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THE NAVAL ARCHITECT



Regulations or classification for UK FPSOs? An intriguing possibility is opening up for UK operators to switch from traditional classification to compliance with new offshore installation regulations. A double-hull section of a typical new FPSO, *Triton 1*, is seen here during assembly at Samsung. This topic is discussed by John Still in our Offshore Technology feature on page 41.

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High performance marine vessels for both commercial and recreational use are being designed and built to meet a wider range of roles and more demanding operating conditions. The high speed maritime industry is seeking to extend its operating envelopes, reduce downtime and increase reliability and safety. More reliable methods of predicting and controlling their behaviour at sea are required, as are more efficient production methods to reduce costs.

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Rising tide of alternative rotating power?

FEW visitors - even naval architectural ones - can fail to be impressed by the sight of Sir Charles Parsons' prototype fast ship *Turbinia*, on display for immortality in Newcastle upon Tyne's Discovery Museum. She must be the only hull in the world powered by three tandem propellers on each of her triple inclined shafts - presumably the inventor's means of extracting the full potential from his revolutionary steam turbines on such a shallow draught.

Inside the transparent cutaway section of the hull, it is just possible to work out, in the antiquated design, which components are the wonderful turbines. Nevertheless, Sir Charles would be extremely disappointed to learn that just over a century later his wonderful invention is hardly used at all in the marine field (many large land power stations continue to rely 100% on huge steam turbo-alternators), the only remaining bastion yet to fully fall being the LNG tanker sector; even here, things are looking decidedly shaky as the dual-fuel diesel engine shows every promise of muscling its way in, especially allied to electric propulsion.

Alternative possibilities also being flagged up as likely candidates include conventional low-speed diesel engines, with or without dual fuel capability. In the latter case, tankers would be equipped with re-liquefaction compressor plant for re-injection back into the cargo tanks.

Notwithstanding this depressing steam scenario, the two remaining steam turbine builders, Kawasaki and Mitsubishi,

(combined diesel and gas turbine) arrangement - the first twin units so to do - in association with four Wärtsilä-engined alternators in the main machinery space (4 x 16,800kW).

CODAG is not the only possible layout, with some forward-thinking leaders - notably Deltamarin - proposing for LNG tonnage a so-called COGES (combined gas turbine and steam turbine-electric) plant where waste heat from a pair of gas turbine-powered alternators is harnessed to drive a steam turbo-alternator. All electric current generated is sent to a double-armature propulsion motor plus ship's services. This concept (outlined in *The Naval Architect* February 1988, page 9) is used in RCI/Celebrity's pioneering all-gas turbine *Millennium* (*Significant Ships of 2000*), but is again being suggested (perhaps accompanied by a great sigh of relief from Sir Charles) by Rolls-Royce for next-generation LNG tankers up to 250,000m³. Maybe more will be revealed at The Royal Institution of Naval Architects' new LNG tanker conference on September 22-23.

As explained in this issue, Rolls-Royce would use its newest MT30 gas turbine in a layout where a 36,000kW machine would work in association with a 10,000kW steam turbine using gas turbine waste heat. All power would be harnessed for both electric propulsion and ship's services (although mechanical drive to a propeller is also a possibility with any gas turbine). Rolls-Royce claims system efficiencies of more than 50%, with 12% extra cargo capacity space resulting from the more compact machinery.

We have concentrated on cruise liners and LNG tankers but gas turbines can equally well be applied - and already are - to fast ferries, including Japan's Techno Superliner in its newest incarnation, under construction at Mitsui's Tamano yard, and in the proposed IZAR/Rolls-Royce European high-speed cargo ship, not to mention FastShip's Transatlantic project should that become a reality.

Just one factor, at least, appears to be holding more owners back from more common use of gas turbines on ships - of whatever type. That is the question of fuel consumption and an ability to burn heavier and cheaper grades of fuel. Peter Nielsen, ALSTOM Chantiers de l'Atlantique's propulsion project manager, for one, when discussing this subject with *The Naval Architect* last year, believes that if this problem can be solved, many more cruise liners (and possibly other ship classes?) could one day be powered by gas turbines. GE is believed to be already working on this problem and so is Stal's gas turbine division in Sweden (today owned by the ALSTOM group).

The principal challenges are a larger combustion chamber and advanced air cooling of the blades - the latter is essential, otherwise heavy fuel will clog them. Medium-power (17MW) turbines of the Stal GT35 type (designed as land-based machines) are already running successfully on IF30 fuel - a mixture of 70% heavy fuel and 30% gas oil - on-board the high-speed ferry *Stena Carisma* between Gothenburg (Sweden) and Frederikshavn (Denmark). Mr Nielsen believes that 100% heavy fuel capability is a real possibility, which is close to what some of those few freight ro-ro ships of the early 1970s (especially around Australia and New Zealand) with heavy-duty gas turbine propulsion were burning during the modest upsurge of this power concept of that time - until two fuel crises forced their demise! If engineers could try and ensure that a waste-heat steam turbine was included in any specification, then the sterling work carried out by Sir Charles Parsons would ensure that his name continues to be remembered for yet another century. ✂

Power plant for the near-future? Rolls-Royce's new MT30 gas turbine (based on the Trent 800 aero engine) is set to offer new challenges in the commercial marine market, with large outputs up to 36,000kW being possible. DNV design approval has been secured, and ABS certification test runs are under way.



appear not to be giving up totally. As Doug Woodyard reports in our annual propulsion report in this issue, Kawasaki still promotes its mini UA-120 model with an 8800kW output - for small short-haul LNG tankers - and even in 2002 designed a powerful new model: the UA-500, with an eye on the anticipated gas tankers of 200,000m³ and more which many in the industry believe may be ordered soon.

Leading major diesel engine manufacturers (abandoned by owners in the LNG sector since, or despite, the dual-fuel Sulzer-engined *Venator* of the early 1970s) are, of course, fighting hard to re-gain entry. And then there is the gas turbine. Ah, yes, at least Sir Charles would have been pleased to note the superb rotational characteristics devoid of any reciprocating mechanical jars.

Perhaps it is significant that the brand-new eighth edition of *Pounder's Marine Diesel Engines* (reviewed in this issue) has an extra three words in its title '*and Gas Turbines*'. The market leader General Electric has been basking in the sunshine of an increasingly expanding commercial shipping portfolio, especially in the cruise liner sector. A rosy glow must be even more enhanced by the recent delivery of Cunard's new flagship *Queen Mary 2*, with her twin LM2500+ sets with Brush alternator drives (2 x 25,000kW) in the base of the funnel. These operate in a CODAG

Call for more UK engineering graduates

DURING the presentation last month of his annual review and in an informal following discussion, Roger Swann FRINA, chief executive of diversified **British Maritime Technology (BMT)**, made a call for more graduate engineers and naval architects, to ensure the continued well-being of BMT and other marine and engineering companies. He noted that at the present time, in the UK, more university students had selected media studies courses than engineering, a regrettable feature that he partly attributed to the current obsession with secondary school league tables; these meant easier subjects were taught and/or chosen, rather than more difficult mathematics and science subjects.

The number of engineering undergraduates is 20% lower than it was 10 years ago and the status of engineers is not seen as a prestigious one in the UK. BMT had already set up strategic partnerships with schools and universities to try and reverse this trend, but since the government did not appear interested, according to BMT, Mr Swan speculated that in future, companies such as his might have to pay for undergraduates to take engineering courses.

NO SMOKING DURING OUTFITTING -

For centuries, fire has been a major hazard during the period while a ship is under construction. Today, the arrival of huge ferries and cruise liners with massive quantities of outfitting materials, and associated vast numbers of subcontractors, has made fire an even more serious event, as a few recent spectacular casualties have revealed - especially that on *Diamond Princess* at Nagasaki. Many fires start because welders fail to check what is on the other side of their plates, but even more hazardous is a casual attitude towards smoking while onboard.

Capt John Noble, deputy chairman of The Salvage Association, has called for a new culture of vigilance and more effective control of the armies of subcontractors that are often onboard during outfitting. Smoking should be totally banned onboard. Only in such ways can the huge remedial costs be reduced (US\$250 million on *Diamond Princess*, where an enormous part of the hull and superstructure had to be cut away and renewed). Unfortunately, of course, the extensive fire subdivisions required on such ships when in operation are not activated during outfitting.

Capt Noble also recommends better training and management practices to avoid further disasters; firefighting should also start immediately rather than 25 minutes later, as in one case. Underwriters are becoming very disturbed, and The Salvage Association has been appointed to inspect shipyards worldwide for their procedures, as part of the Joint Hull Clause 143 Agreement. At least 14 yards have been inspected to date, and far-reaching recommendations made in some. Not all casualties are related to fire, as the recent unfortunate part-capsize of the liner *Pride of America* at Lloyd Werft's quay during a storm has shown.

TWO IZAR DREDGERS DELIVERED - At the end of last year IZAR's Gijón yard delivered two suction dredgers, *Taccola* and *Francesco di*



Delivered in December last year from the Gdynia Shipyard, in Poland, was the 24.90knot *Amaranta*, the second of a new series of 4444TEU container designs for Peter Döhle. This 8234 class of six vessels (headed by *Norasia Valparaiso*, seen here), plus four options, represents the peak of Polish container ship construction - these are the largest and fastest yet built in that country. They are upgraded versions of an earlier 4000TEU concept and are planned for high stability intake - the hull has been lengthened - and sustained speed (a more powerful Sulzer 8RTA96 engine fitted). A refined hull form, propeller, and rudder with bulb were modelled at the CTO tank in Gdansk. More details can be found in *Significant Ships of 2003*.

Giorgio (*Significant Ships of 2003*) to Jan De Nul. These are IZAR's seventh and eighth dredgers to be delivered in two years. The diesel-electric vessels have a length of 95.4m, a width of 84.7m, a deadweight of 6955tonnes, and hopper capacity of 4400m³. Main generators are powered by two diesel engines each of 2700kW, with twin 2150kW electric propulsion motors for a speed of 12.3knots. The diameter of the suction pipe is 900mm, and dredging can be carried out in water depths of 21.0m/24.3m. The same yard has also recently delivered two further dredgers for French company Dragages Ports, with 5000m³ and 8500m³ capacity.

A&P PROMOTES NEWBUILDING HALL -

In an interesting move, UK shiprepairer the A&P Group has reached an agreement with the Cammell Laird Waterfront Park to promote and use the former Cammell Laird yard at Birkenhead for shipbuilding. The covered construction hall there, built in the 1970s, was, at the time, one of the most modern sites in Europe.

Although largely unused since the collapse of the UK shipbuilding industry, the hall has been used for fabricating modules and sections for other UK builders and repairers. A&P took over the repair facilities of Cammell Laird in 2000. The covered facility was to have been part of the local 'waterfront' development, which includes a snowdome facility. However, under the terms of this new agreement, A&P Birkenhead will be the 'preferred' user of the facilities to explore the shipbuilding market.

EU PARLIAMENT VOTE ON SHIP POLLUTION -

In January, the European Parliament voted on a new EU directive aimed at combating pollution. Under the new rules, it will be a criminal offence to cause marine pollution from ships. Sanctions will be applicable to any

person or organisation causing or contributing to illegal pollution intentionally or through gross negligence - this includes the master, owner, operator, charterer, or classification society.

Parliament members also inserted a clause on voyage data recorders with a speeded-up timetable for their installation on different types and sizes of vessels. Further amendments were adopted on the definition of illegal discharges and on the development of information and warning systems. A majority of members also called for a European coastguard to carry out spot checks on all coastlines.

STRUCTURES OF QUEEN MARY 2 -

We would like to point out that the article '*Queen Mary 2: fortitude for 40 years*', that appears on pages 26 and 27 of our new special publication devoted to the Cunard liner was actually written by Lloyd's Register (by Mike Gudmunsen and Warwick Malinowski), and not as implied in the introduction. This article first appeared in *The Naval Architect* May 2003. 

PEOPLE

As a result of a management re-organisation at Atlantic Marine yards in Jacksonville, Florida, and Mobile, Alabama, **RON J McALEAR**, former president and chief executive officer of Kvaerner Philadelphia Shipyard, becomes president of new construction at Alabama Shipyard and of the repair facility at Mobile. **ED FLEMING**, who has been president of the Jacksonville repair division since 1989, has also assumed new responsibilities as president of Atlantic Marine Inc, the Jacksonville new construction yard. He replaces Ed Doherty, who is retiring. 

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Deeper draughts for optimum mega container liners?

Prof Dr-Ing Gerhard Jensen, Technische Universität Hamburg-Harburg, and Prof Dr-Ing Andreas Kraus, Hochschule Bremen, examine possible future container ships of different capacities, then vary their principal dimensions, including the draught, to find out what effect the removal of the draught limit would have on optimum parameters of future designs. Results for a 12,000TEU design indicate that a draught of approximately 16m should be seriously considered for such a project.

THE principal dimensions of ships are often governed by cost, and by dimensions of locks, ports, and waterways also hydrodynamic considerations being only of second priority. This also affects international container transport. For a long time the dimensions of the Panama Canal locks have limited the beam of container ships to 32.20m. When American President Lines (APL) had the first series of Post-Panamax container ships built at HDW in Germany, the rest of the industry did not follow.

Only after the second series of even larger ships, then built at HDW and Daewoo, and with increased container traffic, did other owners follow. Today, there are approximately 100 Post-Panamax container ships in service or on order.

For the design draught of very large container ships, a value of 14.5m has been established due to draught limitations in many ports around the world. Even in studies for ships with 10,000TEU, 12,000TEU, 15,000TEU or even larger, the same draught limit is used, leading to an unfavourable beam-to-draught ratio from a hydrodynamic point of view.

Limitations of existing ports were considered as long ago as 1994 in a study on framework conditions and concepts for future container

	Built Ships					Studies			
	APL C10	APL C11	Regine Maersk	Axel Maersk	Berlin Express	HDW 8000 TEU	ABS ULCS	LR ULCS	Malacca-Max
	1988	1993	1996	2003	2003	1997	2002	2001	2000
L_{oa} [m]	275	276	318	352	320	338	330	381	400
B [m]	39,4	40,0	42,8	42,8	42,9	45,0	45,6	57,0	60,0
T [m]	12,5	14,0	14,5	15,0	14,5	14,0	14,5	14,5	21,0
Geometrical Capacity [TEU]	4.340	4.826	>6000	6.600 (>8.000)	7.500	8.152	9.000	12.500	18.000

Table 1. Dimension of built and investigated ships.

transport systems. In that report, the possible development of container terminals, also cargo handling and distribution was a key issue. Much of the technology considered at that time, including 8000TEU ships, have today become reality. What was not foreseen was that, due to rapidly growing container trades, completely new terminals and even ports are being considered in more and more countries, including Germany.

In this respect, the authors located only one ship design, which significantly exceeded the 14.5m draught limit - Prof Wijinolt, from Delft University, presented his Malacca-Max design, which had a draught of 21m. With these dimensions however, the Suez Canal cannot be navigated, even considering

foreseeable extensions to the canal (Fig 1). Maersk's latest ship series already exceed the 14.5m draught limit by 500mm. Table 1 shows principal dimensions of some ships and some studies on future ships.

When the first Post-Panamax container vessels appeared (built by HDW for APL), other owners feared that ships like that would be too inflexible, not only because they could not access the Panama Canal, but also due to the small number of ports offering sufficiently large container cranes. Since then, cargo handling for beamy ships has become possible in many ports throughout the world.

Examining orders of new container cranes for major ports, it becomes obvious that a further increase of the beam up to 55m is expected. This corresponds to 22 containers stowed across a deck; 55m is often designated as Suezmax, because it approaches the upper limit allowed in the Suez Canal. For this beam, the canal authority does allow a draught of 17m (Fig 1).

A draught limit of 14.5m, which is the basis for many studies, points to a beam of 55m with a beam-to-draught ratio of 3.8. From a hydrodynamic point of view, a smaller value would obviously be better. To which extent the economics of a ship can really be influenced by a smaller beam-to-draught ratio was the purpose of a study, from which the authors only present a small part here.

Influence of the propulsion plant

An important basic decision concerns the propulsion system. Many published designs of very large container vessels assume a twin-screw system or the combination of a single mechanically driven screw combined with a

Table 2. Length, beam and draught for the design alternatives.

	ULCS 1	ULCS 1a	ULCS 2	ULCS 3	ULCS 4	ULCS A1	ULCS A1 a	ULCS A2	ULCS A3	ULCS A4	ULCS B1	ULCS B2	ULCS B3	ULCS B4		
L_{oa} [m]	370	370	370	370	370	352	352	352	352	352	352	352	352	352		
B [m]	57.0	55.0	54.3	51.5	48.8	57.0	55.0	54.3	51.5	48.8	55.0	51.5	48.8	46.0		
T [m]	14.5	15.0	15.2	16.0	17.0	14.5	15.0	15.2	16.0	17.0	14.5	15.5	16.4	17.3		
	Suezmax 1	Suezmax 2	Suezmax 3	Suezmax 4	Suezmax 5	Suezmax 6	Suezmax 7	Suezmax 8	Suezmax 8a	Suezmax 9	Suezmax 10	Suezmax 11	Suezmax A1	Suezmax A2	Suezmax A3	Suezmax A4
L_{oa} [m]	396	396	396	396	396	396	396	396	396	396	396	396	430	430	430	430
B [m]	57.0	57.0	57.0	57.0	57.0	57.0	59.8	57.0	55.0	54.3	51.5	48.8	58.0	58.0	58.0	58.0
T [m]	14.5	14.9	15.4	15.9	16.4	17.0	14.3	14.9	15.5	15.7	16.5	17.5	16.5	16.0	15.5	15.0



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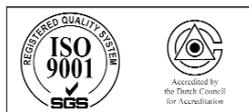
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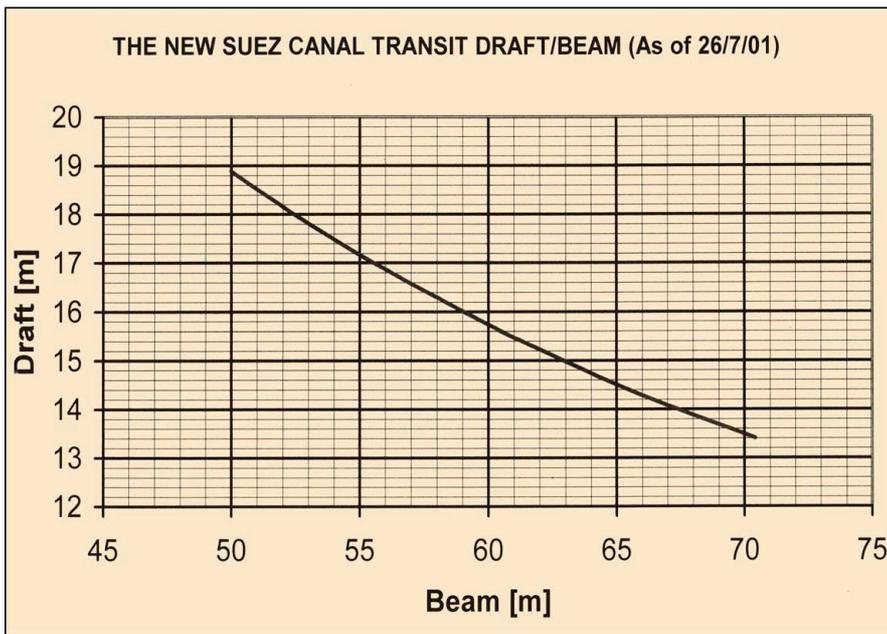


Fig 1. Maximum allowable beam/draught ratios for the Suez-Canal (Ref 2).

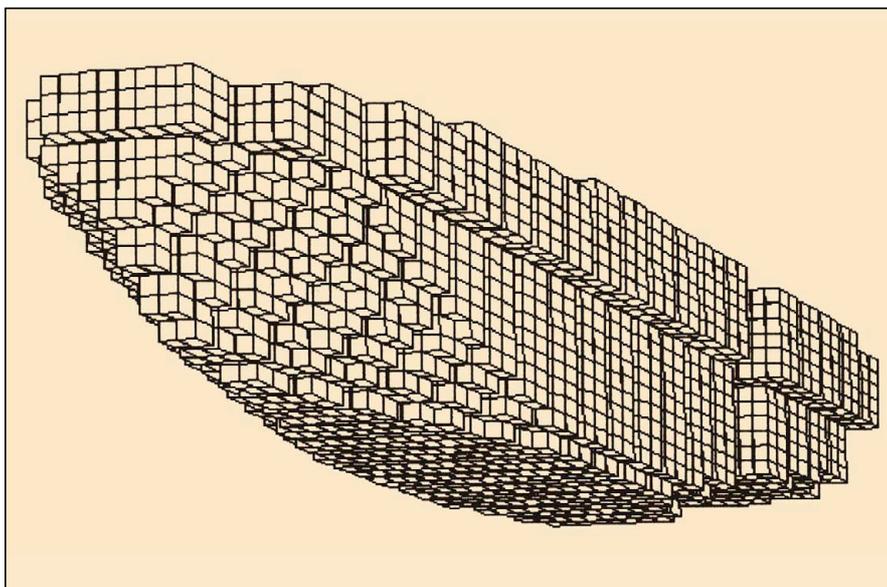


Fig 2. Example of the container arrangement.

diesel-electric pod (such as the Azipod CRP concept). The authors have the impression that many owners dislike these ideas, as they are not keen on the extra investment and maintenance.

On the other hand, major diesel engine manufacturers seem to be ready to produce engines of up to 100MW, if the demand is there. In the study, the authors also considered the possibility of transmitting such a power via a single shaft and found that this problem can be solved. Therefore only single-screw ships were investigated.

Approach

To acquire a reasonable estimate of the influence of draught, systematic variations of ships of different sizes were investigated. Beam and draught of each basic hull were

varied so that the displacement and the block coefficient were constant. In a second variation the authors kept length, beam and displacement then varied draught and block coefficient accordingly.

For each set of principal dimensions, the required power was predicted, assuming a service speed of 26knots. Other, probably higher, service speeds may be required of very large ships to compensate for longer cargo handling times in ports. On the trends within each capacity class this would have only small influence. A higher speed would lead to larger differences between the alternatives, and a variety of different methods were used to make sure that the trends were correct.

For each set of principal dimensions, the steel weight, weight of the propulsion plant, outfitting items and other components were

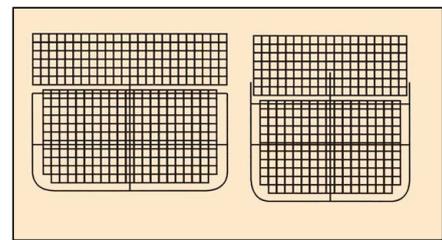


Fig 3. Container arrangement for the two limiting breadth/draught ratios.

estimated. For this study it was important to obtain the correct trends in weight changes when comparing different designs. To ascertain this for the weight estimates, different methods were used and compared. To obtain correct estimates of the cargo carrying capacity of each design, a hull form and stowage plan were generated with the help of NAPA ship design software.

Based on this arrangement and the weight estimates mentioned earlier, load cases with a homogeneous container weight of 11tonnes/TEU and 14tonnes/TEU were calculated, assuming a minimum metacentric height of 1m.

Results

As an example, results for some sets of principal dimensions in the range of a Suezmax ship are presented. In Table 2 these ships are listed as Suezmax 7 to Suezmax 11. All ships have a length around 400m, and beam/draught vary in a range between 59.8m/14.3m and 48.8m/17.5m. In Fig 3, the container arrangements for a breadth/draught ratios of 4:2 and 2:8 are shown. The block coefficient and the displacement were kept constant.

The required power for a service speed of 26knots is the smallest for the ship with the smallest breadth/draught ratio and largest length/breadth ratio. In fact it needs 15% less power. The container-intake of the narrower ship is smaller, however this is true as long as the geometrical stowage space only is considered. If the stack height is limited on deck to a maximum of six containers, the intake of the narrowest ship is 23% smaller than for the beamiest version. On the other hand, the geometrical intake is, in practice, not very meaningful.

More important is the number of loaded containers each different design can carry. For the payload, another trend can be seen, than for the intake, mainly due to the smaller propulsion plant and fuel weights. For stability reasons, the narrowest designs cannot use their full pay-load with a homogeneous cargo of 11tonne/TEU, therefore additional ballast water has to be carried. Fig 5 shows the power for each 11tonne/TEU. The most favourable configuration has a draught of 15.7m.

A similar trend is found for a loading case with 14tonne/TEU (Fig 6). Due to the lower centre of gravity of the cargo, designs with

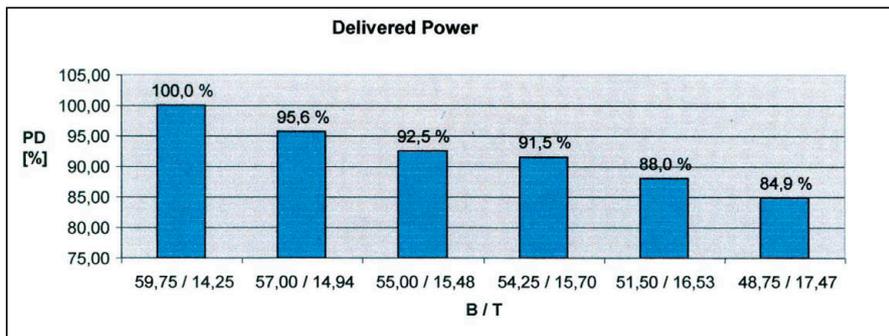


Fig 4. Delivered Power PD.

smaller beam are more favourable. The smallest power/container is needed for the ship with 16.53m beam. Looking at those two load cases only it is not possible to decide on the optimum draught; however a ship with 54.25m beam and a draught of 15.7m needs less power/container in both cases than an alternative design with 14.94m draught and a beam of 57m.

Another advantage for ships with higher draughts is the better propeller submergence or diameter, which eases the design of the propeller for the high power levels in question with acceptable cavitation and vibration excitation. With both engines and propellers, the requirements are at the limit of today's technology and thus the saving of a few percent in required power can be decisive for the feasibility of a certain ship type.

Conclusion

Those trends shown here for one ship size are confirmed for other sizes. Power/loaded container is always smaller if the draught limit of 14.5m is exceeded. A smaller power

requirement does not only mean smaller fuel cost/container, but will also affect the cost for the power plant. Payload capacity is increased because the lightweight and the fuel weight are decreased.

This paper does not intend to present the optimum principal dimensions for the next generation of container ships. If, however, ships with a capacity of 12,000TEU are planned, economic advantages are expected if a draught beyond 14.5m is considered. If the necessary water depth in ports is available, a draught should rather be selected in the vicinity of 16m. ⚓

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Fig 5. Power/container with 11tonne/TEU homogeneous load.

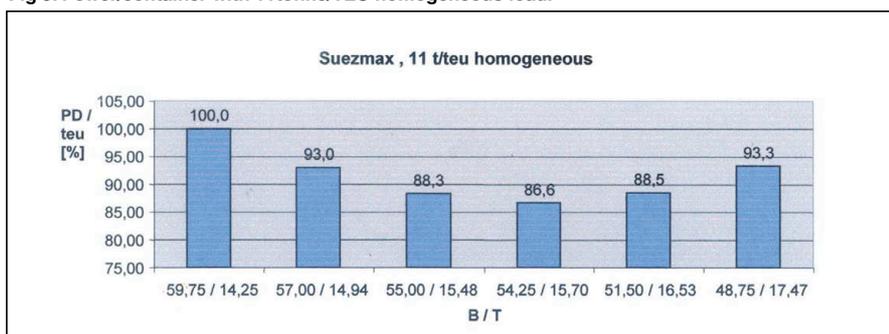
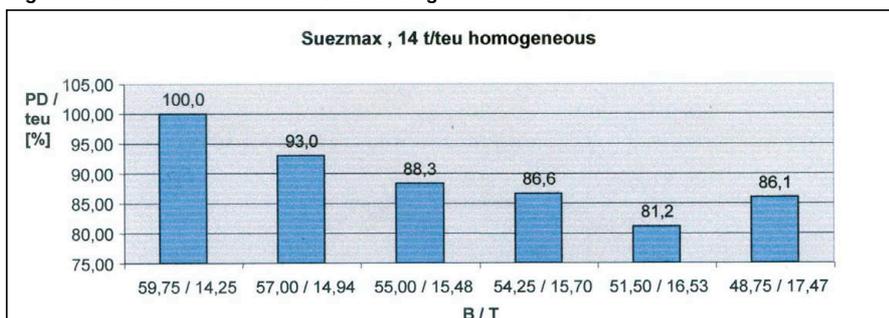


Fig 6. Power/container with 14tonne/TEU homogeneous load.



Vibrations and direction of propeller rotation

Sir - I note that a claim is being made that reductions in vibration can be achieved with inward-turning propellers, as opposed to outward-turning ones. Such a claim should however be put in context, and to my knowledge there is hardly any evidence in support of it.

