proved using analytical techniques and model tests.

Two ship arrangements were investigated - five tanks and four tanks. In comparison with a ship design based on conventional tanks, if cargo volume is held constant, the Prism ship has shorter tanks (given the five-tank arrangement), as the cross-sectional area is higher than the conventional tank design. Assuming better sloshing behaviour, the tanks can be lengthened and the number of tanks reduced by removing one bulkhead. Preliminary sloshing tests have shown that the Prism ship can utilise the four-tank arrangement.

This arrangement results in advantages in lower membrane area to cargo volume - favorable for reduced boil-off and lightship weight.

Because of the draught restriction, these ships would have twin screws to achieve adequate propulsive efficiency. Studies in Sweden by SSPA have shown that hull forms with twin-skeg sterns exhibit favorable powering characteristics even for relatively high block coefficients (up to and in excess of 0.800). This has the effect of allowing the length bp to be reduced, as the length is not needed for the cargo block or engineroom. For the 228,000m³ design, length can be reduced by approximately 6m or 8m.

The Prism ship cargo block is approximately 20m shorter than that for a conventional tank ship. This allows the LCG and therefore the LCB to be located close to amidships for maximum hull efficiency. This arrangement also opens up main deck space potentially for locating cargo handling or other special gear.

Aft of the cargo block area is a portion of the hull given over to the aft fuel tanks. Both heavy and low-sulphur fuel, together with diesel oil, can be stowed here. The deck in this area is well protected by the trunk deck and could be used for cargo handling and reliquefaction equipment.

Fig 5 and Fig 6 show the tank cross-sections within the hull for both ships. The conventional tank proportions are typical of membrane tanks with an upper hopper approximately 30% of the tank total height. The larger tanks, No 2 through to No 5, are approximately 44m long and contain approximately 51,000m³ LNG each. The forward No 1 tank, approximately 30m long by 34m wide, contains 24,000m³ of LNG.

The Prism tank features the higher upper hopper, approximately 50% of the tank total height. For the four-tank variant, the larger tanks, No 2 through to No 4, are 50m long and contain approximately 65,000m³ LNG each. The forward No 1 tank, approximately 30m long by 34m wide, also has hoppers with increased height, although not as extreme as the larger tanks. This tank contains 34,000m³.

Visibility concerns

Visibility was identified as a concern early in the study because of the height of the centre of the Prism tank trunk deck. IMO bridge visibility requirements were evaluated for the base ship, and it was decided that sufficient visibility is provided if the navigation bridge is six levels above the main deck for full load (12m) and ballast draughts (9.6m) with up to 2m trim aft.

To provide the crew of the Prism Ship with sufficient visibility, the navigation bridge needed to be raised two decks, or located eight decks above the main deck. An alternative arrangement could be a wheelhouse placed forward.

Prism tank sizing

A parametric study was performed to investigate and understand the effect of varying different dimensions on the surface area of the tank, as the weight together with the cost of insulation and membrane materials are directly proportional to surface area of the tank interior.

The optimisation scheme investigated the optimum dimensions of the upper and lower hoppers, also tank length and depth for a given width and constant volume. Generally, the closer the tank approaches a cylinder or an equal-sided octagon, the lower the surface area of the tank for the given height and enclosed volume.

Fig 7 presents tank sections for the final tank height. The figure shows the lower and upper hopper combinations studied.

The Prism and conventional tank sections are overlaid (dashed bold line) on the figure. The resulting optimum section is also plotted (solid bold line) on these figures.

Fig 8 presents curves that show the effect on the ratio of volume to surface area (or volumetric efficiency) of varying the lower and the upper hopper heights for three tank depths.

The width of the tank is kept constant (at 45m) as is the contained volume (50,500m³) but the tank length is varied to obtain the target capacity. The curves plotted are the volume/surface area (V/SA) against the upper hopper dimension for a series of lower hopper dimensions. The maximum V/SA typically results when the lower and the upper hopper and the vertical side are close to equal lengths. The V/SA for the base ship (Superflex), for the Prism ship (five-tank Prism), and variant

continued

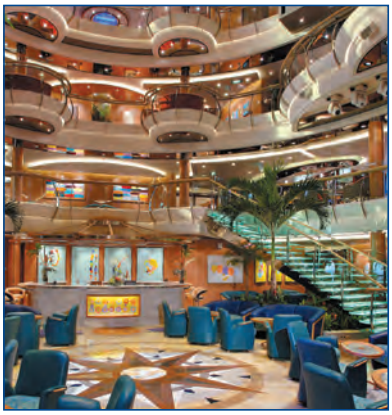
The Royal Institution of Naval Architects

INTERNATIONAL SYMPOSIUM ON MARINE DESIGN

12 - 13 April 2006, La Spezia, Italy

Second notice

In conjunction with: Coventry University; Massey University College of Design, Fine Arts and Music; University of Genoa



The modern yacht, motor cruiser, cruise ship or passenger ferry is the product of a dialogue between the engineer as the ship and systems designer who is primarily concerned with function and performance, and the marine designer who is concerned with both interior and exterior form and style. Such dialogue is essential if the inevitable conflicts between the technical and aesthetic aspects of design are to be avoided, and full advantage taken of advances in materials, computer modelling, construction techniques and equipment. For example, stronger materials and more advanced construction techniques mean that structural material can be reduced allowing greater freedom of design. Advanced computer modelling allows different layouts to be compared at a preliminary stage, thereby allowing novel concepts to be comprehensively tested. Such advances and other have given designers greater freedom and the ability to meet the increasingly demanding specifications of yacht and passenger ship owners.