It is well known that propulsive efficiency is usually slightly higher with outward-turning screws, because of the reduced kinetic energy losses in the propeller slipstreams. Whilst this flow-straightening effect tends to increase the propensity towards vibration, this can usually be counteracted with judicious propeller design.

I know of a solitary case where serious vibration which occurred with outward-turning screws was prevented when the direction of rotation was reversed. This was a freak result, however, tied in with detail of the propeller/hull interaction, which was decidedly odd. It follows therefore that this example should not be generalised. In my opinion, designers should continue choosing the direction of rotation of twin screws using their accepted criteria and should not be thrown off course with this spurious claim.

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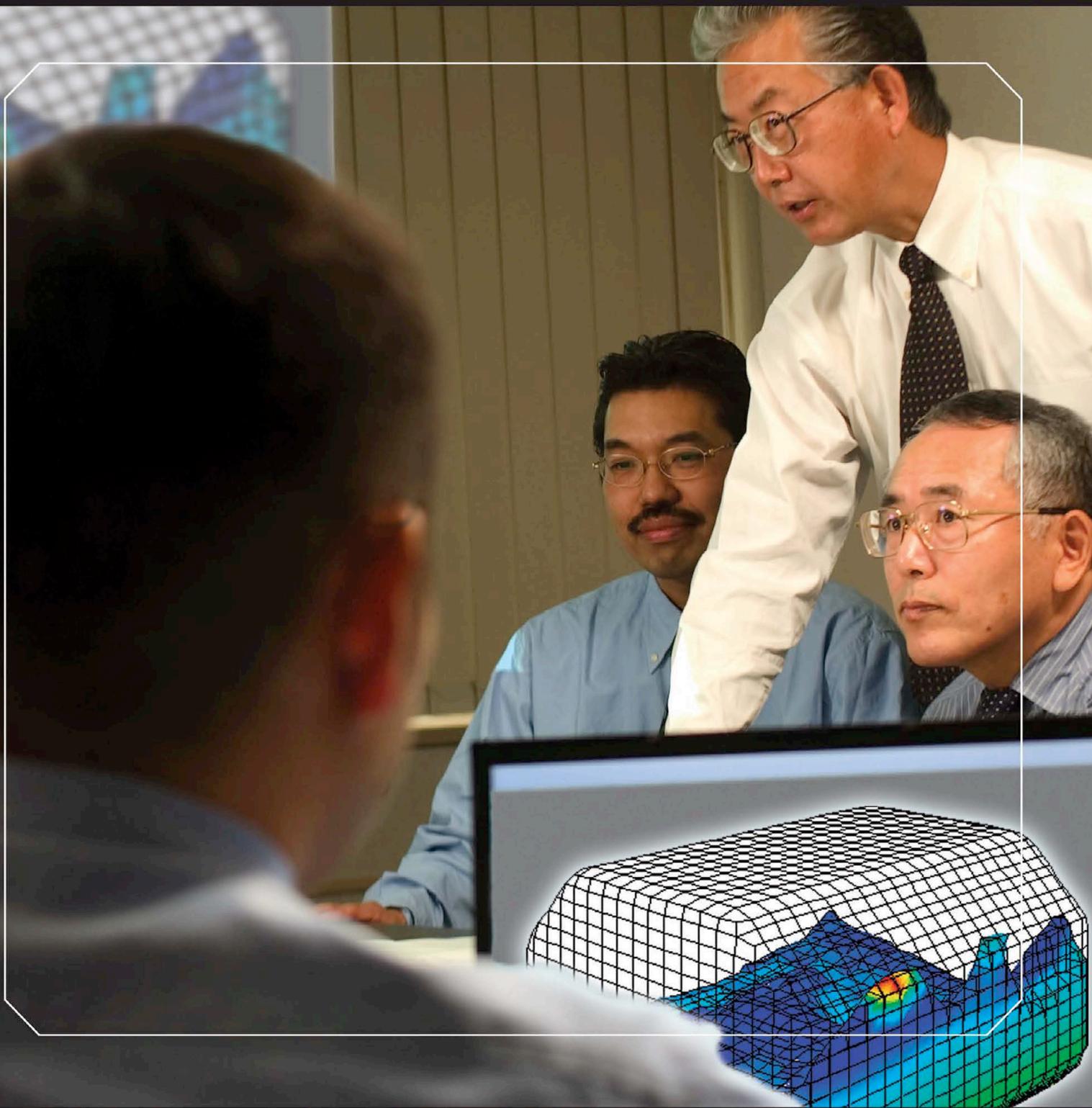
Inland chemical tanker to be supplied with V8 engine

AT the end of last year, Rensen Shipbuilding and General Electric Transportation Systems signed a letter of intent for the supply of a GE eight-cylinder vee-form propulsion engine, for a new chemical tanker being built for Friendship Tankvaart BV. Funding for this project, □. /). □□/22)59: □6685 □3' : □2 □□ □□3 /225 □□ will be made available through GE. This order is the first for GE in an inland vessel in Europe.

The General Electric V8 EFI high-compression unit, chosen for this project, has an operating output of 1345kW at 1000rev/min. GE diesel engines use the newly developed Powerstar TM controller, which is available with multiple customised protection options. This controller houses the electronic governor unit, speed reference, and load core, and protects the engine against overspeed, overload, low oil and water pressures, and positive crank pressure.

The 3800m³ double-skin tanker is due to be commissioned in 2004. The hull will have a length of 110m and a breadth of 11.40m, with a 5.60m draught. Progress Shipping BV, parent company to Friendship Tankvaart, has also expressed the intention to place an order for a further four of these vessels. ⚓

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Growing opportunities for dual-fuel engines

Moves to promote the many benefits of burning boil-off or other types of natural gas in marine propulsion engines are gathering pace, especially in dual-fuel (gas/oil) arrangements. Doug Woodyard heads his annual review of the diesel and gas turbine scene with a report on a number of new ships now entering service.

DUAL-FUEL diesel engine development continues to be driven by the increasing availability and attractions of gaseous fuels, notably their much lower level of noxious exhaust emissions, reduced maintenance, and longer intervals between overhauls associated with gas-fuelled engines. Opportunities for dual-fuel machinery across the propulsion power spectrum have stimulated high-, medium-, and low-speed designs targeting a potential market ranging from FPSO vessels, shuttle tankers, and offshore support vessels to LNG tankers and ferries.

Operation on natural gas results in very low emissions, thanks to the clean-burning properties of the fuel and its low content of pollutants. Methane, the main constituent, is the most efficient hydrocarbon fuel in terms of energy content for amount of carbon; operating on natural gas accordingly reduces emissions of another key pollutant - carbon dioxide - by more than 20% compared with operation on diesel fuel. The lack of sulphur in LNG also eliminates all SOx emissions. Natural gas has very good combustion characteristics in an engine and, because it is lighter than air and has a high ignition temperature, is also a safe fuel.

New-generation dual-fuel ships entering service

Growing opportunities for LNG shipping along the Norwegian coast stimulated the commissioning by Knutsen OAS of a 640dwt mini-LNG carrier from the Dutch yard Bijlsma. Handed over earlier this year, the 1100m³ *Pioneer Knutsen* is deployed on long-term charter to Naturgass Vest, distributing gas from a facility near Bergen to users up the west coast.

A gas-burning diesel-electric propulsion plant was specified to address environmental concerns in Norway, notably the need for reduced carbon dioxide emissions. Cargo boil-off gas - a daily rate of 0.47% is secured by the tank insulation - is fed via a heater to a pair of 900kW Mitsubishi GS16R-MPTK high-speed diesel-driven main gensets incorporating Stamford alternators. Two compressors installed on top of the cargo tanks feed gas to the engines, but should the natural boil-off gas flow fall below requirements additional LNG (forced boil-off) can be taken from the tanks for heating up.

The gas-burning gensets are supported by two 640kW diesel-burning Mitsubishi S6R2-MPTK/Stamford gensets housed in another machinery room for redundancy. The availability of gas-burning or pure diesel engines allows a choice of fuels to be made, depending on the current prices of natural gas and fuel oil. Capacity is provided for storing 84m³ of the latter.



Leading the way: today, a new generation of dual-fuel-engined tonnage is entering service, including the newly delivered mini LNG tanker *Pioneer Knutsen*, built by Scheepswerf Bijlsma, in The Netherlands. Cargo boil-off gas from the two cylindrical stainless-steel cargo tanks is fed to a pair of 900kW Mitsubishi engines driving alternators to power twin Schottel azimuthing propellers, driven by frequency-controlled electric motors. An additional two Mitsubishi-driven gensets burn diesel oil only. Service speed is 12.00knots.

Electrical power from the gensets is supplied for propulsion (two 900kW Schottel azimuthing thrusters with FP blades), manoeuvring (a 200kW Brunvoll bow thruster), and ship's services.

Mitsubishi had earlier earned a reference in the Norwegian market, supplying gas-burning high-speed engines for the double-ended ferry *Glutra*. Reduced emissions also influenced the propulsion plant specification of the Norwegian offshore platform supply vessels *Viking Energy* and *Stril Pioneer*, which entered service last year from Kleven Verft for charter to Statoil. By specifying dual-fuel engines arranged to burn LNG, this operator sought to reduce NOx emissions by 82%-84% and carbon dioxide emissions by 20%-25%, compared with traditional oil-fuelled diesel machinery.

Electrical power for propulsion (twin 3000kW Rolls-Royce Contaz 25 azimuthing CRP thrusters) and all ship's services is generated by four Wärtsilä 6L32DF diesel-driven gensets, each with a rating of 2010kW at 720rev/min. The 320mm-bore engines are arranged to burn natural gas or diesel oil in any proportion. LNG fuel stored in a double-walled vacuum-insulated tank within the hull is vaporised and supplied to the engines at a temperature of around 20°C and a pressure of 5bar via a vaporiser unit.

Larger Wärtsilä dual-fuel engines - four 5700kW 6L50DF models - will pioneer diesel-

electric propulsion in the LNG carrier sector when the first of two 74,000m³ 'Medmax' ships is handed over later this year from ALSTOM Chantiers de l'Atlantique. This French yard is also commissioned to deliver a 153,000m³ carrier (plus option) to the same owner, Gaz de France, in 2005, powered by one 6L50DF and three 12V50DF genset engines with a combined output of 38.5MW. Both engine installations will be arranged to burn low-pressure cargo boil-off gas or liquid fuel, with automatic changeover to marine diesel oil if the gas supply is interrupted while continuing to deliver full power.

Wärtsilä's DF four-stroke engines (illustrated in our February issue, page 14) can be run in either gas or liquid-fuelled diesel mode. In gas mode, the engines work according to the lean-burn Otto principle, with a lean pre-mixed air-gas mixture in the combustion chamber (lean burn means the mixture of air and gas in the cylinder has more air than is needed for complete combustion, reducing peak temperatures). Less NOx is thus produced and efficiency increases during leaner combustion because of the higher compression ratio and optimised injection timing. A lean mixture is also necessary to avoid knocking (self-ignition).

Compression ignition, as in a conventional diesel engine, results from injecting a small amount of marine diesel oil directly into the

cylinder as pilot fuel: with 'micro-pilot' injection, less than 1% of the overall fuel energy at nominal load is required as a liquid.

High-speed full-displacement ro-pax ferries operating in environmentally sensitive regions are also cited by Wärtsilä as candidates for DF diesel-electric propulsion. A 246m long design with capacity for 2000 passengers and 1500lane

metres of freight, evolved by Wärtsilä and Kvaerner Masa-Yards Technology (*The Naval Architect* February 2003, page 10), would feature a power plant of four 12V50DF and two 9L32DF-driven gensets, meeting all propulsive and ship service loads.

A service speed of 28knots is anticipated from a contra-rotating propeller (CRP) system absorbing

17MW on the electric podded propulsor and 25MW on a CP propeller driven by two electric motors. LNG fuel would be stored in tanks thermally isolated from the hull and mounted inside the B/5 line, with venting arranged upwards to a safe location. Depots at terminals on a dedicated route would reduce the amount of LNG to be carried onboard. ✚

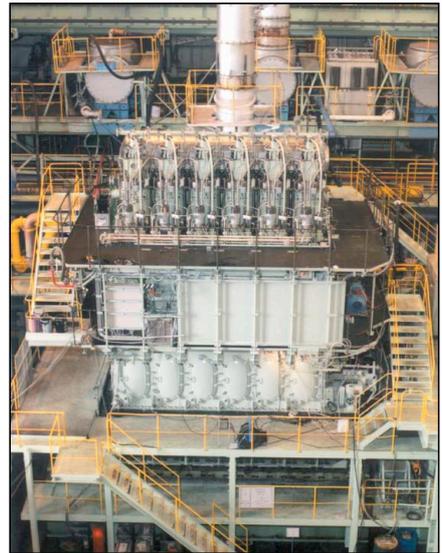
Slots for low-speed diesel engines in LNG tankers?

MAKING the case for low-speed diesel engine propulsion in LNG carriers, MAN B&W Diesel argues that more than US\$3 million is lost annually through the funnel of every steam-powered ship because of the relatively low efficiency (around 30%) of the turbine plant. The Copenhagen designer proposes its electronically-controlled ME engine to secure significantly more efficient operation, with great flexibility for fuel economy and emissions optimisation, and control system software that can be updated routinely through the life of a ship, whose deployment profile may change. A pair of ME engines arranged to drive FP propellers via clutches would inject redundancy, with a shipboard reliquefaction plant returning boil-off gas back to the cargo tanks.

As an alternative to this heavy-fuel-burning ME engine/gas reliquefaction system solution, MAN B&W recently released a dual-fuel GI

version of the ME engine for LNG carrier propulsion. Combining the high-pressure gas injection ME-GI engine with a reliquefaction plant gives operators the choice of either using the boil-off gas in the engine or reliquefying it and burning heavy fuel oil - depending on their relative prices and availability as well as environmental considerations. More details are given in an accompanying article. ✚

The Hitachi engine works in Japan has recently completed that country's first-ever electronically controlled low-speed engine without a camshaft (seen here); this is an MAN B&W 6S50ME-C model developing 9480kW. Although this particular unit is not destined for an LNG tanker (it will power a cargo ship at Naikai Zosen), MAN B&W has recently released a dual-fuel (GI) version for such ships; this would either burn boil-off gas or heavy fuel - in the latter case, gas would be reliquefied.



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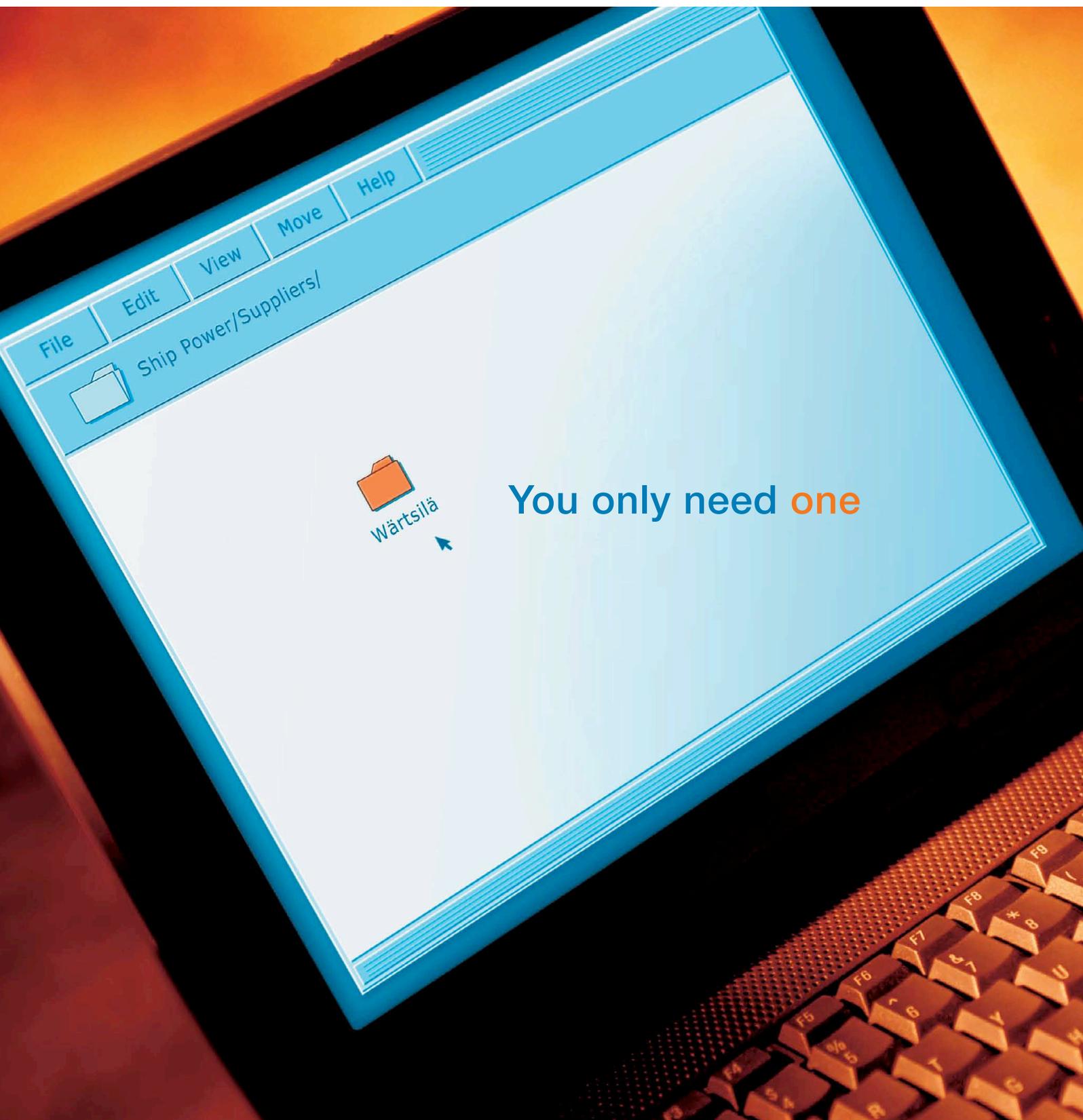
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Wider horizons for gas turbine propulsion

GAS turbines have raised their profile in marine propulsion recently with an installation serving the world's largest and most prestigious passenger ship, while a number of projects and proposals underline the potential in other commercial tonnage. Aero-derived gas turbines are attractive to naval architects as prime movers for a number of reasons:

- low weight and volume
- increased cargo capacity
- high reliability
- reduced installation cost
- freely located plant
- low noise and vibration.

Such merits - along with reduced NOx emissions - have enabled cruise ship and fast-ferry propulsion sectors to be penetrated by GE Marine Engines, which cites favourable service experience with a growing fleet.

The US group's standard LM2500 gas turbine, with well over 1000 naval and commercial references, is offered with ratings up to 25MW, while the output of the LM2500+ derivative extends to just over 30MW with a slightly better specific fuel consumption. A number of installations in large cruise liners combine LM2500+ gensets with steam turbine-generators in electric drive (COGES) configurations to yield high overall efficiency. Cunard Line's *Queen Mary 2*, which entered service in January, features a CODAG plant incorporating a pair of LM2500+ units, as explained in *The Naval Architect's* special January publication devoted to that ship.

Japan's Techno-Superliner ferry project, under way at Mitsui's Tamano yard, extends the reference list. This 140m long aluminium-hulled air-cushioned catamaran is designed to carry vehicles and passengers at 39knots over a 1000km domestic route. Two LM2500+ gas turbines, each rated at 25.18MW, will drive Rolls-Royce Kamewa VLWJ235 waterjets.

Excellent reliability and availability is reported from the plants in service, GE citing its 'reliability centred' maintenance philosophy as a key factor. Land-based specialists can track critical system parameters, the daily monitoring and trending helping to identify demands for maintenance actions in advance of an unscheduled event.

The potential of this company's highest powered design for diverse propulsion duties is highlighted by GE, citing the LM6000's 'trouble-free' service on power barges, platforms and floating production, storage and offloading vessels. With power outputs up to 42.75MW, a single set could serve as the boost engine for large fast ferries in combination with diesel engines, while multi-sets would satisfy high speed deepsea freight carrier propulsion demands.

Challenge from Rolls-Royce

But GE faces a stronger challenge in future commercial propulsion projects from Rolls-Royce, whose portfolio now embraces two highly competitive contenders in the shape of



Cunard's prestigious new passenger liner *Queen Mary 2* is the latest reference for General Electric gas turbines. Two 25,000kW LM2500+ units, positioned at the base of the funnel, drive Brush alternators to work in conjunction with four Wärtsilä diesel-driven alternators in a CODAG (combined diesel and gas turbine) arrangement. It is interesting to note the GE has achieved a 40tonne weight saving for each set on this ship.

the MT30 and WR-21 gas turbines. The British group's new simple-cycle MT30, with a thermal efficiency exceeding 40%, is available this year, offering outputs up to 36MW from a package weight of 25tonnes; the unit has recently secured design approval from Det Norske Veritas. A three-spool marine derivative of the successful aero Trent 800, the engine achieved an output exceeding 40MW during tests, which also reportedly confirmed cycle efficiencies and fuel consumption, and proved low noise and low emission characteristics (including no visible smoke).

Breakthroughs have already been made in the naval sector, the MT30 selected for the engineering development model for the US Navy's DD(X) future surface combatant's integrated power system. Rolls-Royce will deliver an MT30 generator set in early 2005 to Northrop Grumman in the USA. MT30 turbines

are also proposed as part of the propulsion system of two large UK Royal Navy aircraft carriers due to enter service in 2012 and 2015.

Cooperation with the Spanish shipbuilding group IZAR resulted in the European high-speed cargo vessel (EHSCV) concept, a 3400dwt ro-ro monohull with twin MT30 turbines. A baseline design arranged to carry up to 1700lane metres (124 trailers/100 trucks) on two decks at a service speed of 37knots (40knots maximum) would be economically competitive with road transport on intra-European routes above 300nm, the developers suggest.

A number of MT30-based propulsion systems are proposed for future large LNG tankers, of between 145,000m³ and 250,000m³ capacity. The power density of the gas turbine offers the potential to reduce engineroom length by approximately 19m compared with steam

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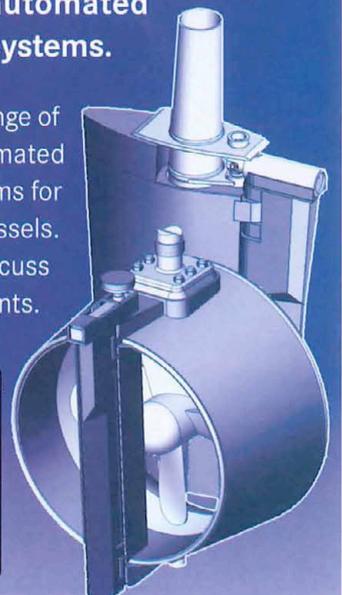
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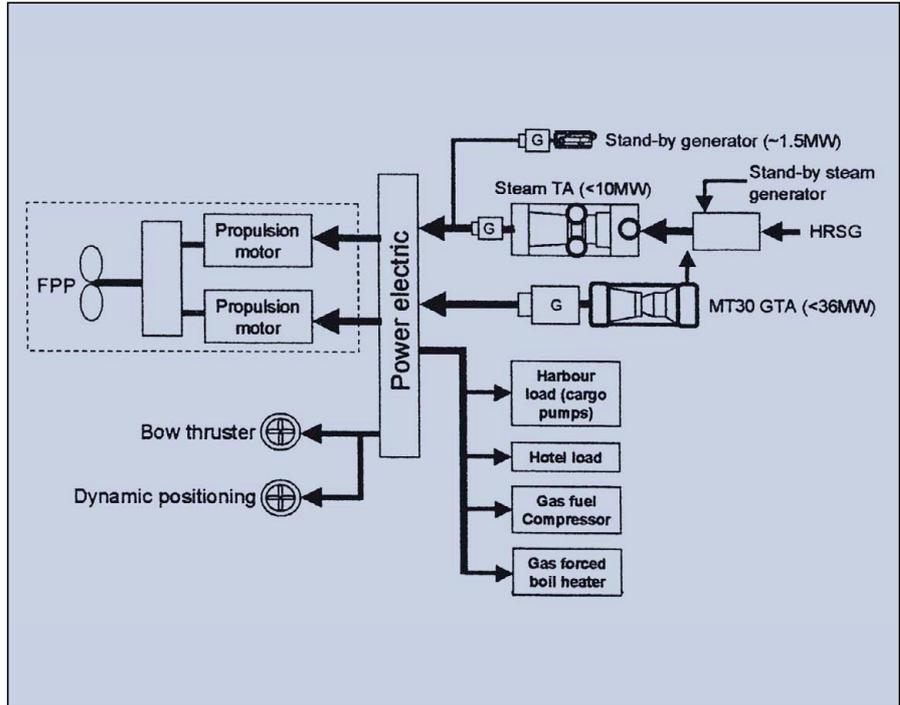
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turbine plant of equivalent output. Machinery space saving on a typical carrier thus allows cargo capacity to be increased by up to 12%, claims Rolls-Royce.

Proposals include a combined gas turbine and steam turbine-electric propulsion system (COGES) featuring a dual-fuel MT30 unit arranged primarily to burn cargo boil-off gas supplied at around 40bar pressure. A waste heat-recovery steam generator incorporated in the exhaust stack of the gas turbine supplies a steam turbo-alternator which supplements the electrical output of the main genset. System efficiencies in excess of 50% are also claimed.

Some operators may prefer a simple-cycle gas turbine-electric system, excluding the steam element and surrendering some overall system efficiency. Mechanical rather than electrical drive is another option, the MT30 then direct coupled to the propeller shaft via a gearbox. Electrical power for ship's services in this case is provided by a waste heat-recovery steam generator and turbo-alternator set and/or an electric motor/generator mechanically driving or driven by the gearbox.

Both COGES and simple-cycle electric propulsion concepts are highly flexible in terms of machinery layout, ease of access for maintenance and simplified installation, asserts Rolls-Royce. Furthermore, the low noise and vibration characteristics of the gas turbine allow the machinery to be located next to the superstructure and accommodation. An MT30-based COGES plant is also promoted for cruise ship propulsion in conjunction with smaller Rolls-Royce 501-series gas turbine-alternator sets also exhausting via the steam generator.



Outline arrangement of a Rolls-Royce proposal for a COGES (combined gas turbine and steam turbine-electric) propulsion plant for LNG tankers, based on its new MT30 gas turbine.

An alternative system for cruise ships exploits the advanced-cycle WR-21 gas turbine in an electric drive without a steam turbine element (the exhaust is used to generate domestic steam supplies). This intercooled and recuperated (ICR) design, based on the RB211 and Trent

aero engines, is rated at 25MW and promises significantly improved fuel economy throughout the load range compared with simple-cycle turbines. Twin WR-21 turbine-generator sets are proposed for a typical cruise ship.

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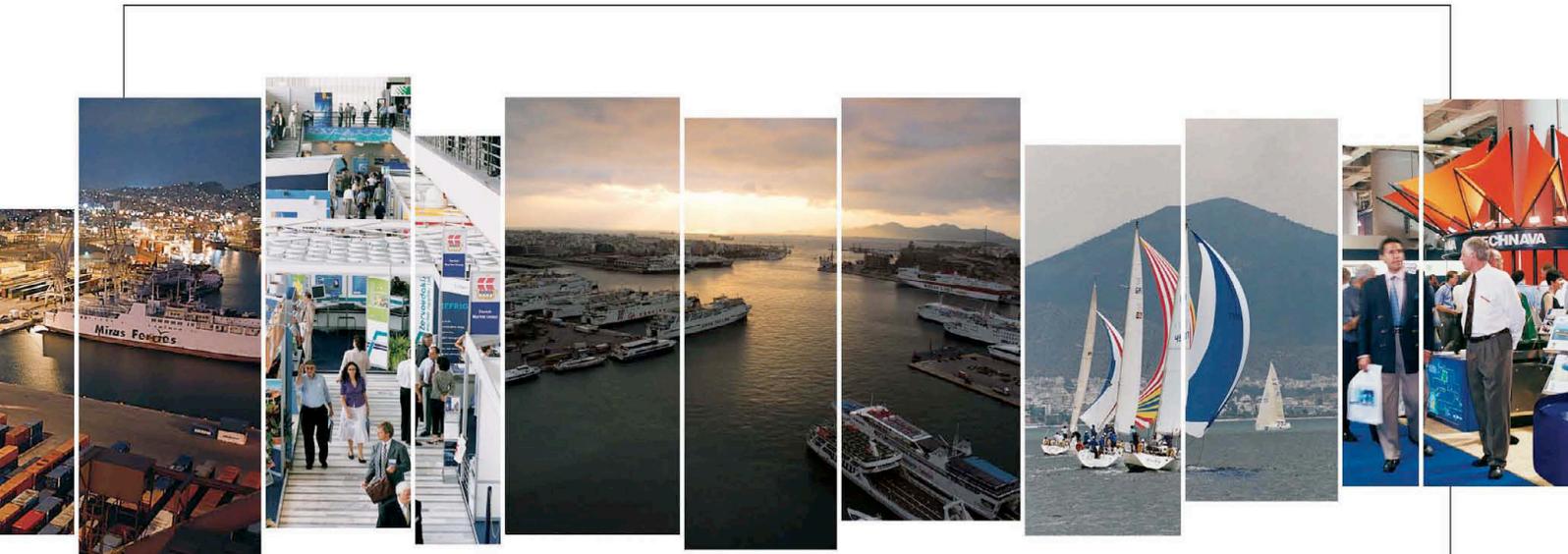
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Competitive pressure rises on steam propulsion for LNG tankers

SINCE the emergence of a high-profile Liquefied natural gas (LNG) trade in the early 1970s, steam turbines have retained a dominating grip on LNG tanker propulsion - despite being ousted during that time from all other mainstream commercial shipping sectors, including large passenger vessels, container ships, and tankers. Nevertheless, today the steam turbine's supremacy is being more seriously challenged by diesel and gas turbine machinery in both mechanical and electric-drive configurations.

Stimulating the original choice of steam turbines for LNG tankers was the need for a high-power output, proven reliability, and ability of the associated boiler plant to burn low-grade fuel as well as cargo boil-off gas. Turbine maintenance was also relatively modest in cost.

Among the drawbacks - now less acceptable - is the comparative inefficiency of steam plant and hence high fuel consumption, which also translates directly to high carbon dioxide emissions. A declining population of competent seagoing steam engineers, poor manoeuvring characteristics, and limited propulsion redundancy are also cited by opponents proposing diesel-based solutions.

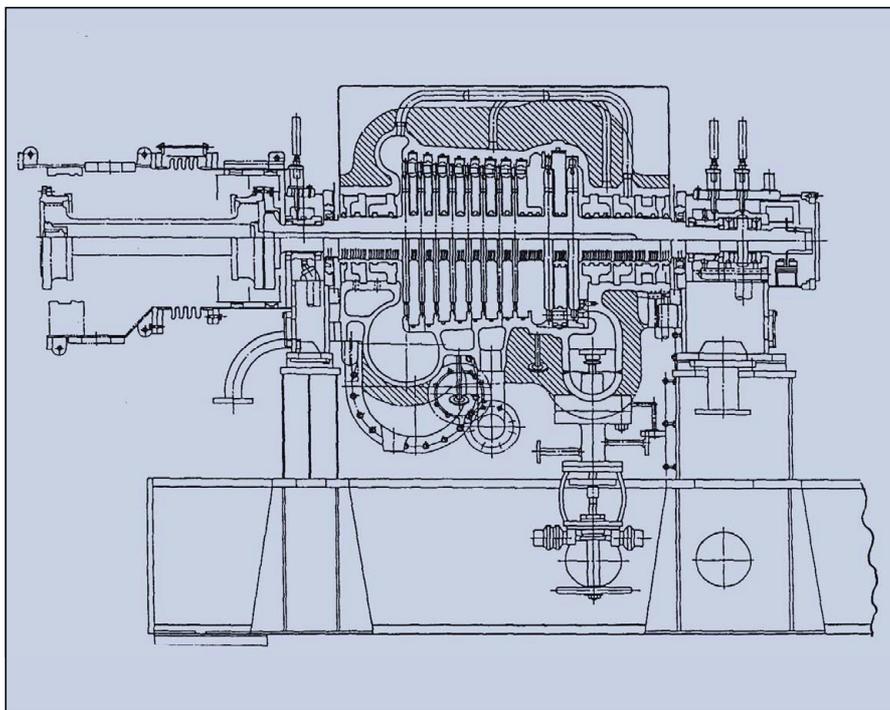
Steam plant development has been muted, compared with impressive diesel engine advances, and the number of designer/manufacturers of large steam turbines and boilers active in the marine market has dwindled to a couple of Japanese suppliers. Among the few specialists remaining to contest the niche is Kawasaki, which has a pedigree dating back to 1907, when it started producing steam turbines under technical tie-ups with Curtis Co (USA) and John Brown Co (UK).

Kawasaki's own-design K-, S- and H-series of the 1950s and 1960s, with entry steam pressure and temperature conditions ranging from 18kg/cm²/340°C to 40kg/cm²/450°C, gave way in the mid-1960s to the UA and UC types (60kg/cm²/510°C). These non-reheat types were supplemented by the UR reheat design.

References were earned in the LNG carrier arena from the early 1980s with UC-400 and UC-450 turbines for 125,000m³ and 128,000m³ capacity tonnage - respectively with maximum ratings of 29.4MW and 33MW - built by Kawasaki Heavy Industries for Japanese and overseas owners.

Deliveries in the 1990s switched to the UA-type with outputs generally ranging from around 26.5MW to 28.7MW, but an 8825kW version was supplied for a 19,100m³ carrier handed over by KHI in 1995 to Hiroshima Gas. The UA-type, a non-reheat two-cylinder cross-compound impulse/reaction design with high-pressure and low-pressure stages, can accept steam entry conditions of 62kg/cm²/525°C. Design refinements have benefited turbine efficiency, while computer analysis has enhanced structural anti-vibratory performance.

A wide-ranging UA programme extends from the UA-120, with a maximum continuous rating



The high-pressure section of a Kawasaki UA steam turbine. The two remaining major manufacturers of large marine steam turbine (Kawasaki and Mitsubishi) appear determined to retain their market share.

of 8800kW, to the UA-440 rated at 32.4MW; a more powerful UA-500 design has been offered since 2002 to target anticipated 200,000m³-plus LNG carriers. UA installations have earned a high market share from Japanese, South Korean, and European newbuilding projects, references in the past year including the 145,000m³ *Energy Frontier*, whose UA-400 turbine with a maximum rating of 26.9MW at 80rev/min delivers a service speed of 19.5knots.

Packaged plants are supplied to foster a reduction in overall machinery weight, an ergonomic engineerroom arrangement, and ease of installation. The HP turbine and manoeuvring valve are sub-assembled on a common bed and the LP turbine is coupled with an underslung main condenser. Both assemblies are connected to a reduction gearset incorporating the main thrust bearing.

Kawasaki also manufactures the special double-reduction gearing associated with the turbines, whose high-pressure and low-pressure elements typically rotate at 5000rev/min and 3300rev/min respectively, a speed which must be reduced to 80rev/min-90rev/min for the propeller.

Another Japanese group, Mitsubishi, entered the steam turbine business a century ago and now offers the MS-2 and MR-2 series, which are respectively non-reheat and reheat-type two-cylinder cross-compound impulse-reaction

designs. A range of models covers power demands beyond 44MW, the five basic elements forming each package being matched to the specific requirement. Last year's delivery references included the 137,000m³ *Pacific Notus*, whose MS32-2 turbine delivers a service speed of 19.2knots with an output of 21.32MW at 81rev/min. Mitsubishi also enjoys a healthy share of the main boiler market provided by LNG carriers, having developed advanced dual-fuel units and electronic control systems.

Opportunities for rival prime movers - diesel engines and gas turbines - to enter the LNG arena have been boosted by developments in dual-fuel burning technology, the recent newbuilding order boom, and the interest of operators in securing higher operational flexibility with efficiency for varying contractual speed and deployment scenarios. Alternatives to the long-dominant steam turbine are covered elsewhere in this report.

Recent breakthroughs by dual-fuel diesel and gas engines at both ends of the LNG tanker propulsion spectrum - in the 110m³ *Pioneer Knutsen* and a 153,000m³ capacity project for Gaz de France - as well as the marketing efforts of gas turbine suppliers must give cause for concern to those favouring the whiff of steam. Options for enhancing the efficiency and flexibility of steam plant are limited, and only the residual conservatism of LNG tanker shipping can prevent the surrender of its last bastion. ☪

Medium-speed engine advances: more power from the same space

LEADING medium-speed engine builders have upgraded their larger bore models to offer ship designers an opportunity to specify more powerful, economical, and emissions-friendly plant without increasing installation space requirements.

MAN B&W Diesel's redesign and uprating of its 480mm-bore 48/60 engine to B-status has strengthened the appeal of both in-line and V-cylinder models for passenger and cargo ship propulsion. Recent orders called for 10 12V48/60B engines for two vessels booked at Meyer Werft for Norwegian Cruise Line, each (five per shipset) developing 14.4MW; and seven 8L48/60B models (9600kW) will power a series of feeder container ships commissioned by German owner Hermann Buss from China's Zhoushan yard.

Launched in 2002, the B-version offered a 14% rise in specific output to 1200kW/cylinder at 500/514rev/min from a lighter and more compact design than its predecessor. A power band from 7200kW to 21.6MW is covered by six-to-nine in-line and V12, 14, 16, and 18-cylinder models.

Other development goals resulted in a minimum specific fuel consumption of 173g/kWh (for the V-engine at 85% MCR) - 7g/kWh less than the original design - and NOx emission values on the IMO test cycle some 8% less at 12g/kWh. Accompanying the higher output, better fuel economy, and enhanced environmental friendliness is a lower specific weight (down by 16% to 11.9kg/kW). The original 12V48/60 engine, for example, weighs 193tonnes while the more powerful B-derivative equivalent has a weight of 181tonnes.



Caterpillar Motoren has uprated its successful M43 engine to 'C' status, with an output of 1000kW/cylinder.

Overall dimensions were also shaved: the height remained the same but the B-engine is 800mm (15%) narrower, thanks to a new exhaust system. A pair of 48/60B engines can thus be mounted closer together than before,

giving an installation width saving of one metre. The turbocharger and two charge air coolers were combined to form a single module on the V-engine.

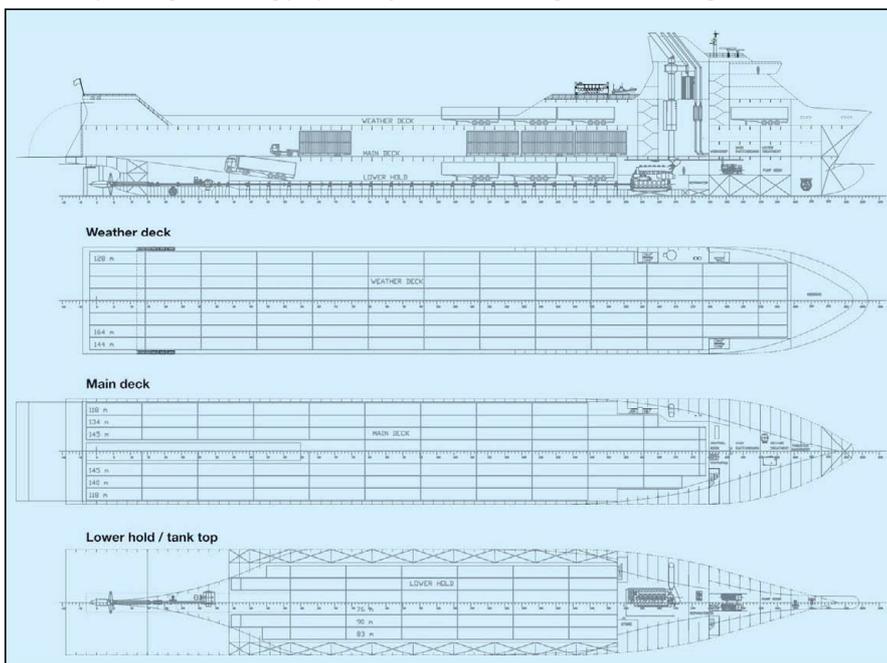
Uprating for MaK M43 range

Another German group, Caterpillar Motoren, recently strengthened the competitiveness of its successful MaK M43 engine by raising the output of the 430mm-bore design from 900kW/cylinder to 1000kW/cylinder at 500/514rev/min. Over 250 examples of the in-line M43 engine - introduced in 1998 - are in service or on order, overwhelmingly for propulsion duty in feeder container ships, ro-ro ferries, and ro-pax vessels. The uprating initially benefits the in-line cylinder models (6, 7, 8, and 9) but will be applied later to the V-models; engines with the original rating also remain available. European customers have already ordered the first uprated engines in eight and nine-cylinder versions.

Apart from seeking a higher power rating, the M43 redesign addressed simpler maintenance, increased operational reliability and reduced noise levels. The facility to install Flexible Cam Technology (as original equipment or later by retrofit) enables lower NOx and particulates emission levels to be attained.

Visible smoke under part load and transient conditions can reportedly be eliminated and NOx levels of 8g/kWh (30% less than IMO requirements) achieved using only primary 'in-engine' measures. Further reductions in NOx

A very long propeller shaft with the gearbox located far aft and a single Wärtsilä 6L64 high-output medium-speed engine is being proposed by this Finnish designer for ro-ro freight carriers.



emissions, without resorting to water or fuel-water emulsion injection, will be pursued by Caterpillar Motoren through common-rail fuel injection technology.

Ro-ro role for Wärtsilä 64?

The world's most powerful medium-speed engine - the 640mm-bore Wärtsilä 64, with a rated nominal output of just over 2000kW/cylinder at 333rev/min - has earned propulsion plant references in container ships, multi-purpose cargo vessels, and chemical/product tankers. With minor modifications, it is also considered attractive for ro-ro freight carriers, with the machinery located well forward to improve cargo flows.

Traditional ro-ro vessels have their engines aft behind the lower cargo hold and underneath the bulkhead deck, a well proven arrangement with a short shaftline. The exhaust pipes are led to the funnel through the engine casing, which can be located on the side of the ship or in the centre. In both cases, however, the casing

impacts on the cargo deck and reduces the number of lanes with unrestricted access directly to the stern ramp.

Mounting the engines in the bow area avoids obstructing the cargo flow, an approach already applied in some ro-ro tonnage designs and existing vessels. An example is the B-Max concept evolved in the late 1990s by Kvaerner Masa-Yards, which features a diesel-electric plant based on four Wärtsilä 9L38 engines and two podded propulsors. The engines are arranged on the upper deck in conjunction with the well-forward deckhouse away from the cargo area.

Wärtsilä has taken the concept further and examined three machinery solutions, all with the engines located forward: diesel-mechanical installations based on either single- or twin-medium speed engines, and a diesel-electric plant.

As reported in this journal last April (page 14), the company's assessment suggests that the first option - a single six-cylinder W64 engine with mechanical transmission - is the most attractive,

owing to an improved shafting arrangement, simple single-in/single-out reduction gearbox, and lower maintenance demand. Fitting such an engine underneath the bulkhead deck with sufficient space for servicing dictates new maintenance tools, a new lower oil sump design, recessing into the tanktop and a low-height crane system.

The proposed layout offers the opportunity to locate the associated reduction gear as far aft as possible so that the longest part of the intermediate shaft turns with the speed of the engine. This higher shaft speed means that a smaller diameter can be used, thus saving weight and cost. Since the thrust bearing is located in the reduction gear, lower axial forces will be experienced in the long shaft between gear and engine.

Overall, Wärtsilä believes the W64-based solution offers the lowest machinery-related costs and the lowest required freight rate (RFR) for the ro-ro ship design and deployment scenario considered. ✎

Enthusiastic reception for electronic low-speed engines

SHIPOWNERS are evidently keen to exploit electronically-controlled variants in the low-speed engine programmes of MAN B&W Diesel and Wärtsilä, whose references - respectively for the ME and Sulzer RT-flex designs - continue to proliferate as more and more licensees log sales. Most bore sizes are now in service or on order for diverse shipping trades, and operational feedback is encouraging.

Confidence that sales of the 'camshaftless' derivatives will overtake those of the conventional MC and RTA designs in the course of the present decade - expressed by senior executives of both groups - would seem to be justified. An increasing number of operators appreciate the merits of electronically controlling fuel injection and exhaust valve timing, enabling optimisation of the two most important parameters for adjusting an engine at all load conditions.

Various running modes can be selected, either automatically to suit different operating conditions or manually by the operator to meet specific goals, such as 'low fuel consumption' or 'limited exhaust gas emissions'. The capability to switch between governor control modes - for example, 'constant speed' and 'constant torque' - is another merit. Benefits in terms of operating economy, the environment and maintenance are summarised by Wärtsilä as:

- reduced part-load fuel consumption
- smokeless operation at all running speeds
- very low, stable running speeds (down to 10% of the nominal speed)
- easy engine setting, and reduced maintenance
- balanced load between cylinders, fostering longer times-between-overhauls.



A notable delivery last year to feature a camshaftless electronically controlled main engine was Agrexco's new hybrid reefer ship *Carmel Ecofresh*, from Estaleiros Navais de Viana do Castelo, in Portugal. She is powered by a 16,520KW Wärtsilä 7RT-flex60 engine, running at 114rev/min and directly coupled to an FP propeller to provide a service speed of 21.00knots. More information can be found in the newly published *Significant Ships of 2003*.

New operational features can be added during the lifetime of a ship by simply updating the system software. For example, an alternative fuel consumption curve introduced for RT-flex engines yields a significantly lower specific fuel consumption in the part-load range, a feature of particular interest for operators of VLCCs and ULCCs which have long ballast voyages.

Wärtsilä's first Sulzer RT-flex engine entered service in September 2001, the six-cylinder 58T-B model powering the bulk carrier *Gypsum Centennial*. Others followed from last August in an Aframax tanker (6RT-flex58T-B), a novel hybrid reefer ship (7RT-flex60C), and a multi-

purpose carrier (7RT-flex60C). MAN B&W's debut installation has served in electronic mode at sea since November 2000, a 6L60ME engine powering the chemical/product carrier *Bow Cecil*.

The most powerful ME and RT-flex models benefited from the surge in orders for ultra-large container ships last year, with numerous 12-cylinder K98ME/ME-C and RT-flex96C engines booked for tonnage up to around 9000TEU capacity requiring outputs up to 68.5MW. In addition, MAN B&W K98MC-C engines with camshafts have been specified for some very large ships, such as Seaspan and Offen's 8000TEU liners at Samsung. ✎

SIGHTS ON NEW TARGETS

Having survived the acute economic crisis of the '90s, the Salut Federal State Unitary Enterprise managed not only to recover the scope of production and the number of personnel but also to set up a design bureau. Its management has been tasked with finding new areas where the factory's engineering expertise and research potential could be used.

In the late '90s, based on results of analysis of the state of the factory, Russia's economic situation and the prospects for development, it was decided that the next of kin products whose manufacture the factory could take up with minimum retooling were industrial gas turbines. Those are used to equip gas-turbine electric power plants, gas pumping stations, sea and railroad transport facilities.

However, before turning out "the metallic prototype" it was necessary to carry out engineering research. That is why in April 2000, a design bureau of industrial gas-turbine systems (GTS) was established. It was staffed with leading experts previously engaged in similar work at the companies of Moscow, St Petersburg, Nikolayev, Perm and Tyumen. The testing and perfecting were carried out without delay. The high rate of work brought about good results in a fairly short period of time. For instance, a ST-20 power turbine project has been completed. Its use in conjunction with the gas generator of the AL-21 engine provides a drive for the 20 MW electric generator. A project has been fulfilled for the 12.5 MW gas compressor units. Preparation is now underway for production of those equipment types.

Quite new to the Salut company is the

Indochina. The novelty lies in carrying the goods from the sender to the customer without transshipment in railroad cars. The route goes via Astrakhan where the cars are loaded onto the ferry and then delivered to Iran via the Caspian Sea. After crossing the border, the goods are reloaded onto the ferry whereupon they go to India and Indochina via the Indian Ocean. To ensure the continuous delivery of goods, the project provides for construction of 8 to 10 railroad ferries.

The high speed of the ferry (35 knots) and large carrying capacity (300 railroad cars) necessitated the building of a power supply unit with unique performance: power no less than 220 MW for 4 screws and efficiency greater than 50%. The in-canal movement and maneuvering, including mooring, must be carried out with the screws operating in reverse. The rearward motion called for power no less than 6 MW. The power reduction was inadmissible even with temperature rising to 45°C.

The team of the design bureau has coped with the assignment. A conceptual design of the railroad ferry's engine room has been prepared (Fig.1). The power plant of each screw includes a gas-turbine engine, two pressures recovery boiler,

recovery boiler the high-pressure steam fed to the steam turbine which tightens up the gas-turbine engine compressor.

Such a power supply unit envisages the feeding of steam to the gas-turbine engine. As this is done, part of the high-pressure steam with temperature 250°C is used after the steam turbine for cooling the turbo compressor (consumption rate 5 kg/s), while the other part (10 kg/s) is re-fed to the recovery boiler where it is re-heated and then injected into the gas-turbine engine combustion chamber. The low-pressure steam is used to cool the power turbine. The boiler output is sufficient to provide steam and hot water for the ferry's secondary users without detriment to the power generation cycle.

To return water coming as steam to the through-flow portion of the gas-turbine engine, a contact condenser is installed behind the recovery boiler. In it, the exhaust gas is cooled down to 60°C and the water contained in it is condensed. To prevent salt sedimentation, the power unit uses distilled water whose cooling is done by overboard water in the heat exchanger. At overboard temperature < 30°C, the system accumulates distilled water as in addition to steam injected into the gas-turbine engine, the exhaust gas contains "extra" water generated in the combustion chamber during the burning of organic fuel.

To keep the unit's power output stable at high air temperature, extra water is injected at the compressor input. So at air temperature 45°C, the water consumption rate of 1 kg/s increases the power output by up to 7 MW.

The accumulation of distilled water in containers enables the power supply unit to operate without output reduction even when water temperature exceeds +30°C and air temperature +45°C. However, such temperatures are rare in the climate where navigation proceeds.

Two gas-turbine reverse engines, each featuring 6 MW, are used for mooring maneuvers. The engines are linked to the side reducer bulkheads. The high per-

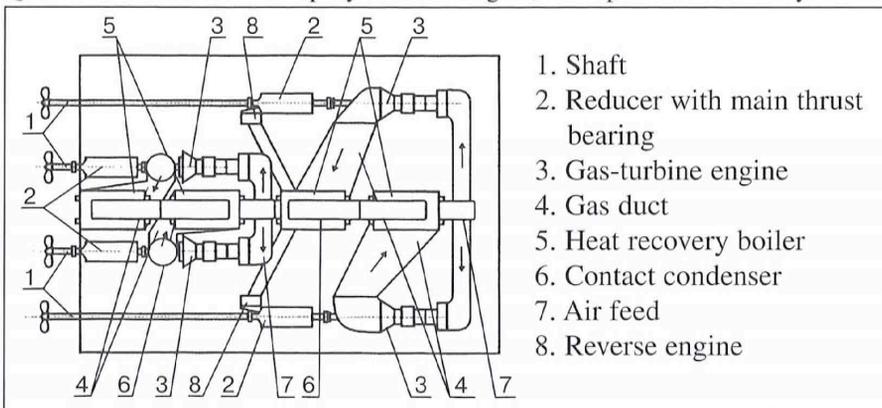


Fig. 1 Engine room

development of gas-turbine units for sea vessels. The first-class specialists of the design bureau took the initiative to design a power system for a railroad ferry. The ferry is to serve part of the new trade route from Europe to India and

steam turbine and contact condenser (installed in the gas duct above the engine room). The power is transmitted via the reducer from the power turbine to the screw. Simultaneously, exhaust gases of the gas-turbine engine create in the

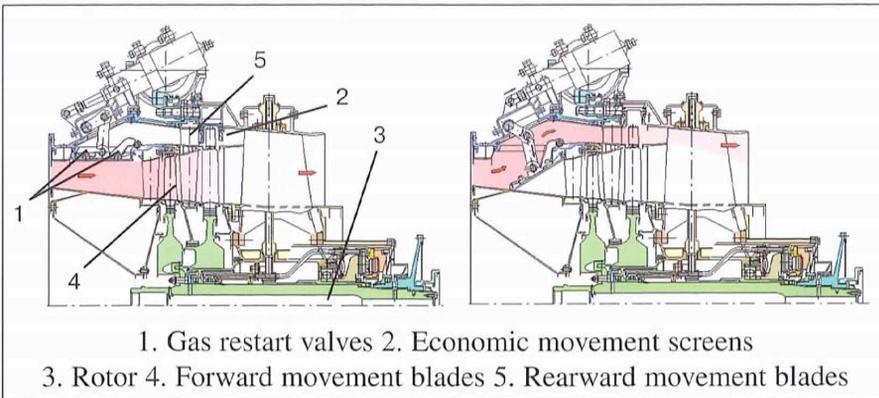


Fig. 2 Reverse type power turbine, 6 MW

formance gas reverse of the gas-turbine engines (Fig.2) allows reversing throughout the entire power range from forward to rearward movement in 3 to 5 s. In this

where prolonged forward movement is required, the economic movement screens of both engines are lowered. In this, case the efficiency of the forward

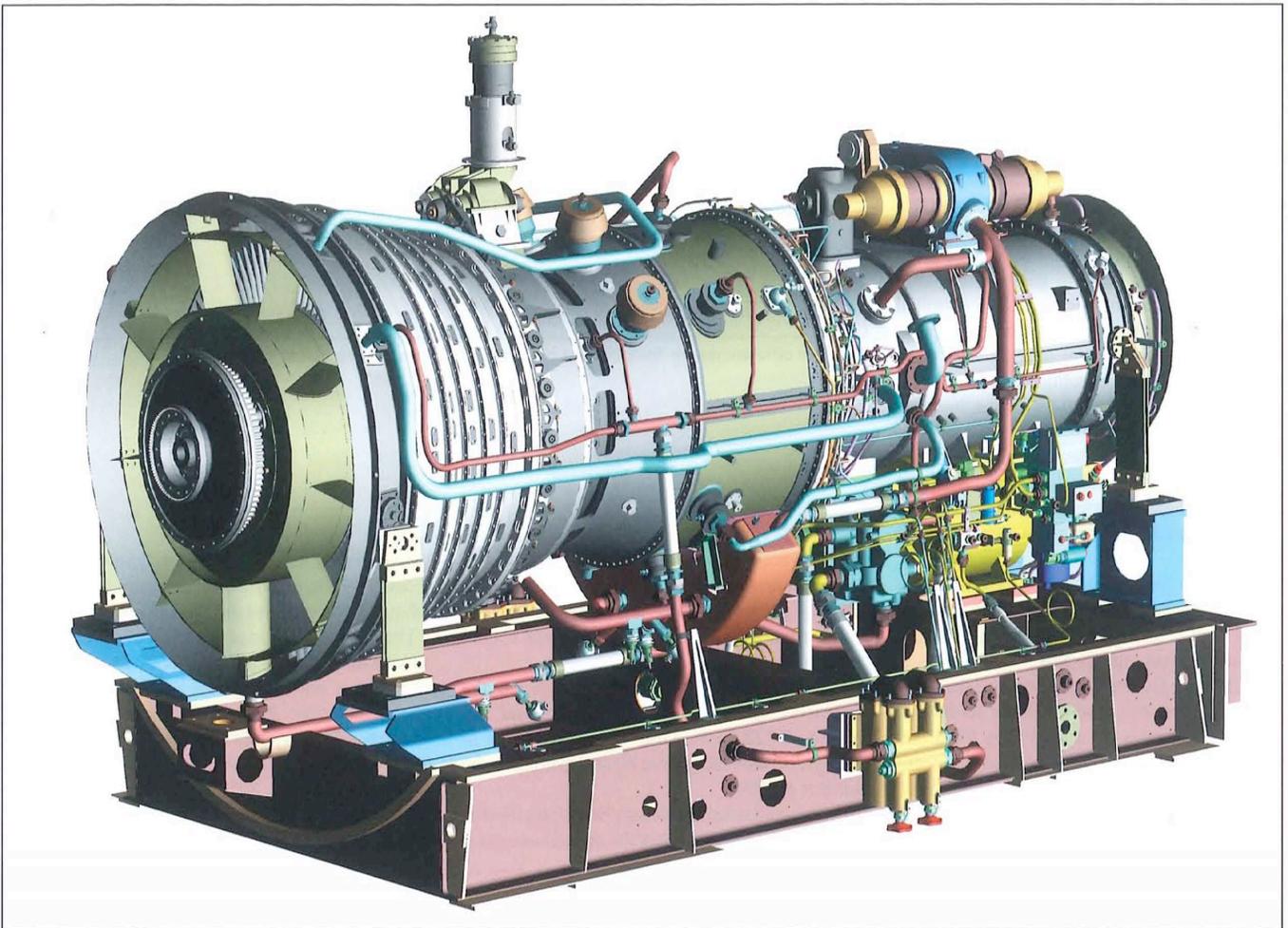


Fig. 3 Gas-turbine engine with reverse type of power turbine

case, the economic movement screens are kept raised and the reverse is obtained only by means of a reversible valve that can be put in any intermediate position. This allows to change smoothly the speed and direction of the screw rotation, which facilitates the mooring. There is a valve position in which the shaft power is equal to zero ("stop the screw"). The screw operating mode remains here unchanged. In movement over canals and straits

movement increases by 5%. The railroad ferry's power unit reducer has a multi-flow construction, which slims it down to 2 m in diameter. The high specific values allowed to reduce the size of all the unit's components. The placement of power supply systems caused no difficulties. Much room was left in the engine room for auxiliary equipment. Access to all subunits during operation is free. If necessary, any component

can be dismantled and replaced by a new one. The weight of the entire equipment does not exceed 1,000 tons.