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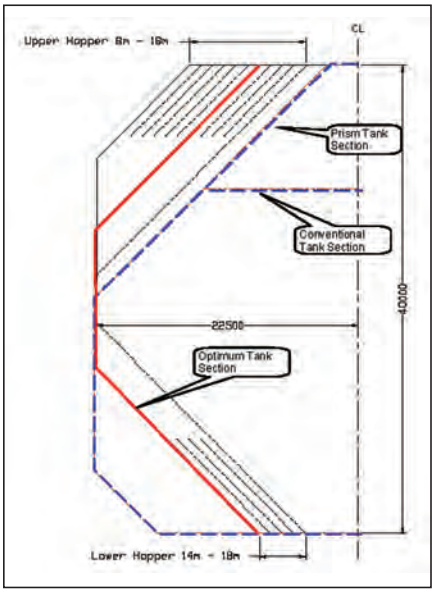

Fig 7. Tank variation details, for a 40m high tank.

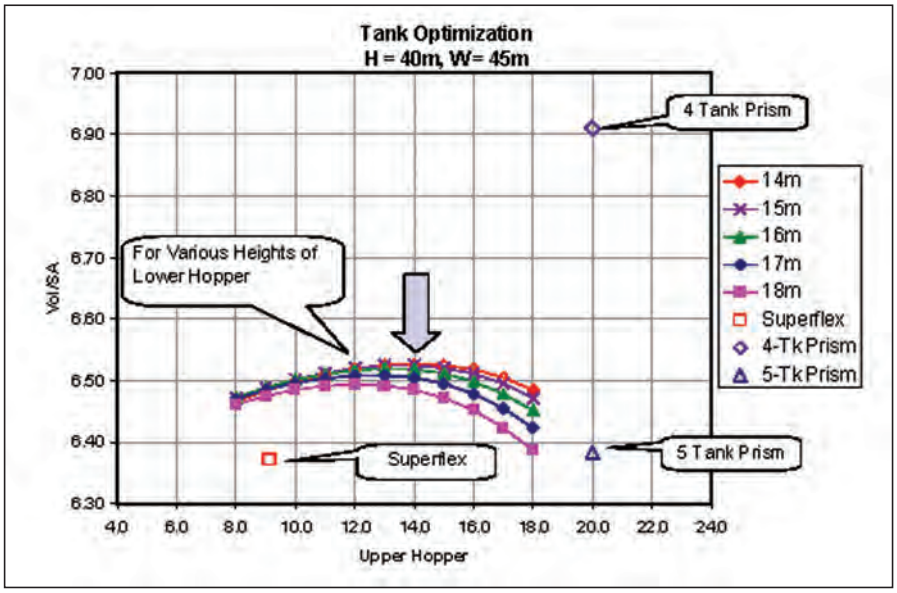

Fig 8. Tank efficiencies for various designs and heights.

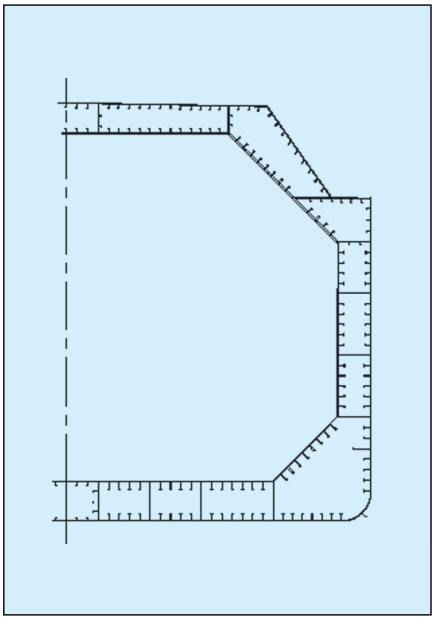

Fig 9. Midship section for a conventional design.

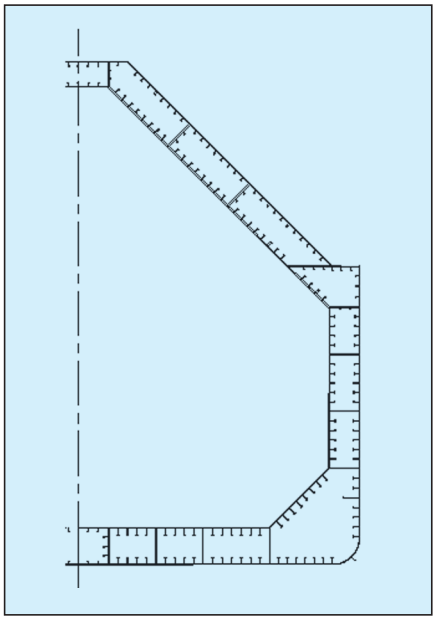

Fig 10. Midship section for a Prism ship.