This project is unique in all aspects. The proposals of other companies to build a power supply unit for a railroad ferry were not competitive.

The Salut Federal Enterprise is prepared to act as a prime supplier of a similar power unit for other sea and river vessels. The marketing section is based on the article by Yuri Eliseev, General Director, Salute Federal Unitary Enterprise, Vyacheslav Belyayev, Chief Designer of industrial gas-turbine systems.



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New dual-fuel engine: an LNG carrier two-stroke solution

MAN B&W Diesel A/S recently launched the ME-GI engine. This range is designed for the highly specialised LNG carrier market. The design builds on experience gained from the earlier MC-GI engines combined with advances in the latest electronic controls.

After careful consideration of the various alternatives for LNG carrier propulsion, the conclusion from MAN B&W was that a two-stroke engine solution is the best system for powering LNG carriers in place of steam turbines.

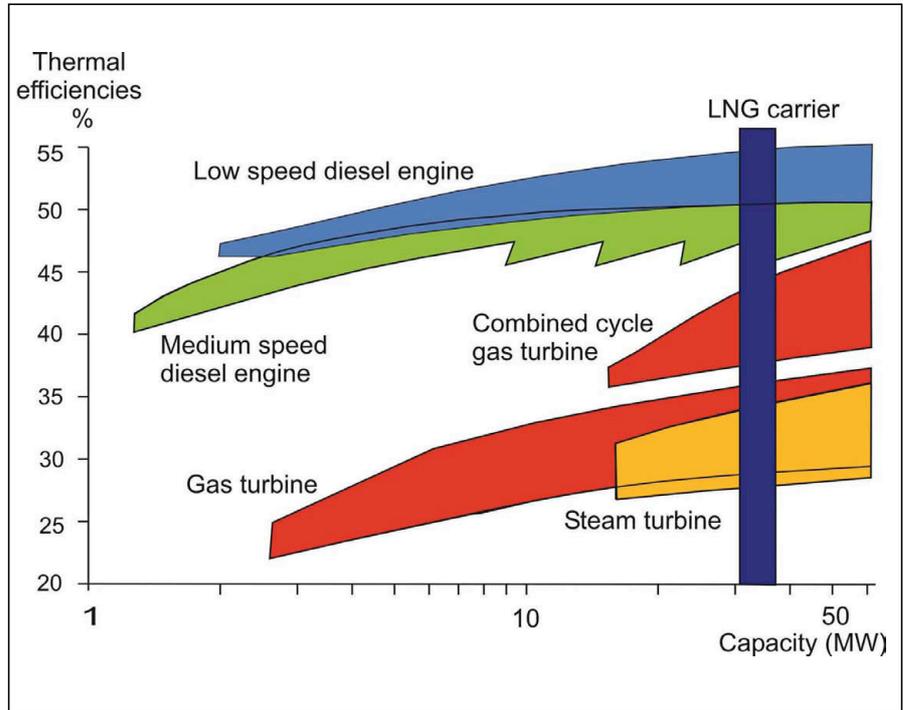
The combination of low installation and running costs for this highly specialised type of vessel makes the adoption of the dual-fuel ME-GI engine attractive. An additional reliquefaction plant allows sale of more gas when the gas price is higher than the fuel oil price.

Traditionally, LNG carriers have been driven by steam turbines that are fed from boilers fired by boil-off cargo gas, supported by heavy fuel oil. Responding to a market demand for more efficient engines, while retaining the option to burn the boil-off gas, MAN B&W is now re-introducing its high-pressure gas injection low-speed models - now in electronically controlled form. Designated ME-GI, this gas burning option is being offered in parallel to the heavy fuel-burning solution with gas reliquefaction.

The combination of the ME-GI engine, installed with a reliquefaction plant, allows owners and operators the choice to either use the boil-off gas in the engine or to reliquefy the gas and use HFO instead. The choice is dependent on their relative prices and availability, as well as environmental considerations.

Out of all the options for a prime mover, the low speed two-stroke diesel engine gives the best thermal efficiency for any conventional propulsion system, claims MAN B&W. This is especially the case for LNG carriers, where the power requirement is around 30MW to 40MW. Thermal efficiencies of around 50% for diesel engines far exceed the 30% offered by steam turbines and any other combination alternatives.

A combination of dual-fuel enhanced engine control and monitoring systems enable the latest



Thermal efficiencies for the different propulsion options, as calculated by MAN B&W.

ME technical developments to be applied to LNG carriers. The precise timing and combustion rate shaping gained through electronic control of injection and exhaust valves produce greater control at any load.

The ME-GI dual-fuel engine builds on the experience gained from the MC-GI dual-fuel engine. A 12K80MC-GI-S engine has been in operation in the Chiba power plant (Japan) since the summer of 1994.

The reliquefaction technology that is proposed as an additional feature to allow the sale of more gas is

state-of-the-art technology. It is well known in the process industry and is derived from numerous reliquefaction units installed on LPG ships.

The ME engine range has proved to be very successful since its introduction. The first ME engine was put into service on the 37,500dwt chemical tanker *Bow Cecil*. This engine, a 6L60MC-ME, has performed as expected for more than 16,000 hours. The ME version of engines are available from the 4S50ME-C through to the world's most powerful ME engine, the 14K108ME-C. ⚓

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Merger enhances marine electrical services

The Callenberg Group AB, Sweden, has signed an agreement with CW Obel A/S to acquire Semco Maritime's marine service and switchboard division. The acquisition, which took effect in December 2003, consolidates the experience of marine electricians and engineers from both organisations, while enhancing Callenberg's capability to serve its customers on a global basis.

Fully owned by the Swedish private equity group Segulah, the Callenberg Group is the largest independent marine electrical engineering company in Scandinavia. Callenberg serves the international marine and offshore industries, offering customised solutions from its headquarters in Sweden, and from subsidiaries in the US and Singapore. Semco Maritime is Scandinavia's largest manufacturer of marine switchboards. The company's marine service division has the capabilities to serve yards and ship operators on a global basis.

In connection with the acquisition, a new company, Semco Callenberg Marine A/S, has been established as a subsidiary of the Callenberg Group AB, Sweden. Semco Callenberg Marine will conduct business from its existing location in Odense, Denmark, employing the same management and staff.

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Hatch covers for Efnav Panamax newbuilding at STX Shipbuilding

One of the most recent contracts concluded by Tsuji is for side-shifting hatch covers for four Panamax bulk carriers on order by Greek owner Efnav Co at STX Shipbuilding, in Korea, with delivery of the first shipset at the end of 2004. These hatch covers will be manufactured at the new Chinese plant of Tsuji.

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New-generation integrated bridge system

Northrop Grumman Corp's Sperry Marine has introduced its next-generation integrated bridge system for ships, called Vision FT, that incorporates the latest advances in marine navigation technology and combines all of a ship's navigation sensors and systems - including radars, electronic chart display and information system, gyrocompass, depth sounder, speed log, differential global positioning satellite (GPS) receivers and autopilot - into a completely integrated package.

The centrepiece of the system is Sperry Marine's Voyage Management System (VMS) software, which provides easy and precise route planning and gives a clear real-time picture of the ship's precise position and movement, along with radar targets and automatic identification system data, on an electronic chart display and information system.

The Vision FT represents a significant advance in IBS technology; the new bridge console designs have been optimised for modern, large-screen, high-resolution flat-panel colour displays, with easy front-panel access for maintenance and repairs. The man-machine interface has been upgraded with a new ergonomic trackball control device and drop-down menu windows for easy operation to minimise the need for operator training.

Sperry Marine has also introduced innovative new technologies in conjunction with the Vision FT IBS. The PocketBridge remote wireless multi-function handheld devices will make it possible for a ship's master and officers to view data from the IBS and other ship systems on a palm-type computer anywhere on the ship. Another new capability is NaviVision, an aircraft-style 'head-up' display that projects vital ship navigation data directly onto the bridge windows.

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Liftaway hatch covers for feeder container ships

Twelve 900TEU feeder container ships (plus four options) building at China's Zhejiang Yangfan yard will be supplied with MacGregor liftaway hatch cover sets. These Hermann Buss-owned, Germanischer Lloyd-classed ships will have container capacity arranged in the four holds, on hatch covers, and on a weatherdeck area, immediately forward of the superstructure.

The 129m long, 22.6m wide, and 11.8m deep design will have a deadweight of approximately 8300tonnes, on a draught of 8m. Each weatherdeck hatch cover shipset will comprise 14 liftaway panels, with twin-panel sets yielding a clear opening of 6.6m long by 15.6m wide (hatch 1A), 12.6m by 15.6m (hatch B) and 12.6m by 18.3m (hatches 2-4B).

Covers are designed for uniformly distributed loading of 1.75tonnes/m², and container stack load ratings of 45tonnes/20ft units (hatch 1A), and 60tonnes/20ft units, and 90tonnes/40ft units (hatches 1B-4B). It is also possible to stack three bays of 45ft containers or two bays of 49ft containers on the hatch covers.

Weather-tight sealing between hatch covers and coamings will be secured by sliding-type rubber packing, and between panels by a double rubber lip with special MacGregor end-pieces. Flexipad support pads will be bolted to the hatch cover outside to act directly against the coaming top, transferring the weight of the cover and containers to the ship's hull.

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Wipers for world's first LPG FPSO vessel

Wynn Marine has received an order from IHI Marine Inc to supply the window wiper system for the first-ever newbuilding LPG FPSO vessel, to work with the Sanha project off Angola. As a

leading marine wiper specialist, Wynn Marine was able to design a completely unique wiper system, based on off-the-shelf parts, prior to installation. In this case, Wynn has designed the wiper system around two of its most durable wipers, the Type C and Type 1800. Both systems are core features of Wynn Marine's Ocean Range wiper though unusually, the complete system will feature a combination of straightline and pantograph wiping actions.

The Type C is an internal straightline wiper that offers what is claimed to be the most advanced design of linear action window wiper systems available today. The Type 1800 Seahorse is an internally mounted pantograph wiper designed specifically for ships with heavy-duty applications. Both systems provide good window clearance and are able to operate in extreme weather conditions.

The Sanha Project LPG FPSO vessel is under construction at the IHI Kure Shipyard in Japan and will be completed in July 2004. Owned by the international ChevronTexaco consortium, the vessel will be used for the Sanha Condensate Project at the Cabinda Block-0 located off Angola.

*Wynstruments, Wynn House,
Lansdown Estate, Cheltenham
GL51 8PL, UK.
Tel: 01242 232266.
Fax: 01242 231131.*

E-mail: tony.parker@wynn.co.uk

Record-breaking orders reported

Kongsberg Maritime has received orders to supply 30 German newbuilding projects with its AutoChief 4 (AC4) propulsion control system. In addition, Kongsberg Maritime will supply 22 of the vessels with the DataChief C20 integrated automation system. The order, from Reederei Claus-Peter Offen in Hamburg (with partners), is claimed to be the largest newbuilding order ever taken from a German owner. Construction of the vessels will take place in Korea at the Hanjin, Samsung, Hyundai Heavy and Hyundai-Samho shipyards.

The primary functions of the DataChief C20 integrated automation system are alarm, monitoring and control. Modular design enables Kongsberg Maritime to configure the DataChief C20 to a vessel's specific requirements, covering the entire range from low complexity alarm systems to highly integrated alarm and monitoring systems with advanced process control and power management.

The DataChief C20 offers extra functionality for ballast automation, air conditioning management, and information management. In addition, its auxiliary control system offers functions for other application areas including lubricating oil, sea water, fuel oil, cooling, steam and purifier plant. Control is via distributed processing units. Operator interaction is through interactive colour graphic pictures on the remote operating stations, or locally from the local operating station.

*Kongsberg Maritime, Kirkegårdsveien 45,
PO Box 1000, 3601 Kongsberg, Norway.
Tel: +47 330 32329.
Fax: +47 322 88201.*

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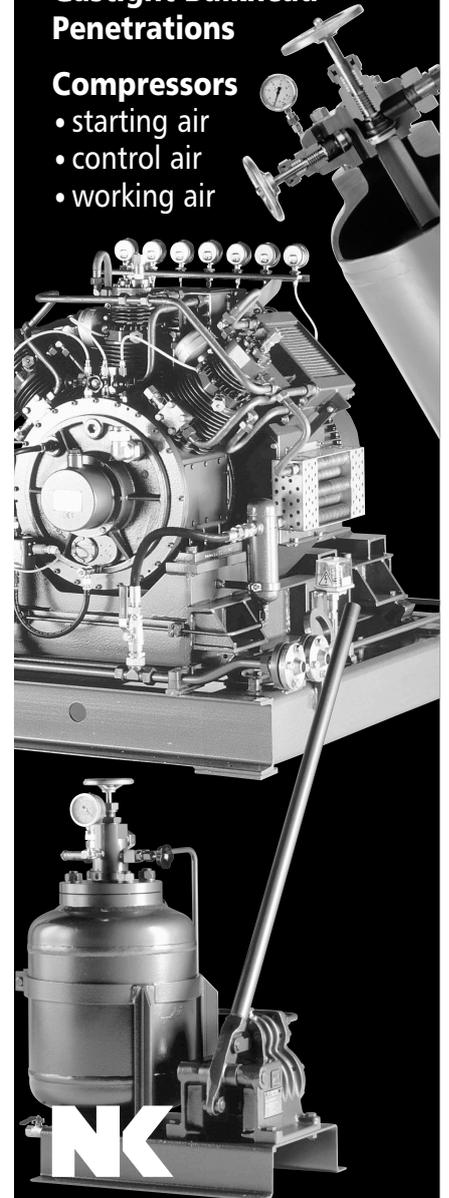
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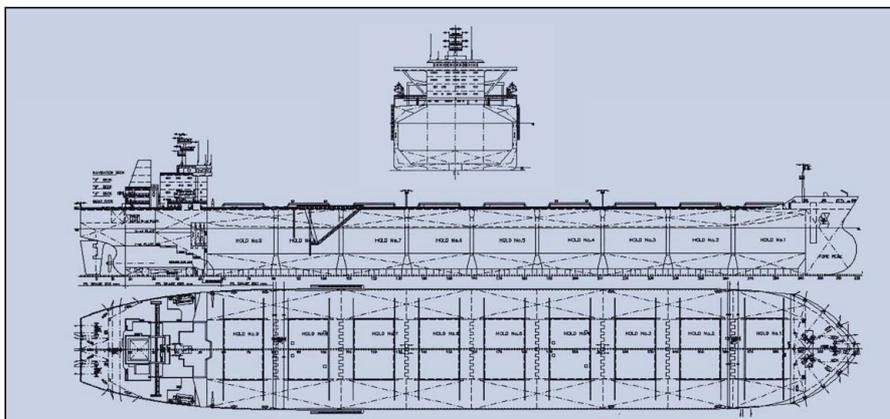
Preparing the way for next-generation double-skin designs

French classification society Bureau Veritas has linked with a Chinese designer and yard, three European consultancies, and a Korean yard, to develop new choices for owners seeking to comply with anticipated IACS and IMO legislation; these are longitudinally-framed and transverse-framed Capesize models, and a Kamsarmax-dimensioned Panamax type with longitudinal framing.

MUCH uncertainty currently pervades the marine industry as to the exact dimensions and details that will be adopted by IMO for next-generation double-skin bulk carriers - as proposed by that organisation's Maritime Safety Committee for all ships of more than 150m length. Nevertheless, leading classification societies, together with their umbrella body (The International Association of Classification Societies - IACS) are not standing still amongst these shifting sands; they have been, and still are, working to bring forward updated rules, and to improve design details, as has been reported on several occasions during the past two years in this journal.

Currently, a so-called Joint Bulk Project is under way to develop the newest common rules for IACS (following similar moves for tankers that are expected to be announced by the end of 2004). Two groups are studying various aspects of bulkers: the so-called A3 group (Class NK, the Korean Register, and the China Classification Society - CCS), and the Unitas group (Bureau Veritas, Germanischer Lloyd, and Registro Italiano Navale). By the end of the current year, they hope to issue formal preliminary IACS bulk carrier rules for adoption in 2005.

Notwithstanding these excellent efforts amid the unclear dimensions of the critical double-skins, owners wanting to order bulkers today face dilemmas over which rules and dimensions to select prior to eventual adoption. Bold ones are not waiting and have already proceeded with double-skin designs, based on what they hope will be acceptable; these include Federal Navigation's super-optimised Great Lakes designs from New Century



General arrangement plans of the double-skin Capesize bulk carrier, with transverse framing, designed by ICEPRONAV and the Constantza Shipyard, in Romania.

Shipbuilding (China); Graig Shipping, with its Diamond 53 Handymax designs (*The Naval Architect* November 2002, page 7) under construction in China - and very recently ordered in Vietnam; Louis Dreyfus, with two large Capesizes (171,500dwt) at Daewoo; the Angelicoussis group with three Capesizes also at Daewoo; and of course, several owners at that already experienced practitioner of double-skin (within the present regulations) construction, Oshima Shipbuilding in Japan.

At the end of January, *The Naval Architect* was able to discuss some of the issues involved with one of the class societies at the forefront of solving these dilemmas: Bureau Veritas (BV). One of this society's specialists in the sector, Mr Andrea Zamburlini, reports that BV is involved, as classification authority, with Louis Dreyfus' Capesize bulkers mentioned above, but at the same time is also working to analyse the compatibility of new designs with the principles of rules to be decided. It is doing this in partnership with two Italian consultancies, another in Romania close to the

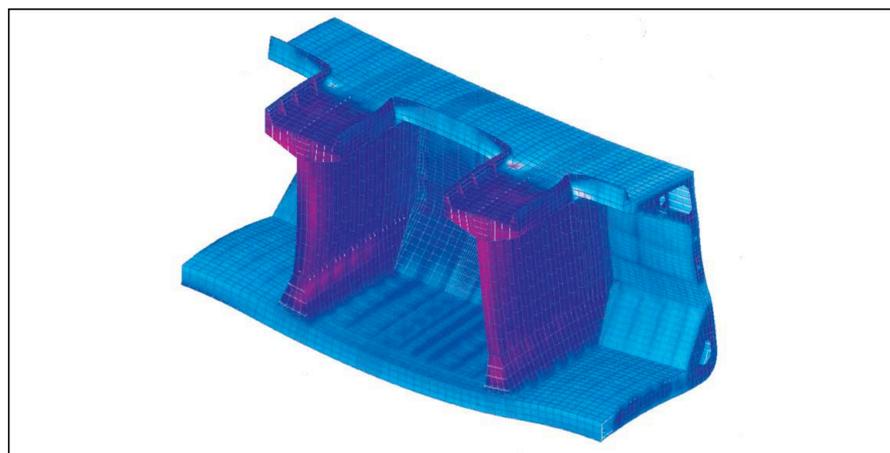
Constantza Shipyard, and with a well-known Chinese designer with a good association with one of the most dynamic Chinese yards.

Results of the current studies are not complete and the designs are not fully approved, but closer to final approval are the new Dreyfus ships, based on single-skin rules plus IACS' unified-requirement UR S25 recommendations (for ships contracted after July 1 2003) regarding hull loadings. The owner has also requested compliance with UR S18, which covers transverse bulkheads. The contract was signed in December 2003, and the ship was designed directly by Daewoo. For several years, Daewoo has been very interested in the principle of double skins for large bulk carriers.

Three other new double-skin designs

The objective of the BV study - primarily based on Capesize ships of around 150,000dwt and Panamax hulls of around 70,000dwt - is to work out practical cases with designers, fulfilling the principles of the new rules, and so

A Von Mises stress and deflection finite-element analysis model made by Bureau Veritas for No 5 hold of one of the bulk carriers studied.



**DR PETER CHENG AND SHANGHAI WAIGAOQIAO SHIPYARD
CAPESIZE BULK CARRIER
(longitudinal framing)**

Length, scantling.....	275.60m
Breadth, moulded.....	45.00m
Depth, moulded.....	24.84m
Draught, scantling.....	18.12m
Deadweight (cargo) in nine holds.....	173,000dwt
Block coefficient.....	0.860
Typical cargo hold length.....	25.48m
Typical web frame spacing.....	2.73m
<i>Note: No plans of this design available</i>	

The Royal Institution of Naval Architects

WARSHIP 2004: LITTORAL WARFARE & THE EXPEDITIONARY FORCE

8 - 9 June, Victoria Park Plaza, London, UK

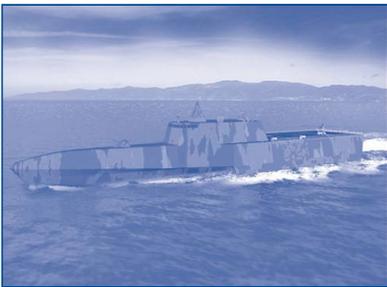
First Notice & Call for Papers



As military doctrines around the world begin to shift towards out-of-area operations, the requirements for naval vessels have also begun to change. The focus of naval operations is shifting inshore and many traditionally blue-water navies are beginning to re-focus on their littoral and expeditionary force capabilities.



This attention has led to a huge increase in work on amphibious and assault vessels. Countries including the UK and USA have new classes of large dock-ships in construction and all over the world, from Italy to Australia, navies are looking into the modernisation of their amphibious and logistics forces. This includes proposed large air-capable ships and designs with dual civil and military roles.



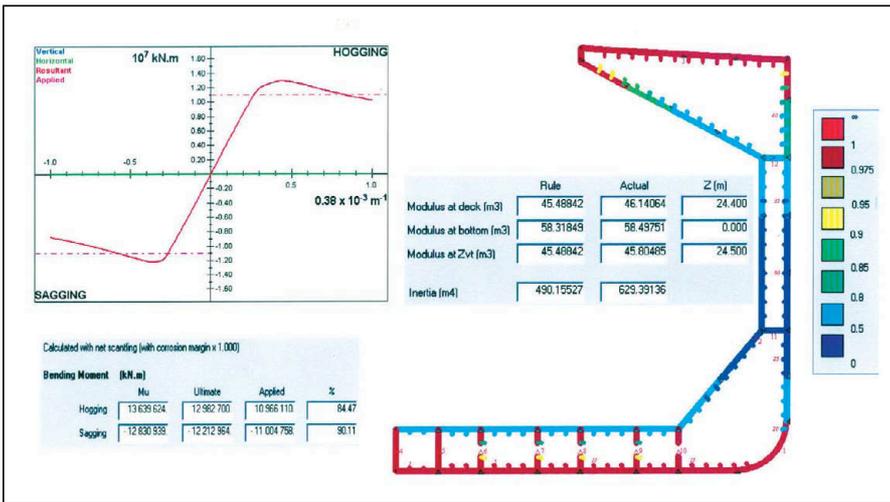
At the same time, there have been a number of major combat vessel projects. The most prominent of these is the US Littoral Combat Ship, a novel and highly potent warship optimised for operations in the littoral. This will be able to capitalise on the experience of a number of recent advanced designs, including Sweden's *Visby* Corvettes and Norway's *Skjold* SES Fast Attack Craft.

Warship 2004 aims to explore all of these trends: looking at the modern idea of a littoral warship, exploring the capabilities of the new-generation amphibious assault ships and landing craft and investigating the associated support requirements of modern out of area operations, including mine warfare, hospital and logistics vessels. Papers are invited on all aspects of modern littoral and expeditionary warfare by 19 March 2004.

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Bending moment, hogging and sagging calculations, and modulus details for a 174,000dwt Capesize double-skin bulker with longitudinal framing, as analysed by Bureau Veritas.

**ICEPRONAV/CONSTANTZA SHIPYARD
CAPESIZE BULK CARRIER
(transverse framing)**

Length, oa.....	295.82m
Length, bp.....	283.00m
Breadth, moulded.....	46.00m
Depth, moulded to upper deck....	24.40m
Draught, design.....	18.00m
Draught, scantling.....	18.10m
Deadweight, scantling	
draught.....	approx 173,000dwt
Cargo volume.....	188,000m ³
Speed, service, scantling	
draught.....	15.00knots
Classification.....	Bureau Veritas
I, + Hull, + Mach, Bulk Carrier,	
ESP, Unrestricted Navigation, + Veristar	
Hull, NONHOMLOAD, BC-A (Holds 2, 4	
8, 6, and 8 may be empty), Heavycargo,	
Grabloading, SYS-NEQ 1, + AUT-UMS,	
Grain Loading	

Differences from reference single-skin design

Length.....	+1.7%
Breadth.....	+2.3%
Depth.....	+1.7%
Deadweight.....	-4.2%
Volume.....	-1%
Steelweight.....	+7%
Ultimate hull girder strength	
increase.....	+3.2%
Deck modulus increase.....	+2.4%

allow all partners to be fully prepared for the market when the technical issues of double skins are fully resolved.

Partnerships have been created between Bureau Veritas and the following design offices and aspiring shipyards:

- Dr Peter Cheng and Shanghai Waigaoqiao Shipyard (China)
- Meccano Marine & Industrial Engineering (Trieste, Italy)

- Marine Engineering Services (Trieste, Italy)
- ICEPRONAV consultancy, Galatz, and Constantza Shipyard (both in Romania).

Exact work being carried out by the various partners is as follows:

Dr Peter Cheng/Shanghai Waigaoqiao Shipyard:

Capesize bulker with longitudinal framing
All mild steel 245N/mm², with 315N/mm² steel for critical deck areas.

Meccano

Capesize bulker with longitudinal framing.
Mainly (approximately 60%) 315N/mm² steel, with 355N/mm² steel for critical deck areas.

Marine Engineering Services

Panamax bulker carrier with longitudinal framing.

Mainly (approximately 70%) 315N/mm² steel, with 355N/mm² steel for critical deck sections.