(four-tank Prism) concept designs is also plotted. Note that neither the conventional tank section nor the Prism tank section used in the concept designs is particularly close to the optimum section.

For various reasons, including minimising Suez Canal tonnage, the more conventional lower hopper and longer upper hopper arrangement shown in Fig 7 was selected. For the concept ship design study, the Prism tank was given primary transverse dimensions and depth to the upper hopper similar to the conventional ship. The width of the tanks and the dimensions of the lower hopper were also kept the same as the conventional ship. However, the tank top was allowed to be approximately six longitudinal stiffener spaces wide, and the upper hopper determined by a 45deg sloping face between the uppermost stringer in the side shell and the tank inner deck.

This configuration gives a V/SA ratio around 0.5% higher than that of the conventional tanks for the five-tank Prism ship.

For the four-tank Prism ship, V/SA shows an 8% improvement over the conventional ship; this means a savings of 8% for the insulation and membrane.

Structural arrangement

The midship structure for the Prism ship was determined from an ABS SafeHull Phase A analysis of the longitudinal structure. This determines the required bending moments, the required section modulus and moment of inertia, and assesses input plate and stiffener scantlings for both global hull girder bending and local pressure loads. The minimum required bending moments all exceed the calculated still-water bending moments.

Fig 9 and Fig 10 present the midship sections developed. For the Prism ship, the section scantlings for the inner skin are slightly higher than for similar locations in the conventional ship because of the increased static head of LNG.

Steel area (and therefore weight) for each metre of length is higher over the cargo block for the Prism tank, as might be expected.

However, the cargo block is shorter and features one less bulkhead. Lightship steel is therefore comparable between the two designs.

Easy to build?

Early on, fabrication of the high trunk deck was identified as a concern with the concept. Samsung Heavy Industries performed a review of the design, including assessing ease of construction. No significant fabrication issues were found, although two minor ones will be discussed.

The high trunk deck presents no problem from a conventional shipbuilding point of view. The trunk deck itself would probably be fabricated in full transverse sections, of one cargo hold (50m) in length installed on the upper deck of the hull during block assembly.

The primary challenge involves installing the membrane and insulation inside the tank. Shipyard scaffolding would either need to be supplemented or modified for installation in these tanks. Therefore, series-ship production would provide the most efficient use of shipyard equipment and facilities.

Approval in principle

To prove the feasibility of the concept, ABS was approached and requested to review the design. The class society was also asked to give approval in principle if the design was found to satisfy its concerns. For the Prism

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Loading	% Volume	Prism 228K	138K
A	98.5	PR225LCA	138LCA
B	96.0	PR225LCB	138LCB
C	93.5	PR225LCC	138LCC

Table 2. Identification for various loading conditions.

Tz	Hs	Tz	Hs	Tz	Hs	Tz	Hs
4.0	1.9	7.5	11.1	11.0	15.5	14.5	14.9
4.5	3.1	8.0	12.1	11.5	15.7	15.0	14.5
5.0	4.4	8.5	13.0	12.0	15.8	15.5	13.9
5.5	5.9	9.0	13.8	12.5	15.8	16.0	13.2
6.5	8.7	10.0	14.9	13.5	15.5	17.0	11.0
7.0	10.0	10.5	15.2	14.0	15.3	17.5	8.7

Table 3. Forty-year waves from IACS Recommendation 34.

Load Case		Prism Ship Full Load	138K Full Load
Filling(%H)		93.41	97.61
LCG	m-AP	156.870	132.97
LCG	m-Amid	-0.130	-0.03
KG	m-BL	18.657	16.897
KG	m-WL	6.634	5.551
Draft	m-BL	12.023	11.346
Trim	m: Tf-Ta	-0.002	-0.064
DISP	MT	158436	95740
GML	m	617.155	423.946
GMT	m	5.543	2.469
DGMT	m	0.128	0
kxx	m	15.94	15.981
kyy	m	75.348	58.612
kzz	m	76.314	59.073

Table 4. Hydrostatic characteristics of a 228,000m³ Prism tank ship and a 138,000m³ conventional design.

ship concept, ABS was primarily concerned with sloshing behaviour. Therefore, sloshing analysis and model testing was conducted. This analysis and testing programme was devised to prove that the tank design did reduce the sloshing impact pressure by introducing a very high upper chamfer.

The objective in this process was to evaluate the safety of the proposed tank design under sloshing load. First sloshing simulations were performed to select model test conditions, and secondly, model tests are conducted for both the Prism tank ship and the 138,000m³ ship. Finally, test results were analysed to approve the design in principle. The four-tank arrangement was considered for the Prism ship.

As to filling levels, three cases were considered for sloshing analysis: 98.5%, 96.0%, and 93.5% of the tank volume. 98.5% of the tank volume (hereafter 98.5%V) corresponds to the full load departure condition and 96.0% volume is the calculated filling level considering the boil-off of LNG during the loaded voyage. The 93.5% volume is an extra filling level for unexpected or extreme situations. Therefore, a total of six loading cases were analysed in sloshing simulations. Each will be identified (Table 2).

Sloshing analysis

The seakeeping calculation was carried out using PRECAL version 5. The sloshing analysis was carried out using SLOFE2D version 2.1. The density of 474 kg/m³ was used for LNG.

Environmental conditions

The wave scatter diagram from IACS Recommendation 34 was employed for the unrestricted service condition. The numbers in the diagram (Table 3) represent the probability of sea states described as occurrence per 100,000 observations.

A series of 40-year waves were selected for the sloshing analysis (Table 3), where Tz is the average zero up-crossing wave period and Hs is the significant wave height.

The analysis recognises that vessel speed will be reduced in extreme sea states. Therefore, a vessel speed of 5knots is assumed for the waves of 12m and higher wave height, while 14.625knots is applied to those of lower than 12m wave height.

Seakeeping analysis

The 3D linear seakeeping code, PRECAL version 5.0, was used for seakeeping analysis. Panels are generated on the ship surface and linearised boundary conditions applied on the free surface.

Hydrostatic characteristics are shown in Table 4 for the Prism ship and for the 138,000m³ design, respectively. The LCG of the Prism ship is closer to the mid-ship than the conventional ship, even considering the length difference. Also, the Prism ship has larger KG than the conventional ship, which is due to the increased upper chamfer.

Ship speed is determined from the speed reduction curve, Fig 11, that shows the relationship of ship speeds and sea states. Originally a speed reduction curve (dotted line) was proposed.

However, using this reduction curve involves executing seakeeping analysis for a large number of ship speeds and sea state combinations, which is not practical. Therefore, a compromised speed reduction curve (solid line) was employed for the analysis. As shown in the figure, 14.625knots (75% of the design speed) was used for the wave height less than 12m and 5knots is used for the wave heights greater than 12m.

One of the important input parameters for seakeeping analysis is the roll-damping ratio. In this study, a damping ratio of 0.1 was used with an implementation of a bilge keel. However, it is observed that the bilge keel shows negligible influence on the output RAO.

Tank sloshing analysis with 2-D CFD

Two-dimensional sloshing simulations have been performed using SLOFE2D version 2.1. Simulations modelled the response of the tank to regular excitation, ie, a sinusoidal wave is applied to the ship and corresponding ship motion is generated.

Tank No 2 was selected for testing based on comparison of motion of Tank No 5 as well as Tank No 1. In long-term extreme value simulations, Tank No 1 shows relatively smaller impact pressure than Tank No 2 and Tank No 5. In short-term simulation, the impact pressure in Tank No 5 is considerably smaller than Tank No 2. It is believed that vertical acceleration related to the phase of the ship motion (heave and pitch) accounts for this large impact pressure in Tank No 2.

Model tests

Sloshing model tests for both the Prism tank ship and the 138,000m³ ship were performed at Marintek employing the recommended test conditions. For the 228,000m³ ship, only the four-tank version of the ship was tested. The model tank was built to 1/50th scale of the full-size tank, to which four degrees of freedom motion were applied: surge, sway, roll, and pitch.

In addition to applying the four degrees of ship motions, the testing facility includes motion control for the test rig and data acquisition equipment. For the tests conducted as part of this programme, test data were collected from a total of 32 sensors at the rate of 19.2kHz. The sensors included 30 pressure sensors and two accelerometers.

All cases were tested in irregular waves with 40-year return period at the speed of 5knots. The total number of cases is 38 for the Prism

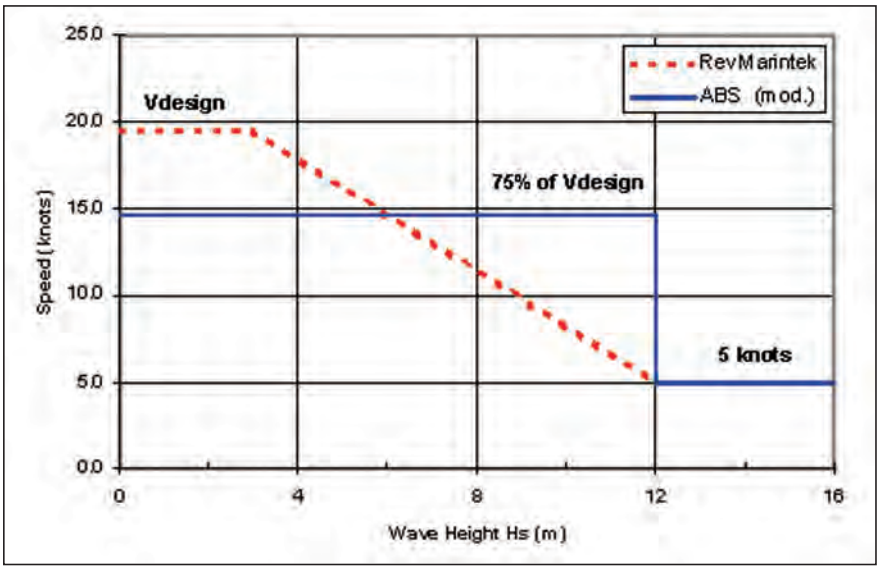

Fig 11. Ship speed versus sea states.