ICEPRONAV/Constantza Shipyard

Capesize bulker carrier with transverse framing.
Mild steel, plus 315N/mm² steel for critical deck and bottom structures.

continued

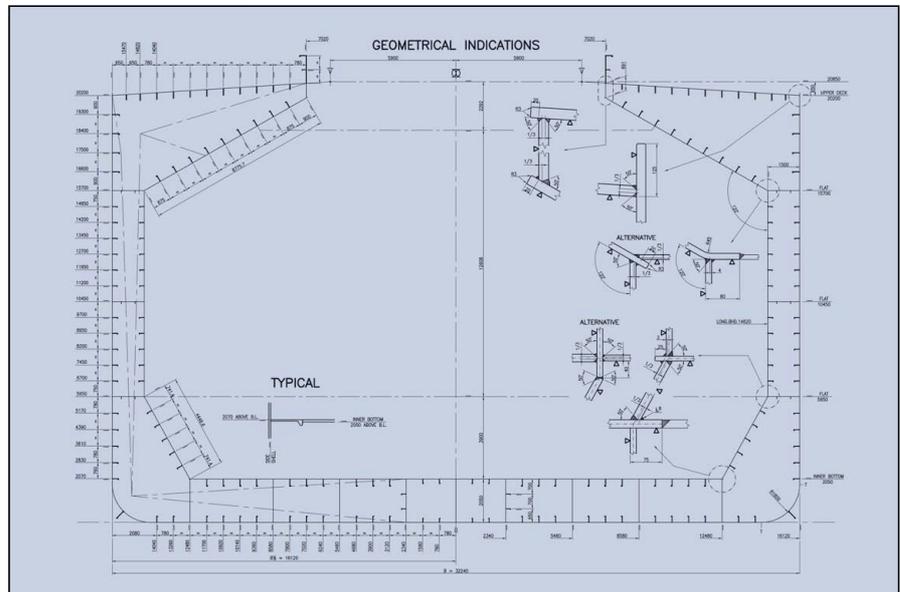
**MECCANO
CAPESIZE BULK CARRIER
(longitudinal framing)**

Length, oa.....	294.80m
Length, bp.....	284.80m
Breadth, moulded.....	46.00m
Depth, moulded to upper deck....	25.35m
Draught, design.....	17.40m
Draught, scantling.....	18.50m
Deadweight, 18.50m	
draught.....	173,000dwt
Cargo volume.....	190,000m ³
Speed, service, 18.50m	
draught.....	15.00knots
Classification.....	Bureau Veritas
I, + Hull, + Mach, Bulk Carrier,	
ESP Unrestricted Navigation, + Veristar	
Hull, NONHOMLOAD, BCA-A (Holds 2,	
4, 6, and 8 may be empty), Heavycargo,	
Grabloading, SYS-NEQ 1, +AUT-UMS,	
Grain Loading	

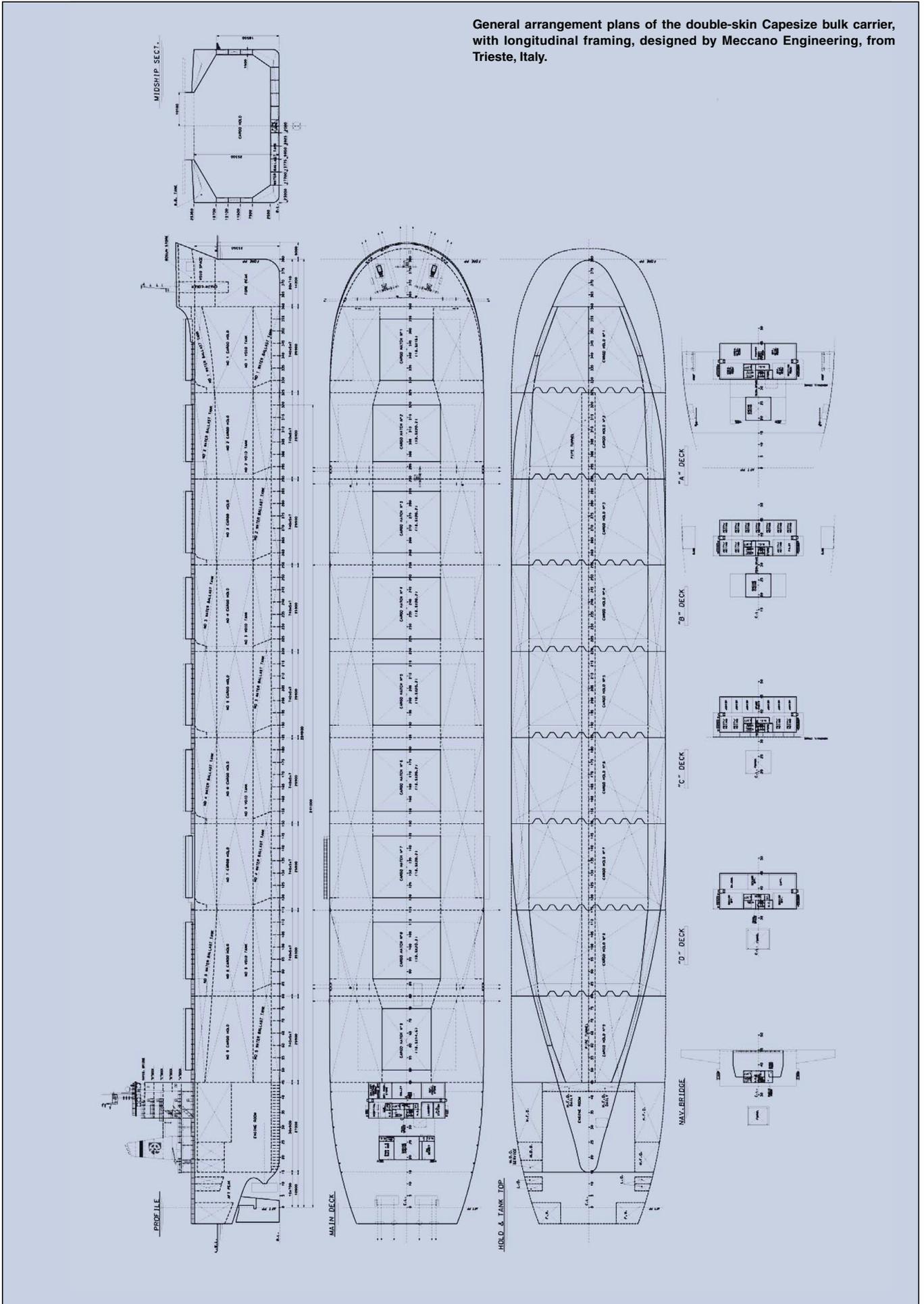
Differences from reference single-skin design

Length.....	+1.5%
Depth.....	+5.5%
Breadth.....	+2.3%
Deadweight.....	-0.5%
Volume.....	-1%
Steelweight.....	+6%
Ultimate hull girder strength	
increase.....	+3.2%
Deck modulus increase.....	+2.5%

Cross-section through the longitudinally framed Panamax bulker carrier from Marine Engineering Services, which is specially dimensioned for the Port of Kamsar.



General arrangement plans of the double-skin Capesize bulk carrier, with longitudinal framing, designed by Meccano Engineering, from Trieste, Italy.



Design and Operation of Trimaran Ships

29 - 30 April 2004, London, UK

Second Notice



The idea of trimaran ships has inspired a tremendous amount of attention, both civil and military. The concept; a stabilised monohull, with small sidehulls adding stability to a slender central hull, has a number of potential advantages. The most obvious are the increased control over stability and greater flexibility in layout, but other advantages include better seakeeping, reduced speed loss in a seaway and possible high speed powering and vulnerability benefits.



The subject has now been thoroughly investigated around the world with a combination of design studies, numerical simulation, model testing and the construction of the large ocean-going technology demonstrator, RV Triton. The trials have proven highly successful and have produced a large amount of data; validating prediction methods and design tools and providing experience of operating a seagoing vessel in all weather conditions.

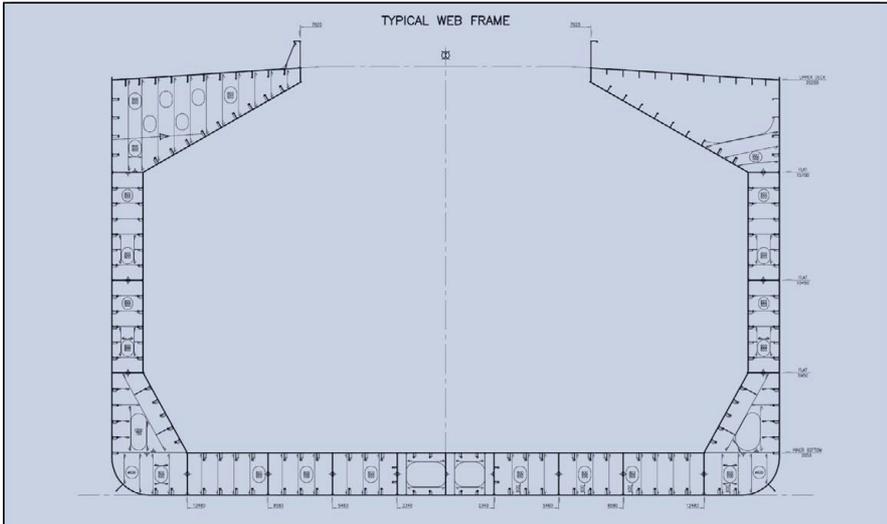


There is now an increasing move to exploit this new technology, culminating in the recent order of a large trimaran fast ferry to operate in the Canary Islands.

This conference will definitively review the present situation with a selection of papers from civil and defence sources, as well as providing a forum to discuss plans for the future. This conference is planned with the UK MoD to include very significant discussion of the results of the Triton trials programme.

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Typical web frame for the MES Panamax design with longitudinal framing.

One of the special aspects that are being examined is the benefits, or otherwise, of both longitudinal and transverse framing for the double-skin section, and already some preliminary results have highlighted some peculiarities; these are currently being ironed out. The designers are using BV's own MARS 2000 software for structural analysis, which aims - among other things - to promote gradual, rather than sudden, collapse of any corroded section. Existing BV-classed Capesize and Panamax bulk carriers with single side-skins are being used as reference points.

All designs are planned to withstand flooding of individual cargo holds, as well as having increased longitudinal strength to meet anticipated revisions of IACS rules (UR S17), as well as new rules for transverse bulkheads (UR S18), and UR S20 (double-bottom structures). Other common features are reinforced hatch covers and a raised forecastle (UR S28, mandatory for ships contracted after January 1 2004).

Since the double-skin spaces will be considered, for design reasons, as water ballast spaces, some 8% extra steel weight will probably result, to combat the extra stresses in the double-bottom plates when this area is flooded. More work is being done on this aspect. The longitudinally framed design will probably end up being lighter since less steel is being used, while the Panamax model has modified detail dimensions to try and recover some of the lost cargo capacity as a result of the extra steel - which is one of owners' most vociferous concerns over the principle of double skins. Heavier ships mean more resistance and more fuel consumed, while a double skin equals lost cargo space.

It should be noted that, in general, owners of Capesize models primarily demand capacity for their ships (because they are often carrying dense cargoes such as iron ore), while operators of smaller ships, such as Panamax classes, are seeking volume. Some of the interesting plus and minus aspects of the

MARINE ENGINEERING SERVICES (MES) PANAMAX BULK CARRIER (longitudinal framing) (reduced length for entry into the port of Kamsar, Guinea)

Length, oa.....	229.50m
Length, bp.....	222.22m
Breadth, moulded.....	32.24m
Depth, moulded to upper deck....	20.20m
Draught, design.....	12.60m
Draught, scantling.....	14.60m
Deadweight, design draught...	62,000dwt
Deadweight, scantling draught.....	75,000dwt
Speed, service, 14.60m draught.....	14.50knots
Classification.....	Bureau Veritas I, + Hull, + Mach, Bulk Carrier, ESP, Unrestricted Navigation, + Veristar Hull, NONHOMLOAD, BC-A (Hold 4 may be empty), HEAVYCARGO, GRABLOADING, SYS-NEQ1, +AUT-UMS, Grain Loading

Differences from reference single-skin design

Length.....	+2%
Depth.....	+3.5%
Breadth.....	0
Deadweight.....	-3.8%
Volume.....	-8.5%
Steel weight.....	+6%
Ultimate hull girder strength increase.....	+3.5%
Deck modulus increase.....	+2.5%

new designs can be seen in the accompanying technical particulars table for each of the three European models.

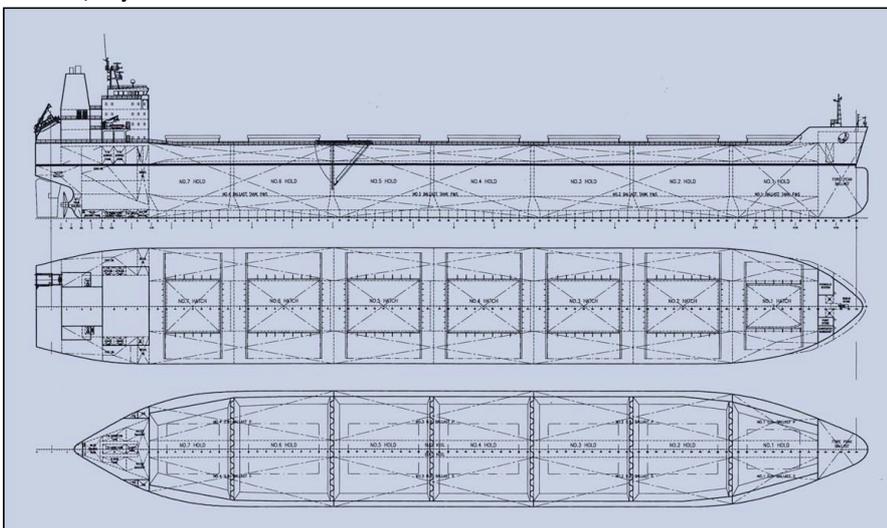
What width for double skins?

The vexed and still undecided question of the width of the double skins is causing some difficulty for all parties. Currently, IMO is calling for 1000mm minimum overall width for ships of all sizes, but since that organisation is also suggesting a minimum of 600mm x 800mm for access cut-outs on ships with longitudinal framing, a minimum of 1100mm overall width seems likely for Capesize designs, believes Bureau Veritas. In turn, this could allow 800mm wide access holes.

For transversely framed designs, IACS is, for its part, suggesting double-hull widths between 950mm and 1300mm, which would give a satisfactory manhole width of 600mm, a figure which BV feels could eventually be mandated. Overall, the French classification society believes that the new designs go a long way towards complying with anticipated new legislation, even if the finer details are not in place.

As shown here, Bureau Veritas is aiming to support those confused over IACS requirements, and has been studying four new double-hull bulker designs in detail, with the intention of giving practical guidance on the forthcoming new requirements. As soon as IACS and IMO regulations are finalised, BV will publish guidelines on bulk carriers, which will give extensive guidance and support to both owners and yards on key choices when specifying new ships.

General arrangement plans of the double-skin Panamax bulk carrier (specially planned for entering the port of Kamsar in Guinea, hence the term Kamsarmax) designed by Marine Engineering Services, of Trieste, Italy.

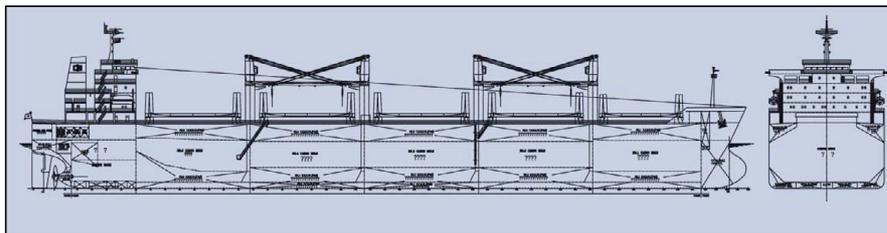


Model tests for Chinese Super-Handymax bulk carrier series

HSVA, the Hamburg Ship Model Basin, was recently contracted by a Chinese consortium consisting of the Shanghai Merchant Ship Design & Research Institute (SDARI), the Bohai Shipbuilding Heavy Industry Co Ltd, and the Shanghai Shipyard, to optimise the hull lines design for a new 57,300dwt Super-Handymax bulk carrier. Ten vessels of this type will be built by the aforementioned shipyards. Hilmar Klug, in *NewsWave*, HSVA's newsletter, details the tests carried out at the model basin.

Prior to performing calm water model tests, HSVA's designers and CFD experts analysed and improved the hull lines using CFD-calculations. These calculations were carried out with the CFD-software Comet, which takes into account viscous effects as well as the free surface, ie, the wave pattern of the vessel.

In HSVA's experience, for high block coefficient vessels with very blunt waterlines,



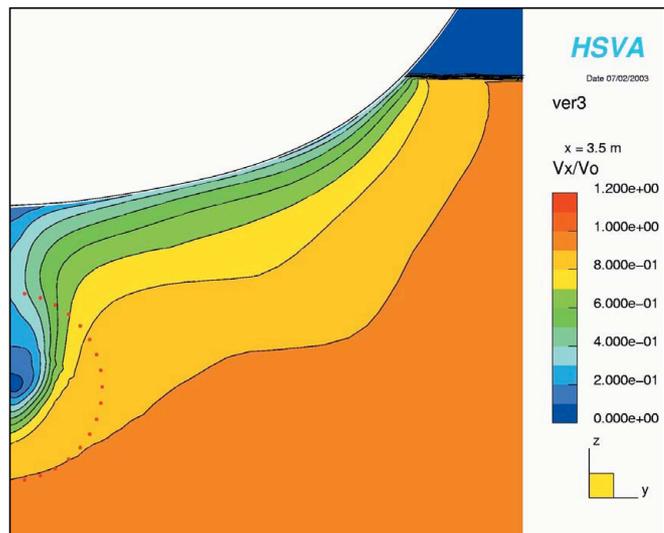
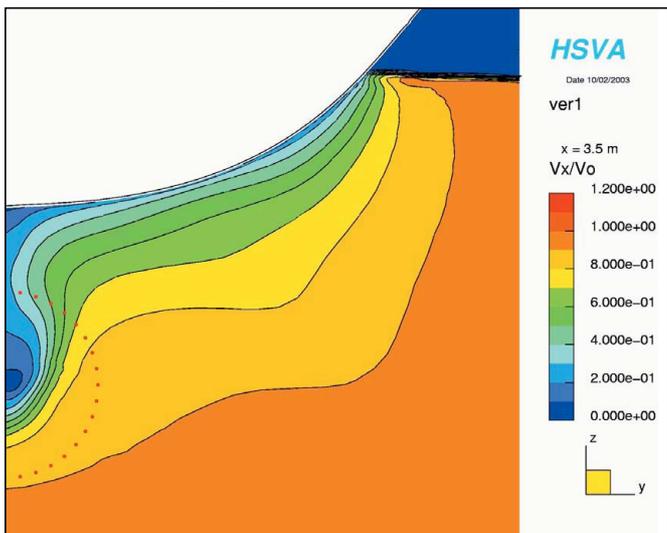
General arrangement of the 57,300dwt Super-Handymax bulk carrier, model testing for which was recently carried out at HSVA in Hamburg.

application of a viscous flow code is preferable to that of a potential flow code. Longer computing times occur, but there are a number of advantages in using this code, namely that the bulbous bow design and the wake field at the location of the propeller can be optimised.

The model test program started with resistance and self-propulsion tests with a stock-propeller

at four draughts. The next steps were a 3D wake field measurement, a paint test, and manoeuvring tests and simulations. All these tests were performed in HSVA's 300m long towing tank. The tests for this series of bulk carriers will be continued with self-propulsion tests with an actual design propeller and cavitation tests in the HYKAT cavitation tunnel.

Computed wake fields made by HSVA at the location of the propeller for the new Super-Handymax bulk carriers. On the left are the initial lines, with the optimised lines to the right.



FACT, NOT FICTION



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Improving bulk carrier safety with electronic logbooks

THE Internet is now truly delivering substantial benefits to commerce. Unfortunately, the impracticality of securing access from its principal asset has thus far not allowed the shipping industry to take full advantage of the digital revolution. However, with the introduction of ship-to-shore communications specifically designed to provide a continuous, broadband Internet service, for example Inmarsat Fleet, this limitation no longer applies, and has opened up a vast array of new applications for IT in ship management.

The FleetMaster electronic log book (ELB) is an innovative new system designed by MarTco, a Kongsberg Maritime company, which has the potential to deliver significant benefits across a range of operational sectors, but especially bulk carriers with their vulnerable structures when carrying dense cargoes.

As the name implies, ELB is designed to replace the traditional, paper logbook with one major advantage: when connected to the Internet, near real-time access to primary vessel data is provided onboard and in onshore offices. This is not at the expense of escalating communications costs, as sophisticated compression software and a common framework of standards ensuring all operational data typically recorded on a ship can normally be transmitted in a file of 20kilobytes or less.

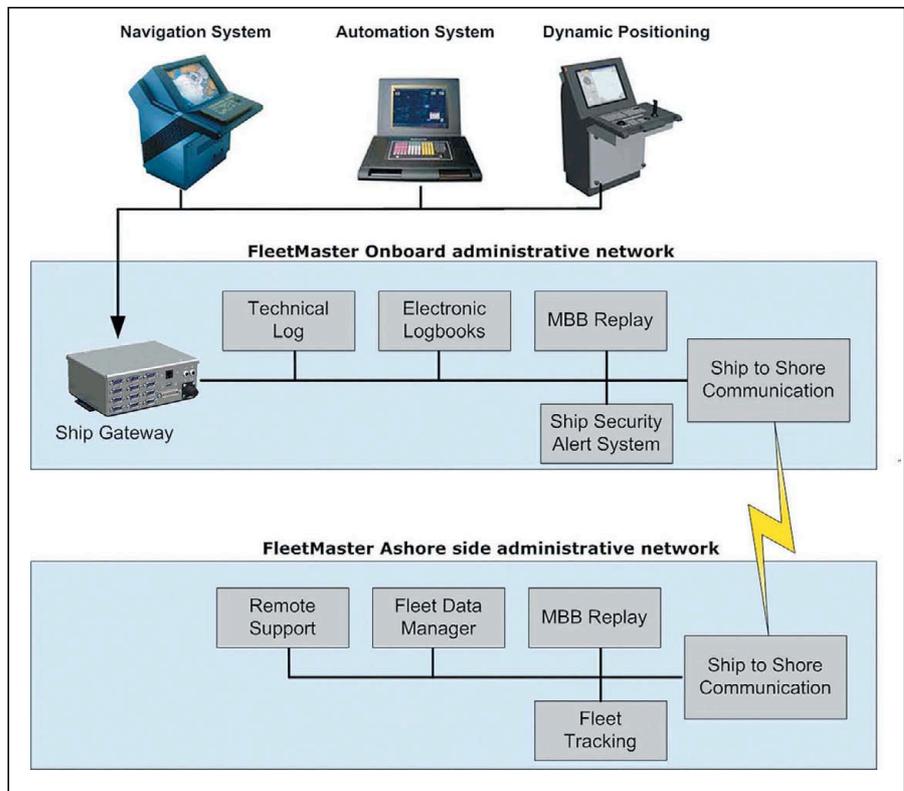
ELB and dry bulk shipping

Ship losses in the dry bulk sector have been disproportionately high for a number of years, often consequential heavy loss of life. As identified in various studies (Ref 1), a common feature in many of these losses has been catastrophic fatigue-initiated fracture failure of the hull.

The specific causal factors leading to hull failure in a bulk carrier are invariably complex, nor are they always fully understood due to a lack of through-life performance data, particularly as paper records may be lost with the ship and are invariably difficult to analyse. Although this has been addressed in part through the use of voyage data recorders (VDR), this technology may only store the previous 24 hours' information, presuming it can be found after a vessel has foundered. The broad consensus however suggests fractures may result from a combination of:

- operating the ship beyond its design stress limits, for example, due to poor cargo loading practices
- poor maintenance
- structural details that are fatigue-crack initiation sites.

This situation is compounded by the difficulty faced by the crew, owners, and regulatory authorities alike in the identification of a developing, impending problem. The first warning of hull fatigue failure in a bulk carrier may be too late.



A representation of a typical FleetMaster system, which allows near real-time access to primary vessel data provided onboard a ship, and in onshore offices. Such technology could be very useful for bulk carriers.

With the problem identified, developing risk control measures to improve bulk carrier safety should, in principle, be straightforward. Put simply, the policy options are:

- ensuring the ship is not operated beyond its design stress limits
- continuous maintenance and attestation of the hull to confirm the validity of these limits and/or recalculation of the limits to take account of degradation or other damage
- providing key stakeholders with real-time warning of developing abnormalities in the hull structure.

Indeed, most, if not all, the recent initiatives targeted at bulk carriers adopted by the regulatory authorities, including the IMO, seek to apply at least one, or a combination of these policies options using technology, or procedural controls or a combination of the two (Ref 2), for example the Bulk Loading and Unloading Code of Practice or BLU Code (Ref 3).

The overall strategy of the BLU Code is uncomplicated: if communications between bulk carrier and terminal operator are improved, there should be no confusion that leads to the ship being operated beyond its design stress limit. If risk reduction is to be effective, this exchange of information between parties must be dynamic and address, amongst other things:

- the development and agreement of the load/unload plan (Ref 4)
- any variations to the plan (Ref 5)
- other key events including damage to the ship's structure or equipment.

Furthermore, the detail of all correspondence must be recorded. This acts to protect the interests, financial or otherwise, of stakeholders should dispute arise. More importantly, it demonstrates the extent to which the agreed load/unload plan was conformed, thereby providing an evaluation of the potential impact of terminal operations on hull structural integrity (Ref 6).

Clearly, there is no reason why existing technology could not be used to fulfil the requirements of the BLU Code. However, this is at the expense of applying skilled resources on each ship to prepare the load/unload plan and instruct the crew, and after lengthy satellite communications remembering to commit everything said to paper.

The application of an ELB could simplify these procedures. For example, when developing or required to modify a load/unload plan, the bulk carrier's master could use the ELB to directly and dynamically access specialist resource onshore. Moreover, as digital communications are used throughout, all correspondence is stored with real-time copies available to owner and

terminal operator alike, the application of established validation technology (Ref 7) ensuring there can be no doubt who said what and when.

Management may also use ELB as a vehicle to communicate key tasks to be performed by crew members and to provide early warning of a potential failure to act. Unlike procedures on paper, computer-generated forms can readily be tailored to meet the specific needs of the ship; different cargoes, different crew; a selection of languages perhaps, or the terminal; tidal variations; and equipment constraints. Furthermore, as the crew complete the ELB in line with the prompts received, essential feedback is provided to confirm that a key task has been completed, or when it has not; with appropriate warnings issued to master an/or terminal captain, and/or to highlight potential flaws in procedure that need to be addressed.

ELB has the potential to ensure the BLU Code offers optimum benefit to bulk carrier safety, while also reducing the potential burden imposed on ship operations and noting that the European Union (EU) now requires all ships and terminals to conform with the provisions of the BLU Code in all dry bulk terminals operating in the EU (Ref 8). There are wider operational benefits through the use of ELBs; they may assist ship and terminal alike in the identification of cumulative, hidden weaknesses in the hull through fitness-for-service analyses.

All information gathered from ship survey and inspection should always be collated, analysed and modifications made to the vessel's design stress limits if appropriate. An ELB greatly eases this task and facilitates the practice of techniques developed for the rapid assessment of structural integrity of damaged ship structures. Analogous to the existing rapid assessment procedure and integrated design (RAPID) developed for aviation (Ref 9), these provide for real-time analysis to determine whether loads recently experienced by the ship interacted unfavourably with existing or recently detected damage and other events as may have been recorded in an ELB.

Rapid real-time assessment of structural integrity

Real-time assessment during ballast transfer at sea is a highly controversial issue, and it appears inevitable that bulk carriers will be required to transfer ballast water during oceanic voyages. The analysis and planning required to perform this task while ensuring the ship does not operate beyond its design stress limits is complex, and requires suitably qualified staff and time. None of these may be available to the typical bulk carrier. This potentially means assistance from shore-based decision-support networks, who do have the necessary resources may be an essential if the procedure is to be completed while ensuring the risk to the ship's crew is maintained as low as reasonably practicable.

Here, an ELB can perform a number of functions. As for the BLU Code, experts may assist the master complete a ballast plan with the detail of all tasks to be performed uploaded onto the ship's server for presentation on its ELB. Critically, as the crew complete these tasks, their performance may be continuously monitored onshore from sensors, for example, hull stress monitoring linked to the ELB using wireless, with dynamic modification to the plan made as required. 

References

1. Including the Formal Safety Assessment of Bulk Carriers Fore-end Watertight Integrity, International Association of Classification Societies, 2001.
2. SOLAS Ch.VI Reg.7.2 and Reg. 7.7 requires the ship is not operated beyond design stress limits.
3. IMO Assembly Regulation A.862(20).
4. SOLAS Ch.VI Reg.7.3.
5. SOLAS Ch.VI Reg.7.8.
6. SOLAS Ch.VI Reg.7.6.
7. For example, Microsoft Windows Digital Signatures.
8. Directives of the European Parliament and of the Council establishing requirements and harmonised procedures for the safe loading and unloading of bulk carriers.
9. [http://aar400.tc.faa.gov/Programs/Aging Aircraft/Commuter/RAPID/Ref](http://aar400.tc.faa.gov/Programs/AgingAircraft/Commuter/RAPID/Ref)
10. Equipment conforming to the IEEE's 802.15.4 standard.

NEW PUBLICATION

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Co-written by Stephen Payne, Director Project Management/Designer QM2 (CCS) and Tim Knaggs, Editor of The Naval Architect

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ALSTOM

Taiwan-built 'ultra-large Panamax bulker'

It is hoped that a newly-developed design, delivered in January this year, named an 'ultra-large Panamax bulk carrier', will set a new standard in bulkers. Designed and built by China Shipbuilding Corp, in Taiwan, for Taiwanese operator Tai Shing Maritime, this vessel is claimed to have the largest deadweight and cargo hold capacity amongst the current Panamax fleet. *Tai Progress* also has an optimised hull form and a large-diameter propeller, which ensures not only excellent propulsion performance, but low fuel consumption (more details about this vessel can be seen in *Significant Ships of 2003*).

TECHNICAL PARTICULARS TAI PROGRESS

Length, oa.....	225.00m
Length, bp.....	217.00m
Breadth, moulded.....	32.26m
Depth, moulded to upper deck.....	19.50m
Depth of double bottom.....	1.70m
Draught design.....	12.20m
Draught, scantling.....	14.10m
Gross.....	41,400gt
Displacement.....	88,366tonnes
Deadweight, design.....	64,000dwt
Deadweight, scantling.....	77,834dwt
Main engine.....	MAN B&W 5S60MC-C
Speed.....	14.50knots
Classification.....	American Bureau of Shipping +A1, Bulk Carrier, 'Strengthened for Heavy Cargoes, Holds 2, 4 and 6 may be Empty', SH, SHCM, +AMS, +ACCU, HCS, ESP, LCM, and China Corporation Register of Shipping 100E, Bulk Carrier, 'Strengthened for Heavy Cargoes, Holds 2, 4 and 6 may be Empty', (ESP), CMS (CAU)



This new-design 225m long bulk carrier, *Tai Progress*, is claimed by its builder, China Shipbuilding Corp, to have the largest deadweight (77,834dwt at scantling draught) and cargo hold capacity (92,152m³) of any in the Panamax fleet.