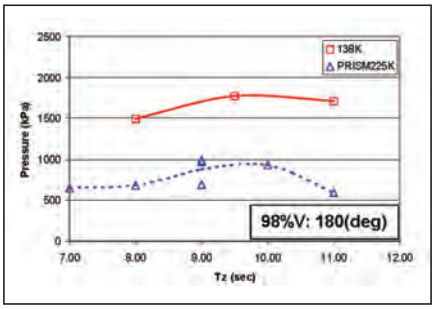

Fig 12. Most probable 3h pressures for 98% volume filling at 180deg heading (head sea) for a 228,000m³ Prism ship and a conventional 138,000m³ design.

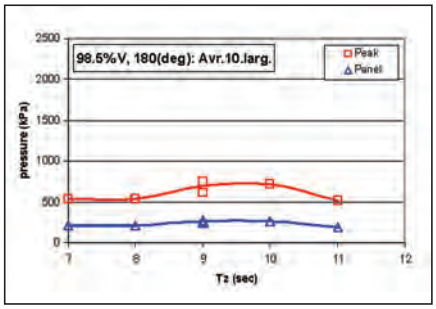

Fig 13. A comparison of peak pressure and panel pressure for the four-tank Prism tank ship (228,000m³) at 98.5%V filling. The averaged 10 largest values are compared for the filling levels and headings of interest. As shown, the panel pressure reveals considerably smaller values than the peak pressure. In average, the reduction in pressure is more than 50% of the peak pressure. In addition, the scatterings of pressure visibly decrease in the panel pressure.

ship, and 16 for the 138,000m³ design. Comparison in detail is presented in the following sections, starting with the Prism tank versus 138,000m³.

Test results and discussion

Test results for the Prism tank ship (comparison of 228,000m³ with 138,000m³) were assessed in a comparative study with the model test results for a 138,000m³ ship.

As mentioned earlier, the five-tank version of the Prism design is shorter, with narrower free surface than a conventional No 2 tank, which is the reason why low sloshing pressure was expected. However, the four-tank model is longer than that on the 138,000m³ design, which might result in larger sloshing pressure.

In fact, it is found that the Prism tank showed comparable or lower pressures than the 138,000m³ ship. The pressures are compared for two headings; 180deg and 210deg, and also for fill volumes of around 98%V and 96%V (where V = 100% tank volume). The model tests for 138,000m³ were done for 95% of the tank height and 92.5% of the tank height, which correspond to 96.8%V and 95%V. Therefore, the comparisons are performed for Prism 98.5%V vs 138,000m³ (96.8%V) and Prism 96%V vs 138,000m³ (95%V). All comparisons for the impact pressure are applied to the most probable three-hour values otherwise specified.

Fig 12 shows the comparison for 98%V filling at 180deg heading condition, (head sea). While the maximum pressure occurs at similar period of about 9.5 sec Tz, the magnitudes show significant difference. The pressure for the 138,000m³ is approximately 17bar and that for the Prism tank is only around 10bar.

Considering the filling level in the tank height is not much different (93%H for Prism, 95%H for 138,000m³), this large decrease in impact pressure is probably due to the geometry of the Prism tank. In other words, the smaller free surface and the larger upper chamfer contribute to the reduction of impact pressure in spite of the longer length and larger volume of the Prism tank.

Table 5. Maximum average impact pressure for the 228,000m³ Prism design and a conventional 138,000m³ ship.

Maximum Averaged Impact Pressure					
Prism 228K			138K		
FL(%V)	P(bar)	Head(deg)	FL(%V)	P(bar)	Head(deg)
98.5	10.3	210	96.8	17.7	180
96.0	17.3	180	95.0	18.1	180
93.5	5.5	180			

Conclusions

Sloshing analysis for ConocoPhillips' Prism tank LNG carrier has been performed by simulation and model testing for the purpose of obtaining approval in principle for the Prism tank concept. Model test conditions were selected based on sloshing simulations, and model tests were conducted for a Prism tank ship and a conventional 138,000m³ LNG carrier.

Sloshing simulations were carried out for Tank No 2 at the ship speed of 14.625knots (75% of design speed as is ABS practice) and 5knots for low seas and high seas, respectively, along 40-year waves in IACS Recommendation 34 wave scatter diagram. Two headings (180deg and 150deg) were selected for the model test based on simulation. Selected test conditions are varied between 8sec-12 sec of zero-crossing period and 10m-16m of significant wave height.

Sloshing model test results were analysed for the Prism tank ship (four-tank model) and a conventional 138,000m³ carrier. The tests were in irregular waves at the ship speed of 5knots. Three filling levels (98.5%V, 96.0%V, and 93.5%V) were applied to the Prism tank ship and two filling levels (95%H, and 92.5%H) to the conventional ship. Due to high filling levels, only head seas (180deg) and bow-quartering seas (210deg) were considered for the model test. The measured pressure is converted to the full scale using the Froude scaling law.

Comparison of the model test results is summarised as follows:

- the Prism tank ship generally shows smaller pressure than the conventional design. In average values, the Prism ship experiences 42% lower pressure than the 138,000m³ ship at near 98%V filling level, while the Prism ship pressures are approximately 4% lower near the 96%V filling level
- as shown in Table 5, the maximum average pressure for the Prism ship is found in the head sea condition with 96.0%V filling level, and is approximately 17bar in full scale. The maximum pressure occurs at Tz = 9sec. For the 138,000m³ ship, the average highest pressure is around 18bar at Tz = 8sec, also in head seas with 95%H filling level
- larger pressure was found in head sea condition (180deg) than bow-quartering sea (210deg) for both ships.
  The pressure difference between headings is smaller in a Prism ship than in the conventional design. This lower dependency on heading angles may be attributed to the larger aspect ratio of free surface in the Prism ship
- among filling levels, 96%V shows the largest pressure in Prism ship. Combined effect from ullage spacing and free surface area could be one possible reason for this phenomenon. The 98.5%V and 93.5%V fill levels are nearly 50% lower in impact pressure compared to 96%V.

For the 138K ship, the pressure at 92.5%H is slightly higher than the corresponding pressure at 95.0%H.

Based on the results, the Prism tank ship seems to show no significant increase in sloshing impact pressure compared to a conventional 138,000m³ ship. In fact, pressure in the Prism tank is found to be similar in magnitude or even lower than the corresponding pressure in the conventional design in spite of its larger tank dimensions.

The relative decrease of pressure in the Prism ship is believed to be due to the unique shape of the Prism tank, specifically, the larger upper chamfer and small free surface area. Consequent change in liquid motion including natural period change is a key factor for making the design beneficial.

Besides improved sloshing behavior, the Prism ship offers further advantages. Among these are the following:

- the hull form may be optimised with regards to LCB location because arrangement is not constrained by tank or cargo block length
- initial cost estimates appear to show a small benefit to the Prism ship over the conventional ship. Further work is underway which may indicate a larger cost benefit for the Prism ship
- the membrane area to enclosed cargo volume is lower, possibly resulting in slight reduction in boil-off. Further work is planned in this area, since reduced boil-off is very advantageous for ships that may use onboard reliquefaction.

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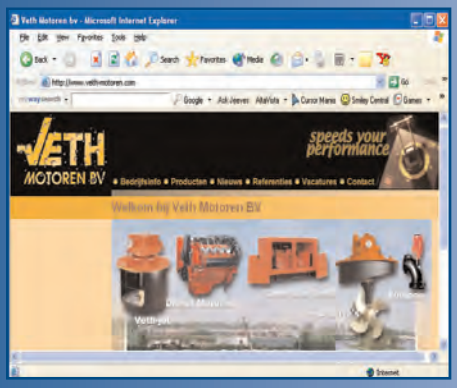

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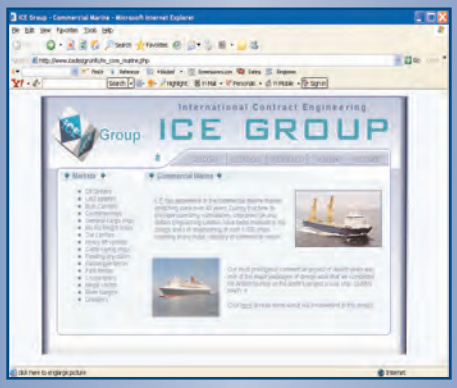

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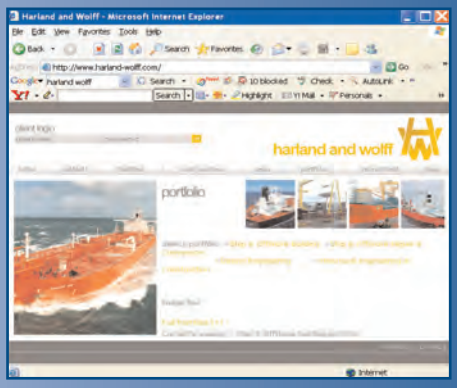

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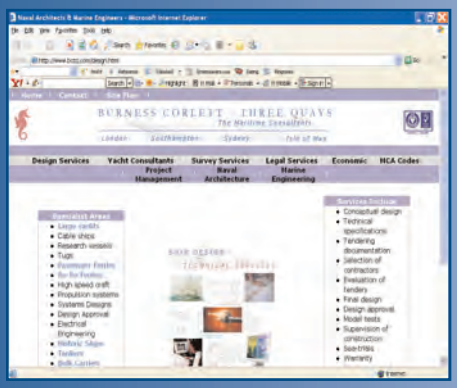

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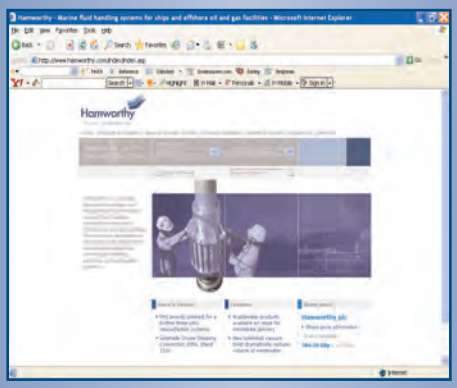