Tai Progress was built with a seven-hold layout. The hull is made up of 70% high-tensile steel, and includes reinforcement for the carriage of iron ore in holds 1, 3, 5 and 7; for sailing with numbers 2, 4, and 6 empty; and for No 4 hold to be available for use as a water ballast tank on heavy-weather ballast voyages. Ballast tanks were designed to comply with IMO regulations relating to ballasting at sea, and the latest IACS unified requirements are fulfilled. A water ingress alarm system serves the cargo holds, satisfying the new SOLAS rules.

Length and width of the hatches, covering Nos 2 to 7 holds (17.10m x 15.03m), provide openings which are the largest amongst vessels of this type. This provides operators with easier cargo handling and faster loading/unloading times. Tsuji side-rolling covers are fitted to all cargo hatches, and these are driven by chains, with manually operated cleating. Cargo loading is handled by a Ohima OEC-Loadmaster computer.

Tai Progress is fitted with a Mitsui-built MAN B&W 5S60MC-C main engine, which is derated to produce 9996kW MCR at 93.5rev/min and 8158kW NCR (81.6% MCR) at 87.4rev/min. This drives a Nakashima FP propeller, with a diameter of 7050mm, producing a service speed, at design draught and NCR output, of 14.5knots, allowing a 15% sea margin.

Electrical supply is derived from three Daihatsu/Nishishiba diesel-driven alternator sets, each rated at 440kW; incidentally, *Tai Progress* is one of the first ships to feature the new Daihatsu DC-17 heavy-fuel-burning engine for its diesel-alternators (five-cylinder machines of 480kW output). Steam is produced from a vertical composite boiler with an output of 1500kg/h, serving, amongst other uses, the air conditioning system installed in the five-tier-high deckhouse aft, which houses a complement of 10 officers and 13 crew, all in single cabins. ⚓

Handymax bulkers ordered in Vietnam

An unusual move has seen Cardiff-based Graig Group place five firm orders and secured 10 options for its Diamond 53 Handymax double-hulled bulkers with Vietnamese state shipbuilder Vietnam Ship Industry Corp (Vinashin). It is believed that a shift to Vietnam is the result of a lack of suitable slots in China due to full order books there.

The contracts are part of a strategic alliance which will see the Vietnamese yard expand the range and quality of its output. Previously Graig has ordered all its ships in China. Graig believes it can help the Vietnamese yard with design, procurement, finance, and quality control. The Diamond 53 design (*The Naval Architect* November 2002, page 7) is believed to offer owners and charterers major operational cost savings, while significantly enhancing safety and environmental protection.

Delivery date for the first Vinashin vessels is January 2006. These ships will be built at two state-backed shipyards, Halong, in the Quang Ninh province, and Namtrieu Shipbuilding Industry Company in Haiphong. These are claimed to be the largest and most sophisticated vessels yet built in Vietnam.

Graig has inspected the yards and is confident that with the right support they can not only build these ships to a good standard, but will also grow to become another important shipbuilding centre. There has already been substantial investment in modern shipbuilding in Vietnam with equipment and practices, with full support from the Vietnamese government. Graig will be opening an office in Vietnam to serve this project, and other projects currently under discussion.

The Diamond 53 Ultra-Handymax double hull bulk carrier design has been developed jointly by Graig and Danish consultancy Carl Bro after detailed discussions with charterers. Graig and Carl Bro have a joint venture design company based in Shanghai. The vessels will be classed with Det Norske Veritas to +1A1 Bulk Carrier standards, with a full Nauticus package including a 3D model. Fourteen Diamond 53 vessels have already been ordered in China, and the first vessel is scheduled for delivery this year.

Diamond 53 is a geared, wide-hatched, 53,000dwt bulk carrier of the newest double-hull type and a high specification intended to address the current concerns raised by IMO/IACS around bulk carrier safety. The vessel has five cargo holds, equipped with end-folding hydraulically operated hatch covers and four 36tonne electro-hydraulic luffing cranes. ⚓

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Pounder's Marine Diesel Engines and Gas Turbines

Edited by Doug Woodyard. Published by Elsevier Butterworth-Heinemann, Linacre House, Jordan Hill, Oxford OX2 8DP, UK. Hardback. 884 pages. Price: £74.95. ISBN 0 7506 5846 0.

It is five years since the last edition of this venerable work, which once again has been edited by Doug Woodyard, a correspondent to *The Naval Architect*, especially on matters relating to propulsion plant (his report on the newest advances in the diesel and gas turbine world appears elsewhere in this issue). This book (first published in 1950) continues to commemorate the name of Mr C C Pounder, a one-time feared and outspoken engineer at the Harland & Wolff engine works in Belfast (alas, now no more). It is good to see that a number of chapters still have the initials CTW attributed at the end - a reference, as explained by the editor in his preface, to Chris Wilbur; he was a well-known engineering member of the UK marine press corps who died prematurely in 1992.

Although naturally slanted towards engineering technicalities, this comprehensive text does provide all the up-to-date and latest details to which those involved with ship propulsion plant may wish to refer. These particularly cover advances in fuel injection, the increasingly regulatory problem of limiting exhaust emissions, and the new technology of electronic valve controls without camshafts - so-called intelligent engines. The text is

complemented by large numbers of black and white photographs, also engine cross-sections and diagrams.

An important addition to this, the eighth edition, is a new, lengthy, chapter devoted to gas turbines (hence the change of title), which, although well-established in the naval field, today appear to be making a comeback in the merchant field, especially in the cruise liner sector, for electric power generation. Prospects also appear quite bright for fast ferries and perhaps LNG tankers and container ships. While General Electric (GE) remains the market leader, others, particularly Rolls-Royce, are closing in fast. Some people in the industry believe that if modern designs can be adapted to burn more economical heavy fuel - GE and Stal are already working on this, then even more owners would be tempted to install these compact power units.

Even if naval architects find the bulk of this book's text heavy going, they would be well-advised to read the preface and introduction, which both set the modern scene and act as a reminder of the brilliant achievements of the past. Equally important for ship designers is Chapter 6, which discusses the critical topic of engine and plant selection.

Tim Knaggs

Ship Knowledge - a Modern Encyclopedia

By K van Dokkum. Published by Dokmar, The Netherlands. Hardback. 32cm x 22cm. ISBN 90 806330 2X. 341 pages. Price: €70.00 for CEMT members, including post and packing in Europe,

from KNVTS, Rotterdam, The Netherlands. Also available from the RINA bookshop, price: £47.00 (RINA members: £43.00), plus post and packing: £7.00 (UK and Europe), £14.00 (rest of world).

This is basically an adapted and extended English-language version of what is claimed as a very successful Dutch publication, *Scheepskennis*, written by Klaas van Dokkum and published in 2001. Using a superb state-of-the-art layout, the 16 chapters lead the reader in great detail through a multitude of facts related to ships, shipbuilding, and shipping. The parts and systems that form a modern ship from initial design up to the completed construction, including paints and coatings, also legal aspects, are extensively covered.

A large collection of clear diagrams, general arrangement plans, cross-section drawings, system diagrams, cutaway ship drawings, (mostly in colour), and many colour photographs - including some fascinating real-life ones to head each chapter - will be of great assistance to this journal's readers, although the publication is said to be eminently readable for everyone with an interest in ships and shipping. The publisher actually describes the book as 'easy reading leisure material', however, the technical standard should most certainly find favour with naval architects and ship designers; in particular, there is an excellent chapter on stability. Indeed, the book should perhaps be on every ship designer's and shipbuilder's shelf, and those of shiprepairers, too - Chapter 14 covers maintenance and docking. It might also even assist students.

Tim Knaggs

Ship speed trials: a new method

The task of a proper performance and analysis of speed trials is often squeezed between the competing interests of the involved parties: designers, builders, suppliers, owners, and operators. The model basin is a party with only a weak share in terms of economic interest but with strong interests in technical validation and feedback. Here, Peter Schenzle and Kai-Enno Brink, from HSVA (Hamburg Ship Model Basin), discuss a new method of ship speed analysis, first published in *NewsWave*, the model basin's newsletter.

FINAL trials information is not only vital for the improvement of a basin's power prediction service, but can be the basis to solve the technical problems which may be underlying a dispute between the directly interested parties.

A proper technical performance and analysis of a ship's speed trial enables a model basin to play an efficient role as a moderator in conflict situations, by bringing the discussion back to the technical point, where solutions for the problem can be developed.

In order to improve the significance of full scale measurements, HSVA has developed a detailed speed trial analysis. The quintessence of the evaluation procedure lies in the analysis

of a number of interrelated and fully documented trial measurements, which meet the following requirements:

- at least three double runs at different engine loads, with and against the wind
- reliable measurements of ground speed, shaft speed, shaft torque, and apparent wind
- contract conditions regarding draught, trim, hull and propeller conditions
- favourable environmental conditions with moderate wind and waves and deep water during the trial.

A method was developed for a stepwise analysis and correction of the trial measurements in order to evaluate the speed power characteristics of the vessel. Thereby small deviations of the measured results for alternating reverse runs are used to calibrate directional influences. The detailed speed trial analysis in general is made according to the following procedure:

1. determining speed through the water by adapting smooth functions for the current component versus time, and torque coefficient versus apparent advance ratio. Correcting speed for shallow water influence, if any
2. calibration of apparent wind measurement by adapting smooth functions for true wind

speed and direction versus time. Converting true wind from measurement level to effective centre of frontal area

3. calculation of wind and wave added resistance and correction of delivered power for small differences between trial and contract conditions of prediction with respect to wind, waves, draught, water temperature and salinity
4. check of corrected power for smooth function of speed and adjustment of assumed parameters in correction procedure, if possible
5. calculation of shaft speed for corrected propeller power and speed through the water according to the above determined propeller torque characteristics.

By the HSVA trial analysis procedure, full-scale measurements are corrected for all relevant influencing factors and environmental effects. As opposed to most speed trial evaluation methods commonly in use, each single trial run is analysed separately in order to arrive at the corrected operating condition of the vessel in the contractual situation. The HSVA Speed Trial Analysis is a rational approach for the evaluation of speed trial measurements, which can be generally accepted by the different parties involved in the commissioning of a ship. 

FPSO hull structures - all change to new UK regulations?

John Still (Lochhead Still Associates, and formerly of Amerada Hess, London), considers an interesting scenario, which might mean some operators switching from traditional classification rules to new UK design and construction regulations.

IN the UK offshore sector, several operators of floating production, storage, and offloading (FPSO) vessels today have the choice to abandon classification society rules in favour of the Offshore Installation (Design and Construction) Regulations 1996 (DCR SI 1996/913). However the operator, known as the duty holder, must employ an independent body to verify his choice of the safety critical elements, which should be inspected by a third party at regular intervals.

Records associated with selection of the safety-critical elements and the results of inspections carried out are reviewed by the UK Health & Safety Executive (HSE) to ensure that the duty holder is not in breach of the regulations. The main benefit of applying these design and construction regulations requirements instead of classification requirements is that it allows the duty holder to select the safety-critical items and decide the frequency of inspections. This article provides a brief overview of classification versus DCR when applied to an FPSO, and benefits of using DCR compared with classification.

Implementation of the safety case

A series of new statutory instruments were introduced after the *Piper Alpha* disaster as a consequence of the enquiry by Lord Cullen [Ref 1] who recommended the introduction of a safety regime offshore, which was introduced in 1992. This safety regime, referred to as the Offshore Installations (Safety Case) Regulations 1992 (SI 1992/2885) [Ref 2], is supported by the following regulations:

MAR: Offshore Installations and Pipeline Works (Management and Administration Regulations) 1995 (SI 1995/738) [Ref 3]

DCR: Offshore Installations (Design and Construction) Regulations 1996 (SI 1996/913) [Ref 4]

PFEER: Offshore Installations (Prevention of Fire Explosion Escape and Response) Regulations 1995 (SI 1995/743) [Ref 5]

PSR: Pipeline Safety Regulations 1996 (SI 1996/825) [Ref 6].

The MAR and PFEER regulations demonstrate that the management systems in place comply with the relevant statutory health and safety provisions. The DCR scheme was introduced to address the following four main areas:

- integrity of offshore installations
- well safety
- safety of the workplace offshore



Two illustrations of a representative FPSO, *Triton 1*, seen during construction and outfitting. The ship was built as a tanker at Samsung in Korea. An upper tank section is seen being positioned (top), with the vessel drydocked at Sembawang, Singapore (bottom), for installation of the moonpool casing.

- verification of safety-critical items within the offshore installation
- both fixed platforms and FPSO vessels are classed as installations
- since no wellhead equipment is located on an FPSO, this part of the DCR does not apply to FPSOs.

Offshore Installations and Wells (Design and Construction etc) Regulations, 1996 (SI

1996/913) were introduced in 1996 and replaced the Offshore Installations 1974 (Construction and Survey) Regulations (SI 1974/289) [Ref 7], which were introduced in 1974.

Hull construction

In a recent representative case, owing to the time required to construct a purpose-built FPSO, the project management team agreed to purchase an existing slot (Hull 1226) within the shipbuilding

OPERATOR	VESSEL	REMARKS
Shell Expro	Anasuria	UK Foreign Office advised the owner to class the vessel. This action was to provide protection for the vessel if attached during transit. On arrival at Tyneside for fitting out process facilities, the class was dropped. No propulsion installed
BP Exploration	Schiehallion	No propulsion installed
Amerada Hess	Triton 1	Engines removed
ChevronTexaco North Sea	Captain FPSO	No propulsion installed

Table 1. Classification abandoned.

Owner - Vessel Operator	Oilfield	Vessel
PGS - Conoco Phillips	Banff	Ramform Banff * ^
Bluewater - Shell Expro	Pierce	Haewene Brim * ^
Bluewater - Amerada Hess	Fife, Fergus, Flora & Angus	Uisge Gorm * ^
Bluewater - Talisman Energy	Ross, Parry & Blake	Bleo Holm * ^
A P Möller - Canadian Natural Resources	Curlew & Kyle	Maersk Curlew * ^
NSPC - ConocoPhillips	MacCulloch	North Sea Producer * ^
PGS - BP Expro	Foinaven	Petrojarl Foinaven * ^
Kerr McGee	Gryphon	Gryphon A ^
Kerr McGee	Leadon	Global Producer III ^

* Vessels owned by non-asset owners are leased to the asset operator for production purposes and are retained in classification as a condition of the mortgage. Mortgage conditions are dictated by a bank allowing it to sell the vessel in the event that the owner encounters financial difficulties.

^ These vessels have retained their propulsion machinery.

Table 2. Classification retained.

programme of Samsung Heavy Industries, in Korea. The vessel was constructed as a 105,000dwt Aframax crude oil tanker and named *Triton 1* (son of Poseidon, the Greek god of the sea). Installation of the moonpool casing to support the turret structure was carried out in Singapore by Sembawang Shipyard.

Construction requirements for tankers or vessels destined for service as FPSOs are normally governed by those rules imposed by the various classification societies. In the UK, legislation was introduced which allowed potential FPSO operators the opportunity to apply either classification requirements, or apply DCR for the construction of new hull structures or conversion of existing tankers.

The service conditions experienced by an FPSO are, of course, more rigorous than a conventional trading tanker. A typical FPSO may remain on station for anything from 15-20 years, whilst a trading tanker is drydocked at regular intervals for inspection and repair. FPSO vessels can either be constructed as new purpose-built units, converted from an existing tanker, or as an 'interception' where a vessel slot within the shipyard programme is purchased from a shipping company prior to or during the building of a trading tanker.

Although their hulls are constructed in accordance with classification rules, FPSO operators may insist on inspecting critical and fatigue-sensitive areas during construction, over and above classification requirements, by their own site inspection team. Also,

depending on the service conditions, the FPSO operator may request the shipyard to change both materials and welding consumables for the outer hull to a grade that would provide better crack-arrest properties for fatigue-sensitive areas.

Classification societies have developed rules for building vessels such as trading tankers and have also introduced rules for vessels destined for FPSO service. In the UK, potential FPSO operators use the classification rules, in conjunction with SI 1996/913, for the construction of new hull structures.

Contract requirements

In a recently constructed FPSO, *Triton 1*, the intent of the contract regarding classification requirements reads: 'Contractor shall initially build the tanker to classification requirements and maintain classification until arrival at the integration quay. Contractor shall perform all design, procurement and construction activities to upgrade the vessel (which excludes topsides) for permanently moored FPSO duty in accordance with the appropriate classification rules, as if the vessel were to be classed with - for, example, Lloyd's Register + 100 A1 AT Floating Oil, Production and Storage Installation - and the following notations:

- OMC - Machinery No Propulsion
- UMS - Unattended Machinery System
- CCS - Corrosion Control System
- IGS - Inert Gas System
- IWS - In Water Survey.

Subsequently, the operator appoints an independent competent body (ICB) in accordance with the DCR requirements to review the class notations as performance standards. It should be noted that classification in this instance relates to the hull and mooring system but not the topsides, although classification societies have introduced requirements for both the vessel and the topsides of FPSOs.

Operating FPSOs in UK waters

FPSOs operating in UK waters fall into two categories [Ref8]: Vessel classification abandoned, Table 1, and vessel classification retained, Table 2.

continued

Table 3. The relationship between DCR/SCR (safety case regulation) and classification.

Marine systems	PFEER	DCR/SCR	Classification	Flag
Primary Structure - Mooring		#	#	
Primary Structure - Hull		#	#	
Ballast system & Distribution		#	#	
Inert Gas System	#	#	#	
Fire & HP Seawater System (ship only)	#	#	#	
Diesel Fire Pumps (ship only)	#	#	#	#
Bilge Pumps		#	#	
Navigation Lights & Equipment		#		#
Spider Attachment		#	#	
Chain Stopper		#	#	
Anchor Chains & Wires		#	#	

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Implementation of design and construction regulations

Classification determines the minimum design and construction standards for a vessel. The owner determines the required classification. Under certain circumstances, the owner may request that a particular system is designed to a higher standard. This change to above the minimum requirements will not alter the classification of the vessel.

Hypothetically, an owner may decide to build a vessel without involving a class society, provided the design will comply with both IMO and MCA requirements. However, to meet IMO requirements regarding flag, the vessel must be built to class society standards. Failure to meet the minimum requirements imposed by the IMO or MCA would result in the vessel being impounded until the shortcomings are rectified. However, if the vessel is to be used as an FPSO in the UK sector, Design and Construction (DC) Regulations will apply.

The requirements will cover many of the ship systems and if any item or items are considered safety-critical they will be included in the examination and verification scheme. In order to satisfy the DCR requirements, the examination and verification scheme is developed by the independent competent body (ICB) appointed by the duty holder. The examination and verification scheme is approved and executed by the duty holder.

It is the responsibility of the duty holder to ensure the examination and verification is completed to the satisfaction of the ICB. Should this not be the case an anomaly report or verification reservation is issued. Provided the duty holder can demonstrate to the HSE that the anomaly or reservation can be justified through an engineering route, the item will be accepted. The DCR requirements place responsibility upon the duty holder to ensure that the vessel and topsides are maintained in a safe condition.

Classification or DCR?

The overall objective of the examination and verification scheme is to set in place independent and competent scrutiny of those parts of the FPSO, which are critical to the safety of the installation. Throughout the vessel's life cycle, the duty holder is responsible for ensuring that the examination and verification scheme has been implemented and is capable of identifying anomalies. The role of the independent competent body is to verify that the duty holder has satisfied the requirements of the examination and verification scheme.

Although classification has similar objectives, the classification surveyor is involved with the inspection of items associated with the classification requirements. To maintain class, the duty holder has to report all damage to the hull to the class society. Failure to notify the society will affect the vessel classification, and if the operator is considered negligent the classification status ceases.

The reporting of damaged areas imposes an additional burden on the marine staff offshore to ensure that all items are recorded and forwarded to the society. The ICB works for the duty holder to verify that the examination has been carried out, whereas the class surveyor will inform the duty holder what he requires to inspect or review.

The relationship between DCR/SCR (Safety Case regulation) and classification is shown in Table 3. Both classification and DCR/SCR requirements are similar although exceptions do exist as shown.

Summary

If a vessel classification is ended and subsequently requires to be re-instated, this can be achieved with the minimum of effort. The use of Bureau Veritas' VeriSTAR hull program [Ref 9] allows a vessel operator to record all inspections and engineering details associated with the hull structure. This system will allow

the operator to assess hull condition against design standards. By maintaining this system, should the vessel require to be classified in the future, this would involve demonstrating to the society that the records have been maintained and the vessel condition is considered adequate to meet requirements. Cessation of classification ensures that the responsibility for maintaining the vessel and satisfying the HSE reviews of the examination and verification scheme is the duty holder's responsibility. J

Acknowledgement

The author would like to thank David Baillie for commenting on the preparation of this article.

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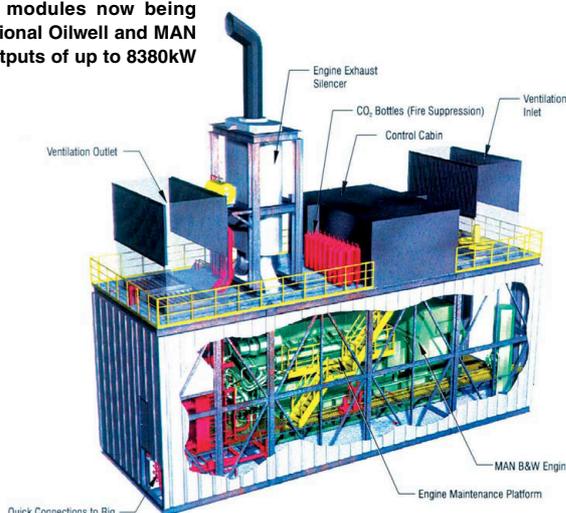
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Offshore power modules

NATIONAL Oilwell and MAN B&W have collaborated to design and supply a containerised power module as an alternative to the traditional power supply for CNG tankers, LNG tankers, FPSOs, drilling platforms, semi-submersibles and offshore production platforms. The largest of this range of power modules weighs 240tonnes and contains a MAN B&W 18-cylinder Vee-from 32/40 series engine driving an alternator with an electrical output of 8380kW. It has the following dimensions: length 17.7m, width 6.0m, height 7.0m, the height overall including the exhaust stack of 13m. Engines can be delivered to run on marine diesel oil, heavy fuel, crude oil, or oil/gas (dual fuel).

The power modules, which are ready-made units, are available with power outputs from 2780kW to 8380kW for each module. The units meet all requirements for applications in terms of safety, reliability, ease of installation and short commissioning times. They comply and meet with all relevant regulations, including classification society requirements. National Oilwell, a well-known US supplier of

A representation of one of the new offshore power modules now being marketed by National Oilwell and MAN B&W Diesel. Outputs of up to 8380kW are possible.



equipment to the offshore oil industry, will assemble the modules at its facilities in Houston

and China as total packages, complete with all necessary ancillary and auxiliary equipment. J

Advanced new pipelay barge for shallow-water areas

IN the next few months, Offshore Contractors (CI) Ltd (OFFCON) will take delivery of *Jascon-5*, which has been outfitted in Singapore to be ready for the 2004 construction season. Primary functions of this 140m barge are to perform pipelaying, construction, and/or accommodation work. *Jascon-5* is equipped with a DP3 system, S-lay pipelay equipment, an eight-point mooring system, and an 800tonne revolving crane.

Jascon-5 was built at Kouan Shipyard, Kouan, in China, but outfitted at Sembawang Shipyard, Singapore, with classification by the American Bureau of Shipping to + A1 BARGE, + DPS-3, PAS standards. The barge has a minimum draught of just over 3m, which will allow it to work in very shallow water. Since the thrusters at the bow and stern do not protrude below the barge bottom, the DP system can still operate in that shallow water.

The vessel's main deck, approved for homogeneous loads up to 10tonnes/m², has a clear area of approximately 1800m², suitable for the location of general fabrication spreads, large cargo blocks, and other items. There is an extensively equipped machine workshop with stores located below main deck, served by hatches on main deck and with a floor area of approximately 160m². Increased loading may be accommodated in certain cases by prior approval, subject to ABS acceptance.

An important feature is the large mast-crane, supplied by the Dutch company Huisman-Itrec. This is located at the stern, adjacent to the pipelaying equipment and has a maximum hoisting capacity of 800tonnes at 28.00m radius. An auxiliary hoist can lift 37.50tonnes at radii between 7m and 35m, with the jib at horizontal; this hoist runs via a trolley over one leg of the crane jib, which gives extra versatility. A 10tonne sling-handling winch is also included. More information on this crane



***Jascon-5*, an advanced new 140m pipelaying barge recently built by the Kouan Shipyard, China, and outfitted at Sembawang Shipyard, Singapore, becomes the new flagship of Offshore Contractors (OFFCON). She is seen here nearing completion and will probably be sent to work off West Africa.**

installation was given in our February 2002 edition, page 42. Two additional jib cranes are positioned to port and starboard; these electro-hydraulic units were supplied by TTS and have a maximum capacity of 34tonnes (port) and 33tonnes (starboard). They include a constant-tension/mooring feature for use when unloading cargo from a supply vessel.

Jascon-5's propulsion system is able to exert a thrust of, in total, 200tonnes (8 x 25tonnes). The system comprises six FP (strut type) thruster propulsion units of the Holland Roer Propeller type HRP 700-WM: three forward (units 1, 2, and 5), three aft (units 3, 4, and 6), and two FP (retractable) HRP 700-WM units, located midships portside and starboard (units 7 and 8). Each thruster is directly driven by a Caterpillar high-speed diesel engine of the D3516B type, developing 1566kW at 1800rev/min.

The dynamic positioning equipment has been supplied by Kongsberg Simrad and is fully redundant. It consists of one SDP21 dual control station on the aft working bridge with a Simrad planning station, and one SDP11 control station on the navigation bridge. In addition to this DP system, *Jascon-5* has an eight-point mooring system using four Marine Equipment and four Rolls-Royce Brattvaag single-drum 120tonne winches equipped with 1500m of 57mm diameter wire rope. Each winch is powered from individual electric/hydraulic power packs.

The single-joint S-lay system for pipes is mounted to port and can handle pipes from 101mm to 1219mm diameter. A conveyor system and powered transverse conveyors with elevating and non-elevating capabilities are included. Four welding stations are fitted on the line with one non-destructive

evaluation X-ray or ultrasonic point, plus a repair and coating station. The stinger has a length of 59.75m and is in two sections. All key points on this and throughout the ship are covered by three closed-circuit TV camera systems.

Jascon-5 has also been fitted with a (free-standing) helideck located on top of the forward superstructure. This has been designed for a Sikorsky S-92H HELIBUS aircraft. The heliport facilities are ABS approved (CAP 437), have a D-value of 21.7m, and all required firefighting and safety appliances have been provided.

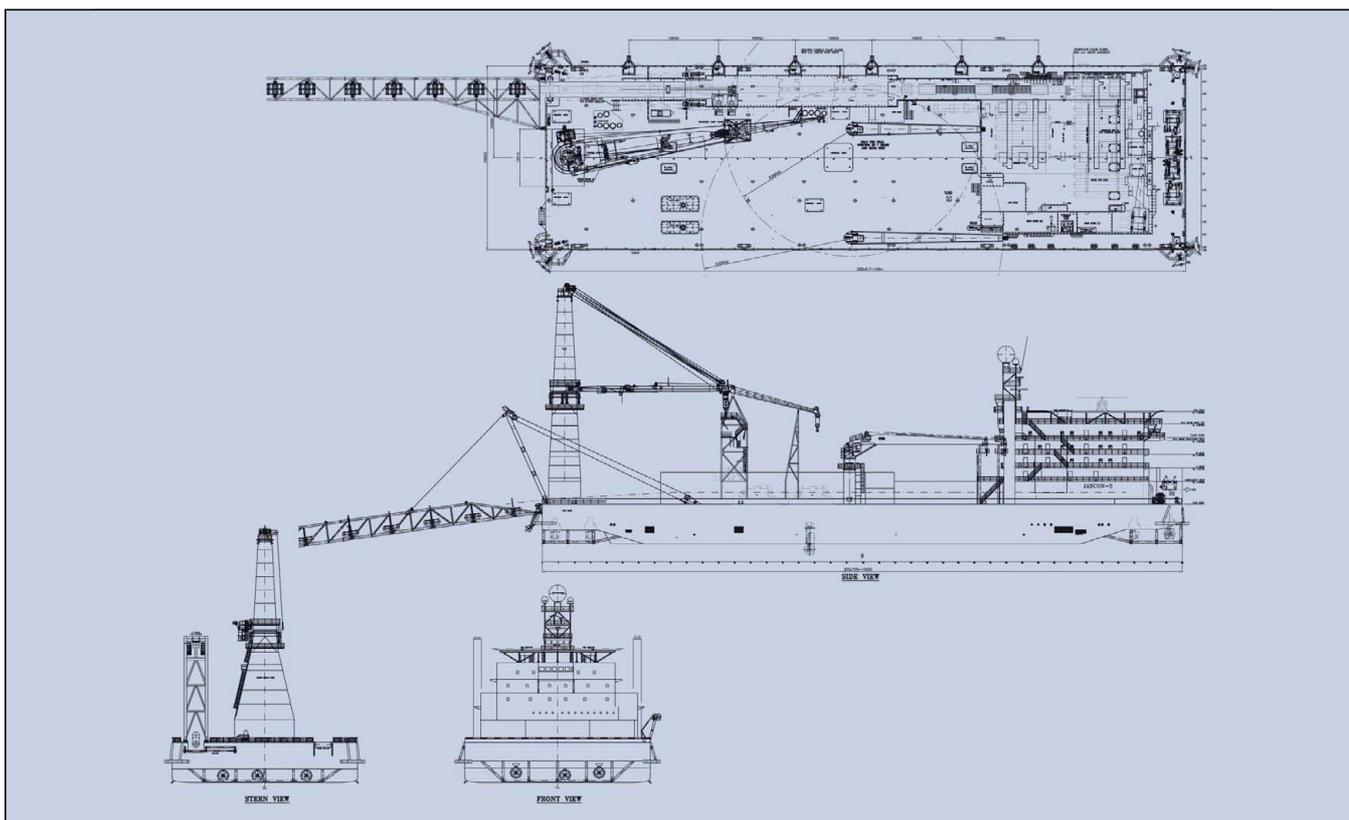
Jascon-5 has fully air-conditioned permanent accommodation for up to 350 people in cabins all with ensuite bathroom facilities. Amenities include a conference room, offices, helicopter departure and arrival lounge, gymnasium, telephone booth, prayer room, and recreation room. General toilet and shower spaces are on the A and B decks. The vessel also has a well-equipped hospital suitable for up to three persons.