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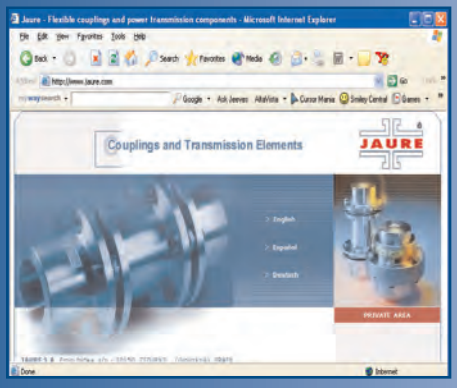

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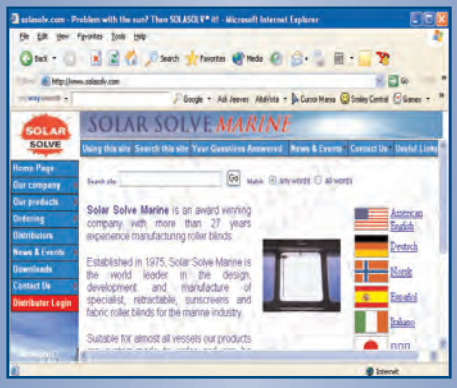

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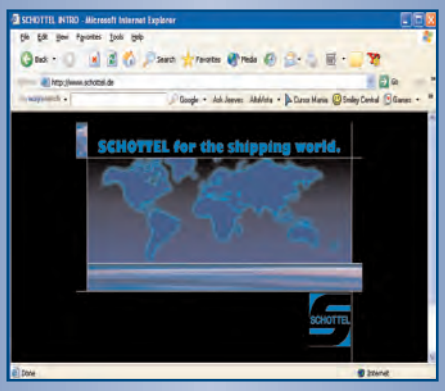

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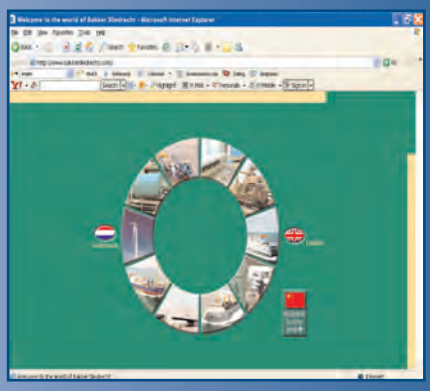

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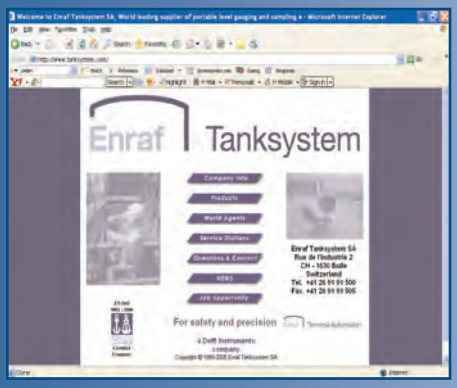

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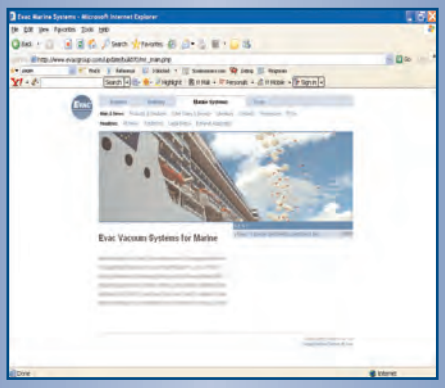

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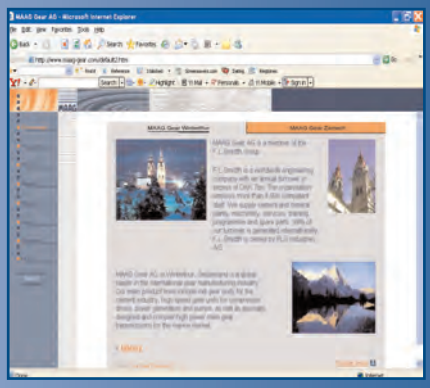

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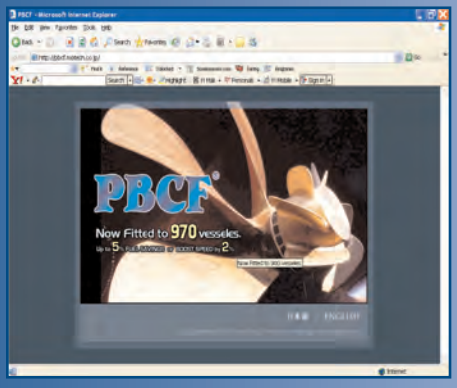

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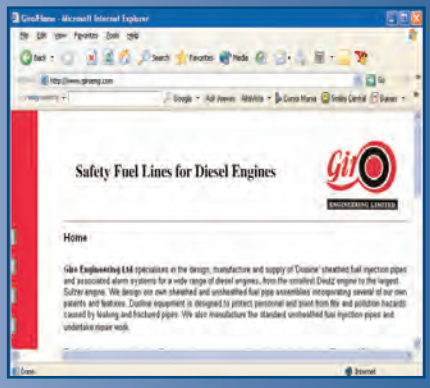