The barge's 180tonne capacity pipelaying ability, in combination with the DP3 system, will enable OFFCON to lay pipes in water depths ranging from 3m-1500m using the extended S-lay technique. For this reason, OFFCON can offer one barge for installing both the infield pipelines and associated export pipeline for a particular field. Her relatively low-response characteristics make *Jascon-5* ideally suitable for swell-dominated areas such as West Africa.

Jascon-5, which will become the operator's new flagship when in service, has been targeted for field developments with either large-diameter heavy coated pipelines in relatively shallow water depths, and moderate diameters

TECHNICAL PARTICULARS *JASCON-5*

Length oa, excluding anchor racks and stinger.....	140.00m
Length bp.....	134.40m
Breadth moulded.....	40.60m
Depth moulded, to main deck.....	8.75m
Draught, minimum draught (mean).....	3.20m
Draught, maximum operating.....	5.80m
Lightship weight.....	10,110tonnes
Lightship displacement.....	14,000tonnes
Gross.....	19,805gt
Net.....	5941nt
Speed, transit.....	6-7knots
Free main deck area.....	1800m ² (approx)
Ballast capacity.....	8735m ³
Classification.....	American Bureau Shipping + A1 BARGE, + DPS-3, PAS



General arrangement plans of the new pipelaying barge *Jascon-5*.

in deeper waters. Ideal locations for the barge are the West African Gas Pipeline project - a pipeline running along the coast of Nigeria, Benin, Togo, and Ghana, also the Total Akpo

project, which calls for a 406mm export pipeline to be installed in 1400m water depth. OFFCON, which is part of the Sea Trucks Group, has a fleet of 14 vessels, while Sea

Trucks itself operates more than 150 vessels and has considerable experience in West Africa, where current focus is on submarine pipelines and offshore platforms. ⚓

Emergency response service gaining popularity amongst tanker owners

INTERTANKO's Council agreed at its Annual general meeting in April 2003 that all members would be required to engage a suitable emergency response service for the determination of stability and strength in a damaged condition from 1 January 2004. The initiative is part of this association's quality drive, presided over by its 'QQuest', or 'quest for quality', committee, chaired by Lars Mossberg, chairman of Swedish tanker operator Marinvest.

Of the 1700 ships enrolled in Lloyd's Register's Ship Emergency Response Service (SERS), 1000 are tankers. The persistent nature of crude oil and the political and public furore which inevitably follow an oil spill have made ship emergency response services such as SERS particularly attractive to tanker owners and operators.

Although SERS was first introduced in 1983, it was not until the introduction of the Oil Pollution Act of 1990 (OPA 90) in the USA that a significant number of ships subscribed to the service. OPA 90, which was introduced after the *Exxon Valdez* spill in Prince William Sound, requires all tankers

transiting US waters to have a vessel response plan (VRP) that includes, among other provisions, 'prompt access to computerised shore-based damaged stability and residual structural strength calculation programmes'.

When a ship is enrolled in SERS, Lloyd's Register creates and stores a 3D computerised model of the ship, along with key plans and information, ready to be used in the event of an incident. By having two response teams on standby 24 hours a day, 365 days a year, SERS can provide both a rapid initial response and an effective ongoing response to an extended casualty. SERS is primarily a naval architectural service which includes:

- estimation of cargo oil or bunkers remaining entrapped within damaged oil tanks
- assessment of the strength remaining in the hull girder after damage
- calculation of damaged floating position and residual stability
- for a grounded ship, calculation of the magnitude and location of the grounding force, accounting for the effects of tide;

SERS also assesses the impact of the grounding force on the shear force, bending moment, and stability curves.

Having assessed the condition of the ship after a casualty, SERS can help identify the best course of action to take by assessing a range of proposed remedial actions. In addition, SERS draws on the experience gained from responding to over 100 real incidents to pro-actively advise on further potential courses of action.

In responding to real incidents, SERS has recognised that familiarity with the issues that are likely to arise during ship casualties will lead to a more effective combined response. Consequently, SERS is keen to encourage emergency exercises and has also developed a one-day training course for their clients that can be delivered in clients' offices.

Clients of Lloyd's Register's SERS include Stelmar, Eleton Corp, Shell, BP, International Marine Transportation (IMT), and Vela International, among many other prominent tanker operators, as well as operators of other kinds of vessels. ⚓

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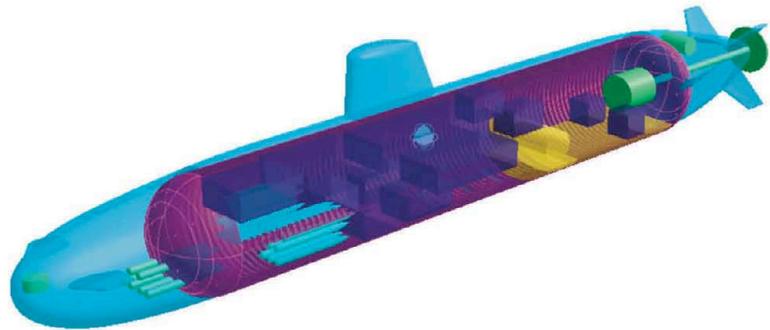
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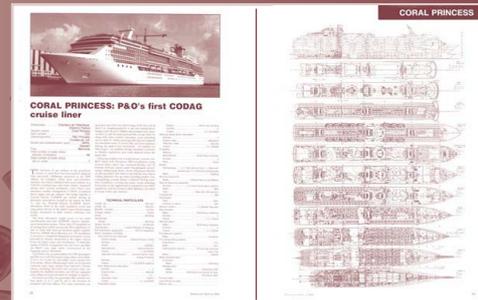
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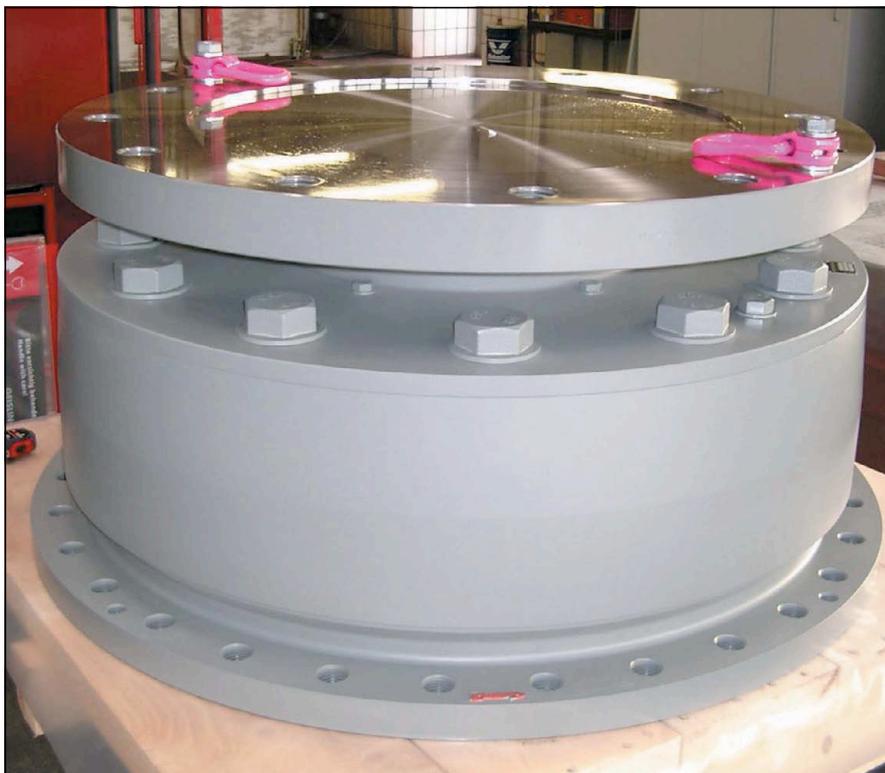
Shrinking noise and vibration with Geislinger couplings

CUSTOMISED and optimised proposals can be made by the Austrian coupling and shafting specialist Geislinger to limit vibration and noise levels from diesel engines, which are, of course, principal exciters on ships. Last year, this company succeeded in winning a satisfactory number of marine contracts in this sector.

Notable amongst these were eight transmission couplings for installation with 2 x 12,600kW medium-speed diesel engines in each of a pair of 22.00knot new passenger/vehicle ferries under construction at IZAR's Sevilla yard for the Algerian operator ENTMV (Enterprise Nationale de Transports Maritimes de Voyageurs), and a further four units for new ferries contracted by Tirrenia at Fincantieri. Still in Italy, 10 couplings were supplied last year to cruise liners being built at Fincantieri for the Carnival group, an operator which particularly wants to reduce both weight and noise; this brings the total supplied to Carnival and its affiliated companies to 130 units.

Geislinger has also recently delivered couplings to Japan, for installation on a ro-ro ferry building at Kawasaki and another of 9900gt at Imabari. These particular ships are powered by Pielstick 12PC4-2B (Kawasaki) and 18PC4-2B engines (Imabari).

In the high-speed sector, couplings have been exported to Australia for fitting on Fred Olsen's new 126m long slender stabilised monohull ferry being built by Austal for this operator's Canary Islands services. Olsen demanded the lowest possible weight, best sound insulation, and easy installation;



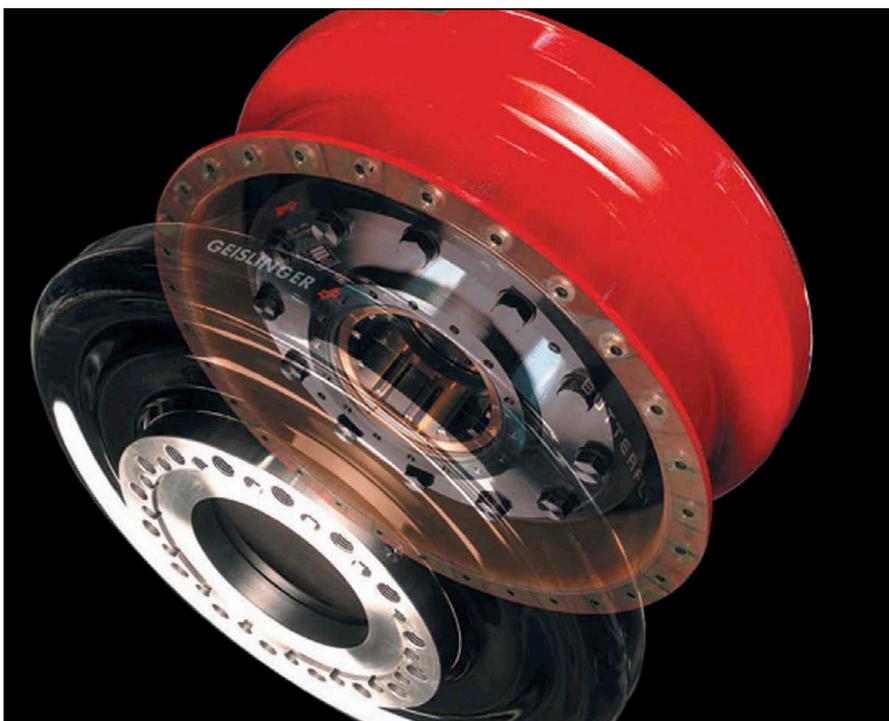
An example of the Geislinger couplings supplied for a Japanese ferry ordered from Imabari Shipbuilding and transmitting the output from Pielstick 18PC4-2B medium-speed engines.

Geislinger therefore specified Gesilco composite couplings in association with torsional elastic steel models. The main

benefit claimed for these very low weight units are low reaction forces under deflection and reduced loads inside the engines and gearboxes. Increased inspection intervals and reduced maintenance costs are expected to result.

Extreme weight savings have also been achieved on another Australian fast ferry, at Incat, which is powered by quadruple 7200kW Caterpillar 3618 engines. This plant uses a Geislinger coupling combination consisting of a torsional steel coupling directly connected to the splined gear input shaft, and a Gesilco unit to compensate for misalignments of the elastically mounted engines. Each combination weighs only 405kg.

Additionally, this Austrian company can offer useful integrated systems, such as gearwheel couplings for camshaft and power take-off drives, flywheel integrated solutions for high-speed diesel engines, and the recently introduced Flydamp, which combines the flywheel with the starter gear ring, torsional damper, and coupling in one unit. ⚙️



One of four couplings exported to Australia for fitting in an Incat fast ferry. This very low-weight unit (405kg) consists of a torsional steel coupling connected directly to the splined gear input shaft of an elastically mounted Caterpillar 3618-type engine, combined with a Gesilco composite coupling to absorb misalignment.



Vibration Problems?

Why deal with the symptoms, when we can eliminate the source!!

Most vibration problems are reduced by adequate conventional counter measures such as stays and dampers. By introducing the G & O electrically-driven moment compensator the source of vibration is eliminated, because the system creates an opposing sinusoidal varying force and phase angle that simply out-balances the source of vibration, resulting in:



- Reduced Maintenance Costs
- Improved Engine Performance
- Improved Crew Comfort
- Improved Economy



Gertsen & Olufsen and its Vibration Compensators are world leaders in eliminating unwanted vibrations and improving the performance and comfort of ships and power plants. The company specialises in the development, production, installation and sale of electrically-driven moment compensators.

Gertsen & Olufsen AS

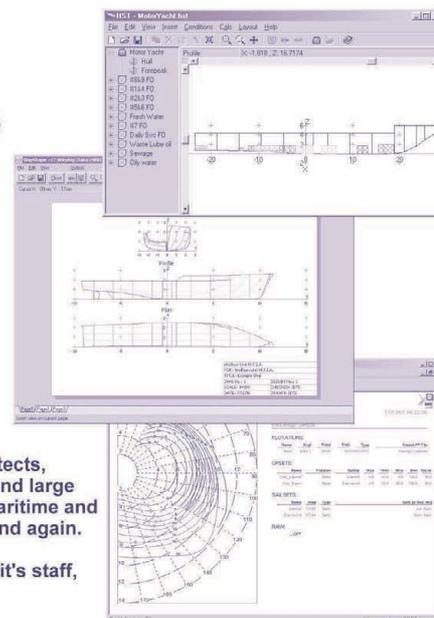
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Eliminating vibrations with moment compensators

VIBRATION compensators from Gertsen & Olufsen, in Denmark, a company which specialises in the development, production, installation and sale of electrically-driven moment compensators, are said to be excellent for eliminating unwanted vibrations and improving the performance and comfort of ships. Guide-force moments, unbalanced moments, axial thrust, and hull beam vibrations are all unavoidable characteristics linked to the low-speed two-stroke diesel engine. Most vibration problems are reduced by adequate conventional countermeasures such as stays and dampers. However, these only reduce the symptoms, and do not eliminate the source of the vibrations.

The most common vibration-related problems and damage types are:

- limitation of engine performance and hence operational economy
- cracking and reduced mechanical strength of superstructures, top stays, and tanks
- leaking, cracking, and reduced mechanical strength of fuel, lube oil and water piping
- abnormal wear on rotating machinery and components

- increased failure rate of electronic and electric components.

By introducing an electrically-driven moment compensator, the source of vibration is eliminated because the system creates an opposing sinusoidal varying force and phase angle that simply outbalances the source of vibration. This can result in reduced maintenance costs, improved engine performance, better crew comfort, and more attractive economy.

Installing a Gertsen & Olufsen vibration compensator is a relatively simple project that does not interfere with operation of the vessel. If required, the company can act as responsible project manager throughout the entire installation, from exciter test to fine tuning of the system. The unique and patented design offers many operational advantages, such as:

- automatic control and safety system
- low power consumption and low noise levels
- easy adjustment of force, direction, and phase angle



A typical Gertsen & Olufsen electrically driven compensator installed on the upper platform of a large low-speed diesel engine.

- superior synchronisation with the main engine
- easy installation and long maintenance intervals.

Meanwhile, Gertsen & Olufsen is investing many resources in developing new models in addition to its existing range. 

Customised floor types limit vibration and noise

SPECIFICATIONS for noise control in ships have become more and more strict recently, consequently, prevention and control of vessel vibration and noise are today receiving more attention than ever. For passenger ships, in particular cruise ships, comfort is significant for rating in the market. The choice of low-noise resilient-mounted engines and low-noise propellers are well-known methods of reducing structure-borne noise and vibration, however in many areas of a ship improvements cannot be obtained by only reducing noise generation at the main noise sources. These areas include:

- passenger areas in the aft of a cruise ship with substantial noise from the propellers
- impact noise excitation to passenger cabins located just below open deck areas, galleys, and discos
- airborne noise from machinery rooms, disco music, and theatres.

Such problems are normally solved by careful design of cabins, lounges, and passenger areas. Acoustic properties of accommodation materials are also extremely important for sound reduction. The most important element for the noise in cabins is often radiation from floors. In order to meet the requirements of the market, Germany-based G Theodor Freese (GTF) has carried out a program of development. The result of this study gives appropriate solutions for noise-reducing measures onboard ships.

In practice, three types of floor are applied in ships, namely, standard levelling floors, vibration-damping floors, and floating floors. The acoustic properties of these types of floor

are very different. The standard levelling floor is normally applied in areas with no need for noise-reducing measures.

Vibration-damped floors

Vibration-damping constructions are normally applied in areas where only structure-borne or impact sound contribution is substantial. The principle of the vibration-damping floor is that vibrations are absorbed by means of a specially designed constrained layer construction (Tefrotex visco-elastic plus steel-plate or primary deck covering, ie, Tefrotex 60), reducing the vibration level in the local plate fields of the ship deck structure, hence reducing radiated noise into the accommodation. A vibration-damping floor with optimum acoustical properties is characterised by the following:

- high loss factor of the visco-elastic material
- low shear module of the visco-elastic material
- high module of elasticity of the top plate
- optimised thickness of each layer.

Loss factors

Tefrotex visco-elastic material can be combined with different types of top layers in order to fulfil any need in a vessel. Therefore Tefrotex visco-elastic has been tested according to IMO Resolution 635 (16)/A. 687 (17), MED EC 96/98, in order to allow combinations with any type of top layers. The loss factor of visco-elastic material is the most important parameter for vibration-damping properties of constrained-layer constructions. By optimising the thickness of the materials applied in the constructions it is possible to obtain high loss factors.

Floating floors

Floating floors (Tefrolith M, Tefroment S, and Tefrolith FF-Steel) are applied in areas where high airborne or structure-borne sound insulation is needed. The principle of the floating floor is that the vibration transmitted is reduced by means of mineral wool so vibration levels of the top plate are hence the radiated noise is lower.

A floating floor construction can be ascribed as a mass/spring system, with a frequency of resonance corresponding to the stiffness of the mineral wool and the weight of the top layer. The floor has the optimum acoustical properties characterised by the following:

- heavy mass of the top plate
- low stiffness of the mineral wool
- low resonance frequency in the floating floor construction.

For frequencies below resonance frequency of the floating floor, noise reduction will theoretically be zero. The resonance frequency for the floating floors is normally approximately 80Hz-100Hz.

Noise transmission in accommodation

In order to be able to select the correct type of noise reducing floor it is important to know:

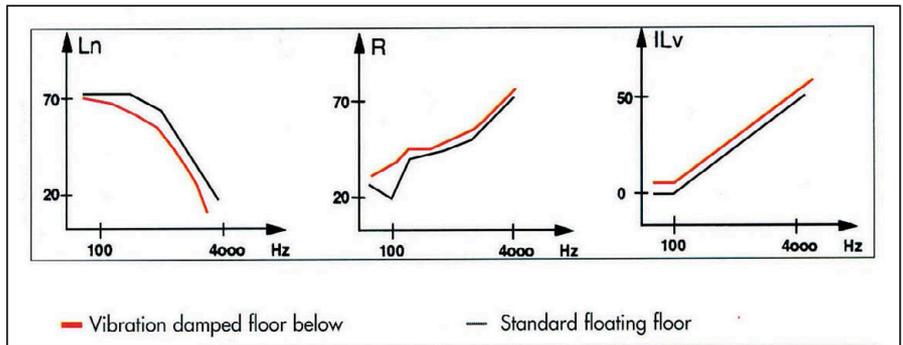
- the type of the noise source (propeller, main engine, auxiliary machinery, air condition machinery, or human activity
- the noise transmission paths in the ship, eg, the location of the cabins relative to the noise sources in the ship.

Specially-designed noise-reducing floors

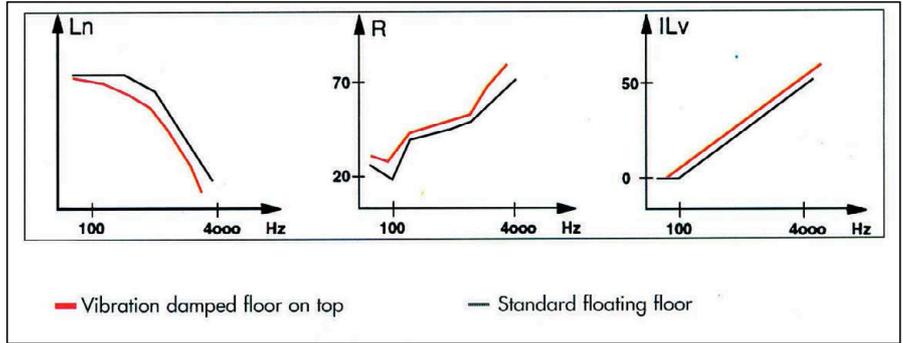
For very demanding applications, where a very high damping is required or the noise spectrum is dominated by either high-frequency or low-frequency components, it is possible to design variations of the standard floors or to combine different types of floors, ie, Tefrotex visco-elastic/steel plus Tefrolith FF-Steel. This construction was installed onboard *Diamond Princess* and *Sapphire Princess* at MHI in Japan. Furthermore, constrained layer Tefrotex visco-elastic plus Tefrotex 60 were also installed onboard these vessels. GT Freese has also supplied flooring to *Superstar Leo* and *Superstar Virgo* (built by Meyer Werft), and *Pride of America* (currently building at Lloyd Werft).

Variation of component properties

For standard floating floors, material properties can be selected in order to provide the exact acoustical performance that is required in each case. This means an optimised solution where price, weight, and acoustic performance are balanced against each other. High noise reduction can be obtained by combining floating floors and vibration damping floors. GTF floors can be combined either with the visco-elastic construction below the floating floor construction or by applying a vibration-damped top layer on mineral wool.



Noise reduction improvements for a vibration-damping floor below a floating floor.



Noise reduction improvements for a vibration-damping floor on top of a floating floor.

Couplings for high-speed vessels

THE primary reason for a rubber coupling between a diesel engine and a marine gearbox is to control torsional vibration of the system and keep vibratory torque in all components within acceptable limits. For high-speed vessels, Vulkan, of Germany, usually offers RATO-S or RATO-R highly flexible couplings; by changing the stiffness of the rubber, users can tune the system to an acceptable solution. The RATO-S and R are linear stiffness couplings and Vulkan aims to get the first natural frequency below engine idle, thus ensuring no barred speeds, so engines can work through their designed speed range.

With high-speed vessels, engines are usually on anti-vibration mounts and the hull is often made of aluminium alloy. This causes two additional challenges for the flexible coupling, as it now has to accept axial and radial misalignment caused by the engine moving on its anti-vibration mounts and angular misalignment caused by hull deflection. The flexible coupling has not only to accept these movements, but the reaction force has to be relatively low so as not to cause high loads on the adjacent bearings.

Both the R (radially soft), A (axially soft), TO (torsionally soft), -S (segment design), and -R (ring design) couplings are flexible in all planes with low reaction forces and are ideal for this type of application. As the couplings are in shear, the drive and driven machinery are separated by rubber, thus giving the added benefit of good noise attenuation.

Vulkan-DMR anti-vibration mounts

When an engine is on resilient mounts, stiffness of the flexible coupling must be taken into account when calculating mount frequencies, so that the coupling becomes the fifth mount. It is therefore important that manufacturers understand each others' products. In 2003 Vulkan and De-Martini Research signed a joint venture agreement to form Vulkan-DMR, thus bringing engine, exhaust mounts, and tailshaft couplings into the Vulkan range of products, enabling Vulkan to offer the complete package and analysis.

Composite shafting

For weight reduction purposes, aluminium alloys are used frequently in high-speed vessels, thus the



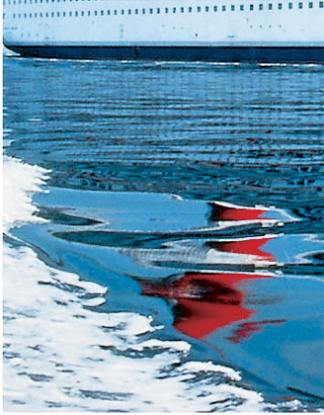
The RATO-S is a linear stiffness coupling for high-speed vessels.

use of composite shaft lines is becoming more popular. This type of vessel often has four drivelines. Additional weight savings can also be achieved by a reduction in shaft bearings as composite shafting can span larger distances compared with conventional shafting. The actual length is governed by critical whirling speeds.

Vulkan composite shafting consists of a composite shaft, steel adapters, intermediate shafting, bearings, bulkhead seals, and as an option, flexible links, membrane couplings, highly flexible couplings, or other driveline products. The composite shaft is a filament-wound carbon- or glass-fibre structure and is available in a torque range from 5KNm-800KNm, with diameters from 170mm-810mm and different length configurations. The composite shafting can be supplied with all major classification societies' approval and is tested in-house with maximum torques of up to 5000KNm.

Pictured here is the RATO-R with an associated composite shaft.





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Hyundai Heavy Industries leads the way

George Bruce recently visited Korea for The Naval Architect and here provides a short report on four shipyards visited, with emphasis on their construction and production strategies, and plans for the future.

THE Hyundai Heavy Industries (HHI) shipyard dominates the area of Ulsan, known locally as Hyundai City. Since 1972 the shipyard has expanded from one site to a two-site operation (the other being Samho – the former Halla yard) as well as the yard-within-a-yard at Ulsan for VLCCs, with nine drydocks in operation. The maximum lifting capacity is 900tonnes. Hyundai is now the largest shipbuilder in the world. In fact, according to the figures provided to *The Naval Architect*, Hyundai shipyards, along with Hyundai Mipo Dockyard, contribute 20% to the world total output of ships.

The initial development in Ulsan was assisted by European technical expertise and the shipyard is extensively equipped with European equipment. Of the many countries which used shipbuilding as a key part of national industrial development, the Republic of Korea was by far the most successful. In 2003 the Korean order intake was some 40% of the world total.

As the biggest of the major Korean shipyards, Hyundai is leading the way. The basic statistics on the shipyard are impressive. From the first ships, two VLCCs delivered in 1974, after shipyard construction commenced in 1972, the annual output has grown to 60 ships totalling about 4.5 million gross tons.

Today, Hyundai is changing the focus of its shipbuilding. As the ability and capacity of the Chinese shipbuilding industry increases, the shipyard is looking for higher value-added products. Thus Hyundai has completed its last bulk carrier, since it does not believe it is any longer able to compete with lower Chinese labour costs. The more recent market it has successfully targeted is the larger container ship sector. In fact, Hyundai has some 30 large container ships of a total orderbook of 85 ships. Overall South Korea has 80% of this market segment.