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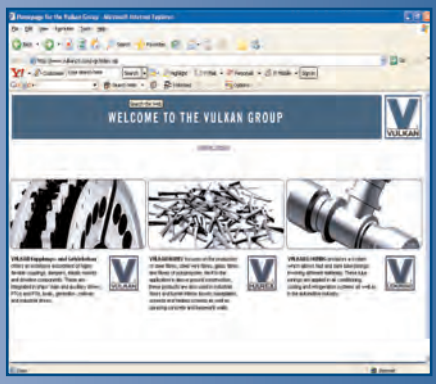

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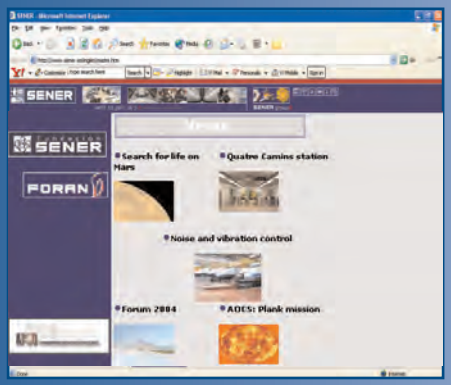

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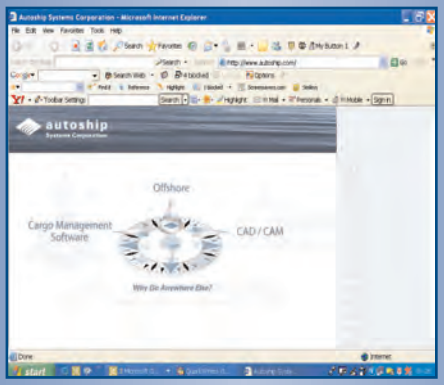

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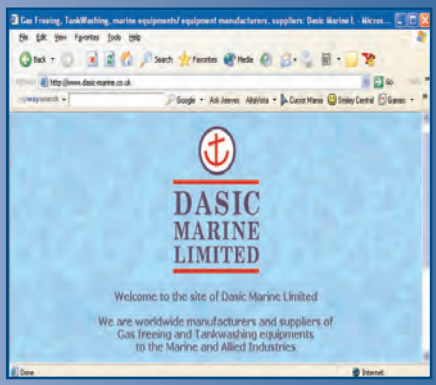

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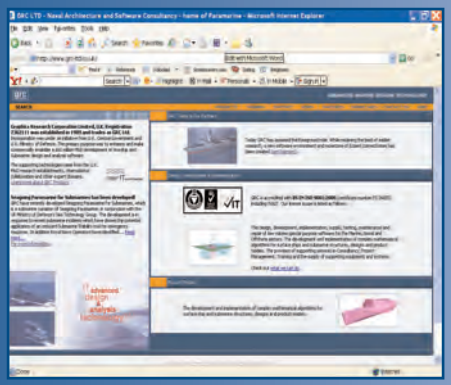

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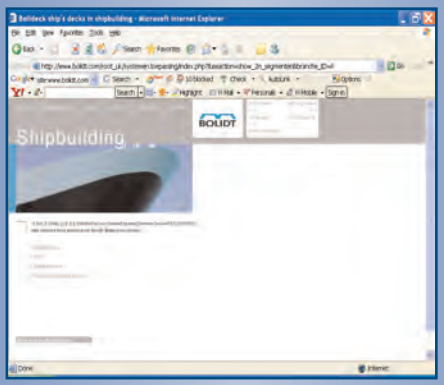

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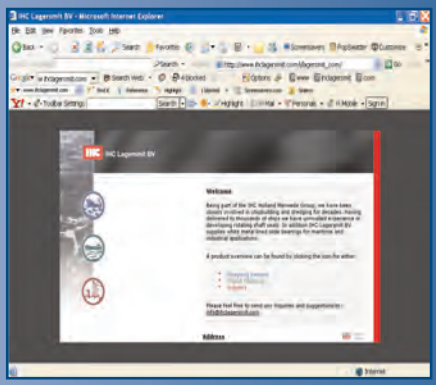

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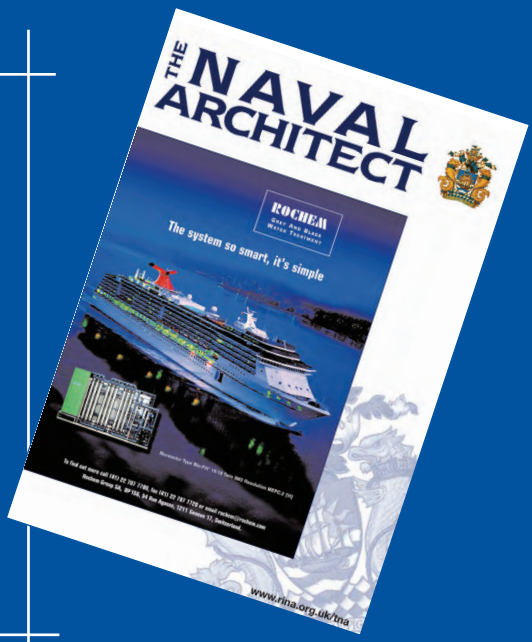

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