Future plans are to create a product mix which fulfils several important criteria. The first requirement is to respond to the market,

creating new ships which are attractive. Second, the product mix must make use of the capability Generally, Hyundai has in large-scale steel production and outfitting. The current focus on container ships is a result of this development policy.

Hyundai does not build ships smaller than Panamax size, preferring to concentrate on larger vessels. There are also offshore projects, including FPSOs. However, unlike Daewoo, the company does not see the LNG market as attractive at current prices. However, new projects are in progress in the research and development institute, including the use of compressed natural gas technology.

Cruise ships are regarded as a longer-term market, following LNG ships. At present, according to HHI management, the necessary sub-contract infrastructure is lacking; however, two ferries have been built recently for Stena. The management at Hyundai were keen to discuss some of the key issues facing the South Korean shipbuilding industry. There is a greater focus on export ships than is the case in Japan. In fact, South Korean yards export 90% of their production.

South Korean wage levels have risen for many years and the current rate of wage inflation is stated to be 6%-7% annually. At the same time the current record world shipbuilding orderbook is causing increases in the price of ship materials and equipment. The demand for steel has recently increased after a period of retrenchment in the industry, which has resulted in a rise in steel prices which are up by some 20% in the past year. These cost increases are set against weak ship prices, although Hyundai believes that the future may bring better freight rates and firmer prices for the ships.

The fluctuating Won is also seen as a problem. In the last few months the Won has appreciated against the Dollar by some 5%, which is significant to a shipbuilder. Since 1997, the relative weakness of the Won has been a benefit to South Korean shipbuilders.

Shipbuilding productivity

Figures provided to *The Naval Architect* by Det Norske Veritas and confirmed from other sources trace the story of the remarkable increase in shipbuilding productivity in South Korea. In 1984 the relatively new industry,



A container ship for Blue Star nearing completion at Hyundai Heavy Industries.

with Hyundai as its leading shipyard, produced about two million gross tons of ships, and employed 75,000 workers. By 1993, with some additional shipbuilding docks, production was up to four million gross tons, with employment dipping to 45,000. Following the significant drydock expansion of the mid-1990s, production in 2002 was up to 13 million gross tons, and the workforce had grown to 95,000.

Allowing for the relatively simple ships built in Korea, the compensated gross ton can be calculated, using an overall factor of 0.6. The resulting productivities are tabulated below in compensated gross tons (cgt) per man-year.

Year	1984	1993	2002
Productivity	16	44	82

Technology

During a brief tour of the extensive shipbuilding and marine engineering facilities, the scale of operations was – as always – very apparent. One of the main drydocks, extended to 640m in length by 92m wide, held six ships in various stages of production. Over US\$400 million has been invested in the mid-1990s in expanded facilities for ship construction.

No detailed review of the work in progress was possible but observation of activity in the various workshops indicated a high level of outfitting and painting of the blocks and units. Where blocks were seen, the joining of the units to form these was apparently based on very accurate steelwork. There was little evidence of the use of welded fairing aids to align adjacent structures.

Most units, particularly those such as double bottom and other enclosed structures were outfitted and painted. The general level of housekeeping was high and the overall impression is of well-organised production consistent with the high productivity that the overall figures suggest. ⚓

Amongst many completions last year by Hyundai Heavy Industries was this large DNV-classed LPG/NH₂ tanker *Hellas Nautilus*, for Consolidated Marine Management Inc. This 82,000m³ fully-refrigerated design made by the shipyard, and the four holds each enclose an independent and self-supporting tank built from low-temperature steel, which is insulated with 120mm thick polyurethane foam covered with 0.5mm aluminium zinc steel sheeting. Each tank is fitted with two Hamworthy KSE Svanehøj vertical deepwell cargo pumps of 600m³/h. Further details can be found in *Significant Ships of 2003*.



Daewoo maintains focus on tankers

THE Daewoo Shipbuilding & Marine Engineering (DSME) Co occupies the Okpo site on Koje Island. This location has expanded during a little over 20 years to an impressive four million square metres. The main activity on the site is still commercial shipbuilding, but there is also offshore construction, together with warship and special ship production.

The yard contains two graving docks (for construction) and two floating docks (mainly for guarantee work). No 1 dock is 530m long by 131m wide. A certificate from the Guinness Book of Records currently identifies this as the world's largest drydock. A Goliath crane spanning the dock has a lifting capacity of 900tonnes, and a span of 206m. The dock is used for commercial ships, and typically has four under construction at any one time. When two ships are floated out, the next two in sequence are moved to the seaward end of the dock and two more commenced. Capacity is around 20 ships annually.

A further 20 ships, depending on size and type, can be built in No 2 dock, supplemented by the floating docks, which are also used for guarantee dockings. No shiprepair is carried out. The 3km of quay space can be used flexibly to moor any of the DSME products.

In common with the other Korean shipyards, DSME places considerable emphasis on the workforce. The company has around 10,000 employees and uses up to 8000 sub-contractors. DSME is a significant employer on the island, and along with Samsung, the other major shipyard located elsewhere on Koje Island, provides work for 28,000 out of a population of 190,000.

The technical department occupies an impressive new building, and a total of 1600 specialists are engaged in design, research and development, and technical activities. A wide range of tasks are undertaken, including structural analysis, fatigue and wave load analysis, and vibration analysis. Model testing and new design development are also important activities.

A 'green' yard

Environmental issues are of increasing importance to the shipbuilding industry, and Daewoo has been developing as a so-called 'green' shipyard for the

The advanced state of Korean shipbuilding technology is demonstrated by this illustration of very accurate steelwork - plus the now-common sight in that country of significant pre-outfitting - on a block just erected at Daewoo.



past 10 years. The company has been awarded the ISO 14001 certification (in 1997) and the Occupational Health and Safety Assessment Series (OSHAS) 18001 certification in 2001. Wastewater treatment, tin-free antifouling coatings and atmospheric emissions have all featured in Daewoo's ongoing programme.

Turnover in 2003 reached some US\$3.5 billion, of which 75% is from the shipbuilding activities. In common with other shipyards in Korea, DSME is reported to be profitable at present. Since DSME separated from the parent Daewoo group in October 2000 and floated on the Korean Stock Exchange, the share price has risen significantly.

Production of ships is currently concentrated on three types. About 40% of vessels are LNG tankers, with five in various stages of construction when *The Naval Architect* visited. A further 40% is accounted for by other tankers, and container ships make up the remaining 20%.

A typical product mix is two VLCCs and two LNG ships in the large No 1 dock, with two container ships in the smaller No 2 dock. The LNG ships are of the membrane type. Current studies are being conducted to develop very large LNG designs of 200,000m³ and 250,000m³ to meet anticipated increases in energy demand.

DSME has moved away from bulk carrier production, which was a significant element until relatively recently, and is looking to more added-value production. It has only limited interest in passenger vessels, although a small number of ferries have been built recently for European and Korean owners.

DSME management stated it is seeking to reduce production costs. To date it has relied almost exclusively on in-house production, to ensure reliability of delivery and quality. However the use of outsourcing is being reviewed. Investment costs approximately US\$200 million annually to maintain and improve the facilities of the yard. Ⓜ

Busy order book at HMD

THE Hyundai Mipo Dockyard (HMD) shipyard was established in 1975 for shiprepair and conversion, on the original Hyundai Shipyard site. In 1984, the yard moved to a new site round the coast but still within the city of Ulsan. The shipyard has four drydocks, three of 380m length by 65m wide, and the fourth of 300m length and 76m width. The company also has an interest in a Vietnamese shipyard (Vinashin), with drydocks of 400,000dwt and 150,000dwt.

In 1995 the company made an important decision to focus on ship construction rather than repair and conversion, although it still claims to repair up to 100 ships each year.

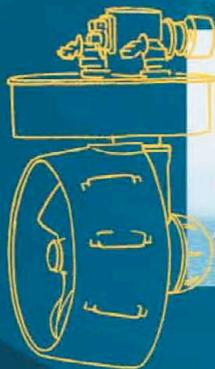
The main reason for this change was increasing wages and a relatively poor location.

The current order book will take HMD through to 2006, with an annual capability of up to 38 ships. The product mix is for ships of Panamax or smaller size, which fits with the Hyundai Heavy Industries mix of ships greater than Panamax. The company thus has a wide coverage of the market. Although the shipyard has built a wide range of ships, there is a concentration on products and chemical tankers of around 37,000dwt. Some of these have been ice classed. HMD has a strong tank coating capability to support the specialist shipbuilding.

Mipo has developed in the last decade through a series of plans, known as Visions. In 1996, Vision2000 was the plan for the switch into shipbuilding. The current plan, Vision2005, is to develop an increased capability for more sophisticated tonnage. In the offshore field the yard has already built several drill ships (including *Pride Africa* and *Pride Angola*, both 1999) and cable layers. A pipelayer has also been completed.

In the longer term the company hopes to aim for the passenger ship market. Chinese competition for the smaller and relatively complex ships is said to be limited, because Korean shipyards can offer better reliability of delivery dates, at least at present. Ⓜ

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Medium-size yard with full order book

STX, based at Chinhae, is one of the relatively smaller South Korean shipbuilders. It focuses production on ships of Panamax size or below. The single dock, of 320m in length by 74m wide and allowing construction of two Panamax-class hulls side by side, is served by two Goliath cranes of 300tonnes lifting capacity. Another crane of 450tonnes capacity is also available for block construction. Vessels can also be built in semi-tandem, so that the delivery cycle time is minimised. As a result, STX delivered 20 ships during 2003.

The total site area of the STX shipyard at Chinhae (which was formerly known as Daedong) is 728,000m² - relatively compact by Korean standards. Despite being a new 'greenfield' site, the location restricts any further expansion, so STX has concentrated on maximising production from its single dock.

STX told *The Naval Architect* that as the bulk carrier market is improving and prices are better, so it will bid for these relatively simple ships. At time of writing and in line with current thinking, the design department has a double-hull model under development; however, the yard acknowledges that prices in China are currently lower than in Korea, typically by 10%. For the market in which it operates, STX regards other South Korean shipyards as its main competitors.

STX considers that a selling point is the quality it provides and the speed of delivery. For the next five years, the designs that the

company is able to offer, plus the management ability, should allow the company to compete with China, despite the latter's lower prices. However, pressure to reduce costs is increasing, and innovation (along with quality and delivery performance) is critical to continuing success.

The shipyard is developing new technologies for both production and design, and has instituted programmes to improve productivity and to reduce costs. In 2003, a programme called 'Dream and Future 2010' began, which has several themes. The intention is to use current management techniques, including so-called 'six sigma', enterprise resource planning, and just-in-time philosophies, to remove costs.

STX employs around 1500, including 250 staff engaged in product development and research. Standard designs are offered and, as mentioned, a double-hull bulk carrier design is in hand to anticipate the improving market. A large number of sub-contractors are also used, and in total there are some 4000 people on the site.

Although all this is seen as a means of reducing production costs, STX management indicated some concerns about the problems of maintaining quality and delivery schedule. Nevertheless, the number of ships built annually, which is planned to rise to 22 in 2004, indicates considerable success in dealing with any problems which occur. In common with other Korean shipyards visited by



Typically of the advanced technical equipment at the STX shipyard is this automatic pipe sorting rack.

The Naval Architect, STX identified the rise in steel prices and the current strength of the Korean currency as current problems which are affecting competitiveness. ⚓

Water ingress monitoring for bulk carriers

THE Unitor water ingress monitoring system is a monitoring system for bulk carrier cargo holds and strategic void spaces forward of the collision bulkhead. This unit monitors water levels and provides warning at two levels in the cargo holds. The system is designed in compliance with regulation 12 of SOLAS Chapter XII, IACS UR S24 and the IMO performance standard for water level detectors requiring bulk carriers constructed prior to 1 July 2004 to have water level detection monitors fitted not later than the date of the first annual, intermediate or renewal survey of the ship to be carried out after 1 July 2004.

The monitoring system is made up of a central control alarm panel, built-in, intrinsically safe barriers, and water level detectors (IP68). The water level detectors can be installed so that they are isolated from the cargo and protected from mechanical damage during cargo operations. They can also be installed without the need for structural alterations or piping work within the cargo holds. Each level detector is corrosion-proof, can be back-flushed with water from a remote location, and has a replaceable filter.

The control and alarm panel indicates the status for each named cargo hold. Pre-alarm

signals are given at 0.5m; the main alarm activates at 2.0m or in the event of a faulty alarm. Integral safety barriers are built into the control and alarm panel.

Water level detectors are fully compatible with all registered bulk cargo. Each detector includes a 30m, factory-bonded cable in compliance with IP68 and IEC60529. Cleaning of filters can be undertaken at any time using air or water and with cargo in the hold. Optional features include deck level or full automatic testing and filter cleaning.

The system's fail-safe design includes built-in safety barriers. It can operate on both main power or from an emergency backup supply. The panel includes a cable damage alarm, built-in time delays to prevent spurious alarms and an override facility for holds flooded with ballast water. The override facility resets automatically when the compartment is de-ballasted. Continuous monitoring is provided.

No secondary barriers are required, and there is a deck top box option for cargo hold cabling, cleaning and test connections. A cable marshalling box limits the number of cables to cabinet, and the system is designed to fit into standard pipe fittings - no special fabrication material is required. For void space installation options only limited piping work is needed, and the system can be

installed in sounding pipes. It does not interfere with use of a sounding pipe or other gauges.

When operating, the system is continuously monitored and a fault alarm generated for short or open circuit. Manual or automatic detector testing and cleaning can be done from the deck or control panel, and filter cleaning and testing from deck level. There is no need to enter cargo holds as testing and cleaning can be carried out with cargo in the hold. Replaceable filters also give protection from dust.

Water level detectors fit directly into standard 2.5in pipe fittings. No special fabrication is needed. The detector has compact dimensions and is claimed to be easily arranged in any space. There is only one type of water level detector, so this reduces the need for spares. There is also a digital level switch which means there are no electronics in the cargo hold.

A design package can be supplied as required to the classification society for approval. Final approval documentation, when required, includes schematics and layout drawings. Unitor supplies the required number of instruction manuals, including system drawings, component data sheets, technical descriptions, procedures, and approval certificates. ⚓

Model/full scale cavitation correlation investigations for a twin-screw cruise liner

The propeller is well-known as one of the main exciters of ship vibrations. The high speed and large power of today's passenger, container, and navy ships requires carefully designed propeller geometries working in a perfectly optimised wake field to keep these vibrations as low as possible. Here, Jürgen Friesch from HSVA, the Hamburg Ship Model Basin, discusses a recent investigation carried out.

WITHIN a research project, funded by the German Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, cavitation observations, pressure fluctuation, and wake field measurements onboard a 42,200gt cruise liner were performed during sea trials in the west part of the Baltic Sea, between Wismar and east of Bornholm. The vessel was a twin-screw ship with a conventional shaft arrangement and the shipyard was involved in the development of the test programme from the beginning.

The pressure fluctuation measurements were performed during the speed trials and at the same time, cavitation phenomenon was documented on video. Photography and viewing was carried out during the day, and in the evening with artificial lighting. Nine pressure pick-ups were installed in special inserts in the hull above the propeller. Eight pressure pick-ups were located on the port side, and one pressure pick-up was located on the starboard side.

During all tests the propeller shaft torque was determined with the help of strain gauges applied directly to the shaft. Parallel to these investigations, speed, vibration, and noise measurements were performed by classification society Germanischer Lloyd.

Full-scale results

The cavitation observations showed phenomena in the form of tip vortex cavitation and stable and unstable sheet cavitation only. Extent and thickness of the sheet cavity was rather small, leading to low levels of propeller-induced pressure fluctuations. No sign of a hub vortex and no hint of face side cavitation could be detected.

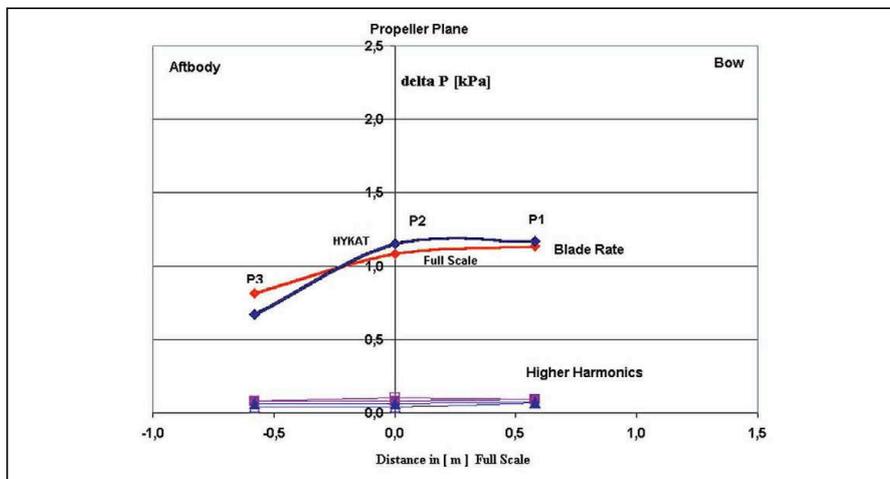


Fig 3. Comparison of pressure fluctuation data at full scale and in the HYKAT tunnel.



Fig 1. Full-scale tip vortex cavitation at 100% MCR.

The tip vortex (Fig 1) started at a blade position of 160deg (according to HSVA nomenclature 180deg means 12 o'clock position). The tip vortex is very thin and is visible up to a blade position of 270deg. In a blade position 260deg the tip vortex sometimes left the blade and was no longer attached. No bursting of the tip vortex could be observed.

Starting around 200deg blade position, small parts of stable sheet cavitation could be observed on the leading edge of the blade, close to the tip. Parts of unstable sheet cavitation could additionally be found on the blades between 0.7R and the tip of the blade. These

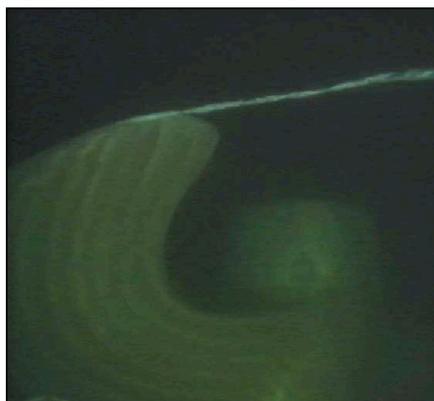
phenomena were visible up to 240deg blade position. Sometimes these patches have a cloudy character. Fig 2 clearly shows that this is the onset of this type of cavitation. Sometimes no cavitation could be observed, but a few revolutions later small parts of cavitation are visible.

The maximum height of the propeller-excited pressure amplitudes was measured with 1.3kPa for the first harmonic order for the 100% MCR condition. The higher harmonic orders were significantly lower and fully negligible. These results reflect good cavitation behaviour of the propeller, resulting in such low values of propeller excitation.

Comparison with model tests

Detailed cavitation tests had been performed in HSVA's large cavitation tunnel, HYKAT, both during the development phase of the ship and after the trials. The correlation is very satisfactory. The full-scale results were a full confirmation of the data which had been predicted by HSVA based on the different model tests. This holds true for both, the observed type and extension of the cavitation phenomena and the predicted pressure fluctuations. Fig 3 shows, as an example, the comparison of model and full-scale pressure fluctuations data for the 100% MCR condition. ⚓

Fig 2. Comparison of cavitation phenomena in full scale (left and centre) and in the HYKAT cavitation tunnel (right).

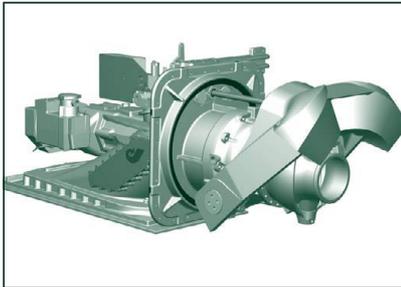


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WATERJET PROPULSION IV

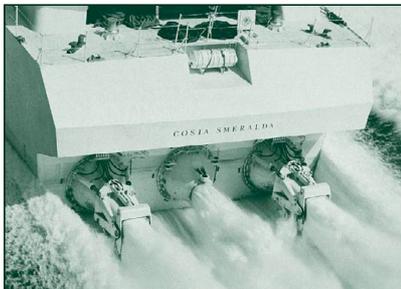
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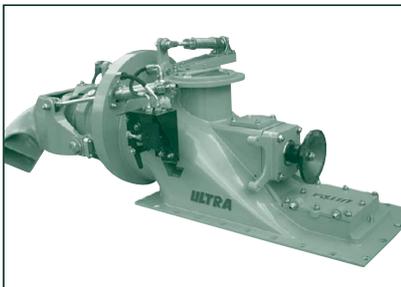


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Designers and manufactures also continue to seek to optimise the strength and weight of the various mechanical components and to improve reliability, reduce installation time and maintenance.

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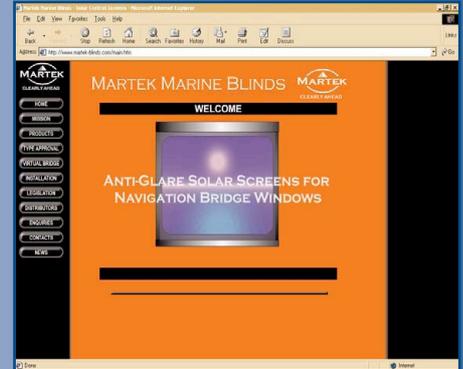
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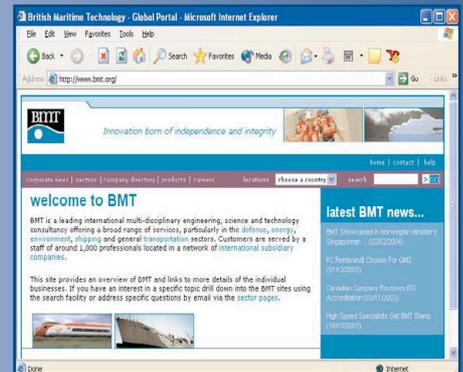
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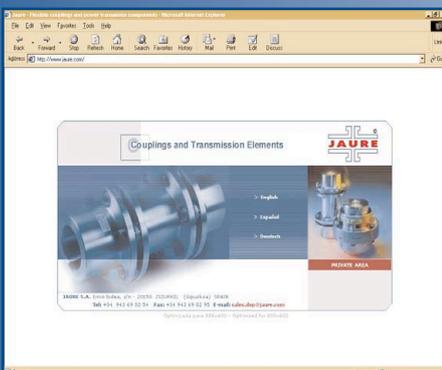
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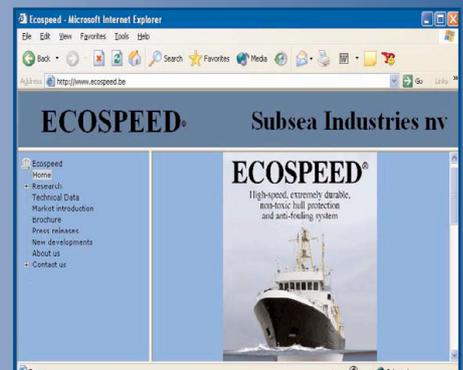
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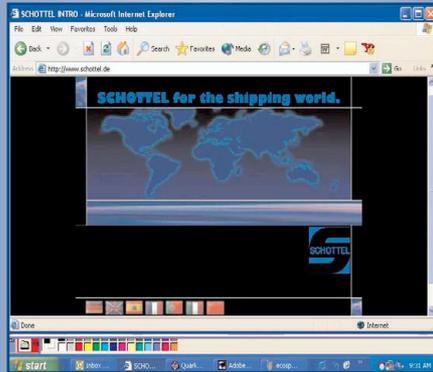
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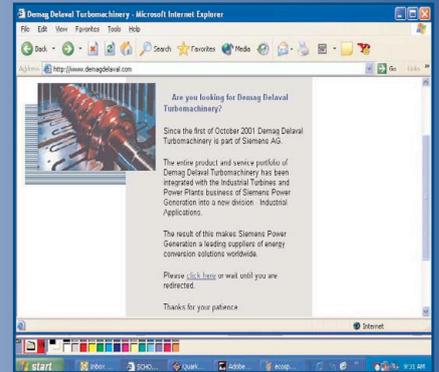
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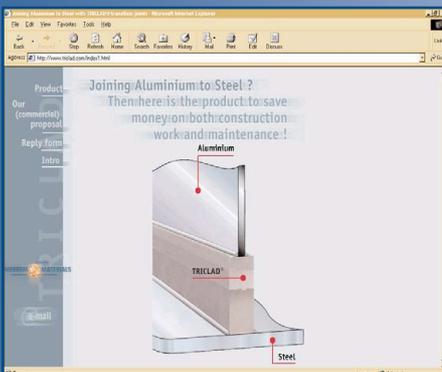
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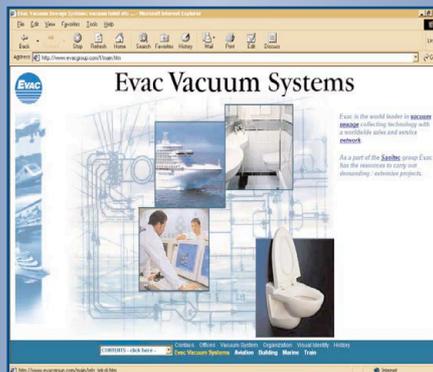
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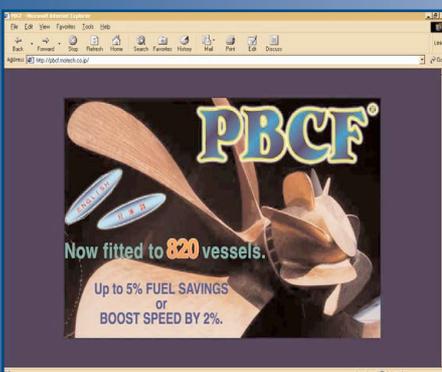
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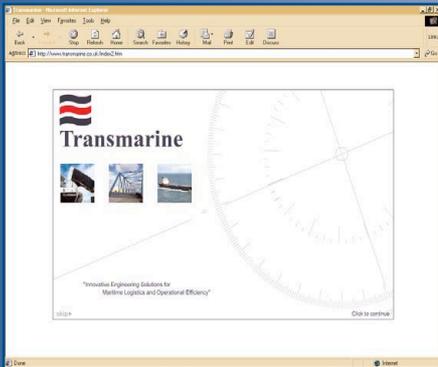
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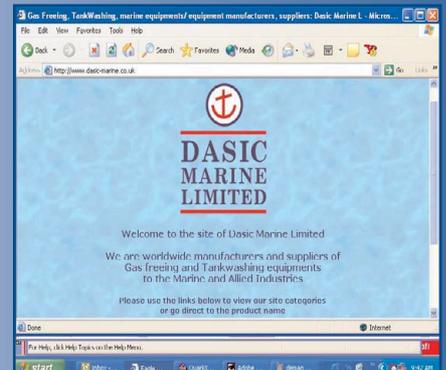
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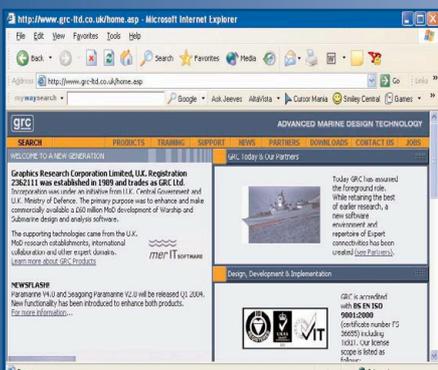
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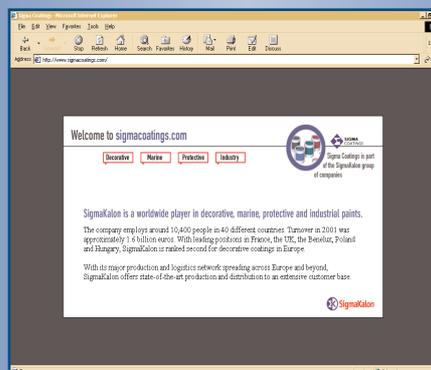
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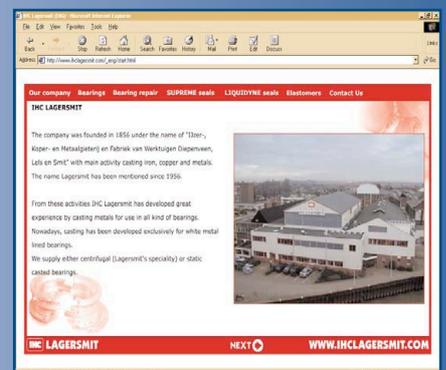
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